BIOMIMETICS

STUDY OF BLOSSOM OF HIBISCUS FLOWER

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Bionic Study of the Blossom of the Flower:

AIM:

- To understand ‘Biomimicry’ - the act of looking at nature for inspiration, and differentiate it into five design approaches and study the degree of mimicry each has achieved

- To study of the physiology of the Hibiscus (*Rosa sinensis*) and understand various mechanisms involved in the opening of the flower

- To interpret two mechanisms which aid in flower blossom into a physical model

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Bionic Study of the Blossom of the Flower:

METHODOLOGY:

- Initial study of biomimicry
- Study of the opening of the hibiscus flower
- Understanding mechanism involved in blossom
- Developing mechanisms in mock-models

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Bionic Study of the Blossom of the Flower:

SCOPE & LIMITATIONS:

- The study would partly rely on published literature and many illustrations are from secondary sources.
- Owing to time limit, the study has outlined only 7 major mechanisms of which only two have been interpreted.
- Due to the absence of lab infrastructure, the experiments were conducted in a non-controlled environment.

PART ONE

COMPREHENSION

BI-O-MIM-IC-RY - from the Greek *bios*, life, and *mimesis*, imitation

- Bio-mimetics is the technological outcome of the act of borrowing or stealing ideas from nature.
- It is also known as biomimesis, biognosis and bionics
- The ideal approach would be to identify the need at the functional level and develop solutions from analogies from nature.

a - Showing form of hibiscus leaves,
b - Structure at the bottom of lily pad,
c - Vein pattern of a leaf,
d – Micro-photo of stomata which aid photosynthesis,
e - Decaying leaf.

- **The study of the bionics regarding the blooming of the hibiscus flower comes under the INTERPRETATION category if we understand the structural arrangement of the different parts of a flower and derive a mechanism from the same.**
- **The study can also be on the line of SIMULATION if the visual qualities of the blossoming of the flower is captured and translated.**

Bio- mimetic approaches:

SIMULATION

INTERPRETATION

INTEGRATION

REPLICATION

EMULATION

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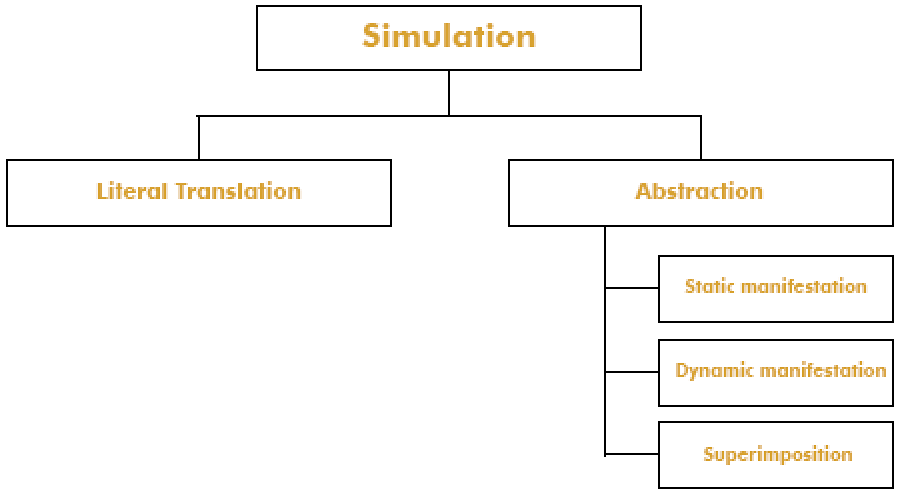
- **The study can also be on the line of SIMULATION if the visual qualities of the blossoming of the flower is captured and translated.**

SIMULATION:

Simulation involves feigning or copying the appearance of forms from nature.



Swiss Confederation Pavilion is a composite structure where superimposed the image of a gliding swan has been superimposed with an image of a slowly dilating water lily. A third image of an opening and closing eye is in turn super imposed on this water lily and all have been integrated into a new cognitive composite.

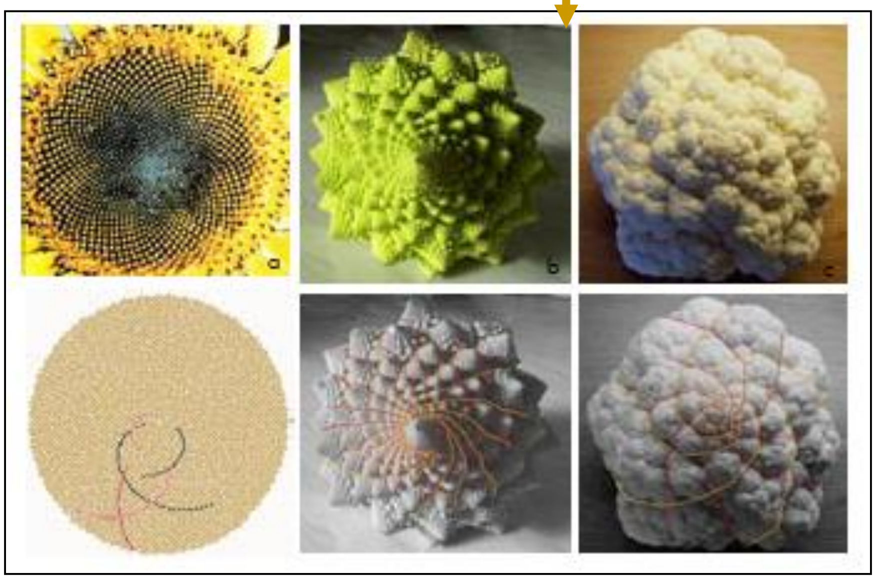
INTERPRETATION:

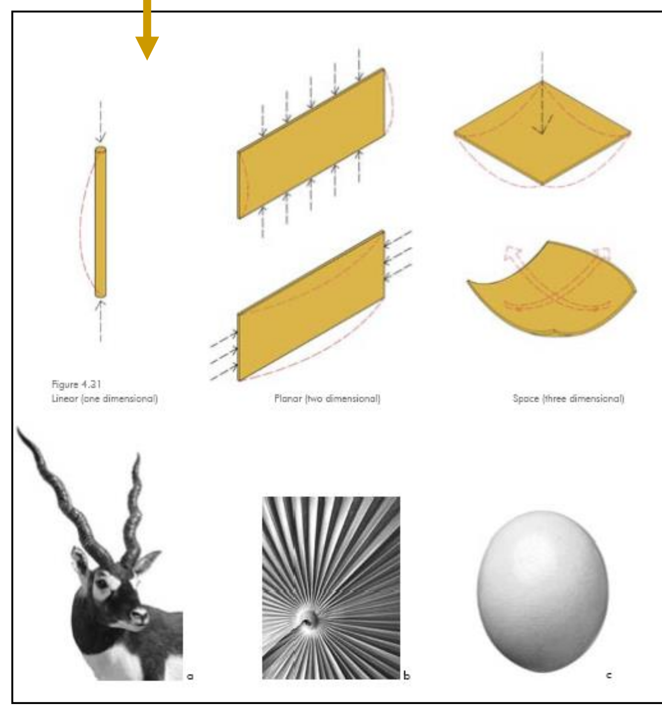
Interpretation as an approach involves the understanding of the principles of nature (geometry and structure) and the interactions between the form and natural environments and employing this understanding in design.

Interpretation

Tectonic Interpretation

System Interpretation

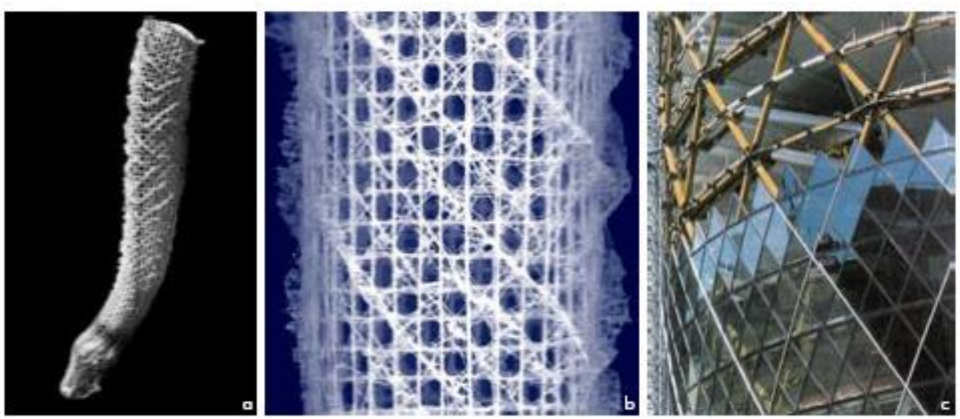




INTEGRATION:

"Integration" as an approach deals with integrating the tectonics interpreted from nature as well as the efficient systems derived from nature to make the building work efficiently, in harmony with the ecological system.

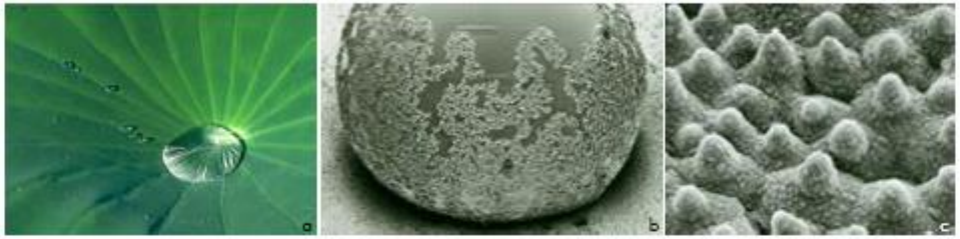
The 30-St. Mark Axe designed by Norman Foster is generally called as 'The Gherkin' - a young cucumber used for pickling as it resembles one, in its form. It is claimed to be the first environmentally progressive high-rise building using passive energy saving systems.



a - Exoskeleton of '*Euplectella*' sea sponge with the opening at the top (*osculum*).
b - Detail of the helically wound lattice structure in *Euplectella*.
c - Structural configuation showing tubular helical struts with triangular faceted glass cladding.

REPLICATION:

"Replication" approach might also be termed "elementary biomimicry". In this, one understands and models natural processes not by copying or interpreting specific solutions such as form, geometry, structure, function etc. but by approaching it as a cohesive whole.

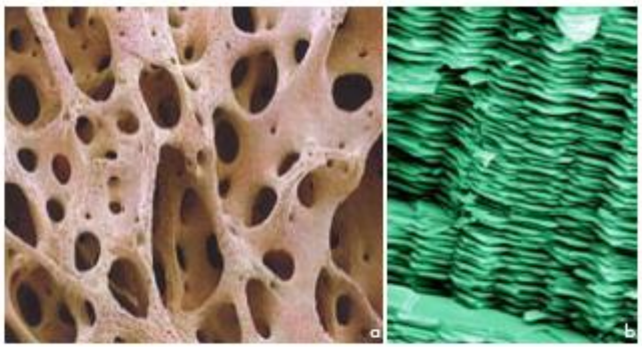


a - Lotus leaf (*nelumbo nucifera*).The water droplets touch the leaf's surface only at few points forming balls as it completely rolls off at the slightest declination.
b - Magnified picture of the water droplet absorbing particles of dirt as it rolls.
c - Microscopic picture of the lotus leaf's surface. A double structured surface optimized through the combination of micro- (cells) and nanostructure (wax crystals) contact areas are minimized.

The process of self-cleaning by replicating the nano surface structure of lotus leaf is used in surface finishes of buildings such as exterior paints, wood surfaces, masonry etc.

EMULATION:

Emulation can be termed as “advanced biomimicry,” it is based on modeling natural processes to the degree of self-assembly and self-repair leading to a holistic, integrated functionality like natural systems.



a - Spongy bone tissue, Scanning electron micrograph of cancellous (spongy) bone tissue. Bone can be either cortical(compact solid) or cancellous tissue forming the interior. The cellular structure is highly differentiated forming an irregular network of trabeculae or rod shaped fibrous tissue.

b - Oysters (or mother-of-pearl) have a strong layer of armour called nacre . The substance is made up of tiny crystals pieced together like the bricks and mortar of a brick wall, as seen in this micrograph.

Cellular materials are synthetically developed on the basis of the internal cellular structure of bones observed in nature. A wide range of foamed cellular metals and ceramics are developed, which are light in weight and can withstand high stresses. The cellular ceramics developed are implanted as bone grafts in surgeries.

CASE STUDY

THE GEOMETRY OF UNFOLDING LEAVES

H. Kobayashi, B.Kresling and J.F.V Vincent

The unfolding of a corrugated folded leaf of hornbeam (Carpinus betulus) and beech (Fagus sylvaticus) is described

Vein pattern studued to generate a corrugated surface.

Numerical models simulated using vector analysis, angles of laminar element planes and locations of creases, which correspond to veins.

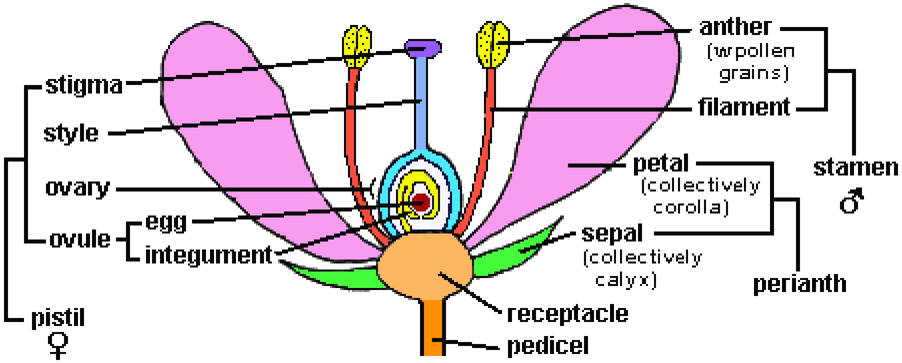
Development of leaf area during unfolding, were calculated.

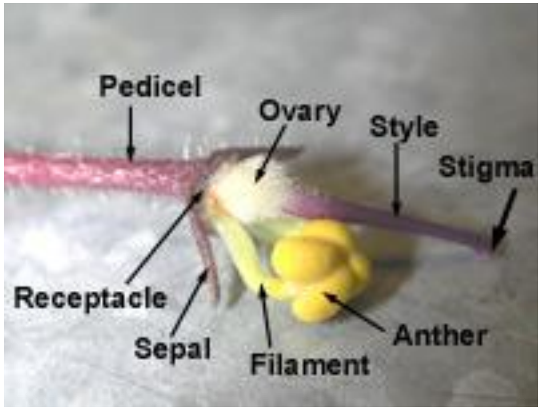
Application used for deployable structures. For eg: solar panel whose folding pattern has been called `Miura-Ori' (Miura & Natori 1985).

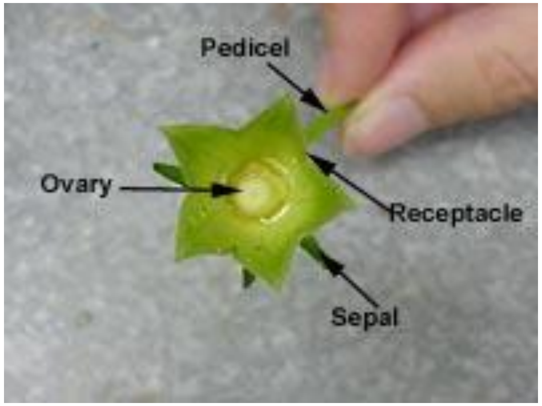
PART TWO

ANALYSIS

Understanding the structure of Hibiscus- biology and physiology







Hibiscus are flowering deciduous shrubs, perennials and annuals. It belongs to the dicotyledon family. It has five petals and sepals forming a bowl shape. The style that emerges from the bottom of the sepal is the tallest part and supports the androecium and gynoecium. The bottom of the style is the ovary. The red colour attracts insects and butterflies and thus promotes pollination.

ANTHESIS STUDY OF HIBISCUS:

Three buds were chosen as specimens for observation in the experiment.

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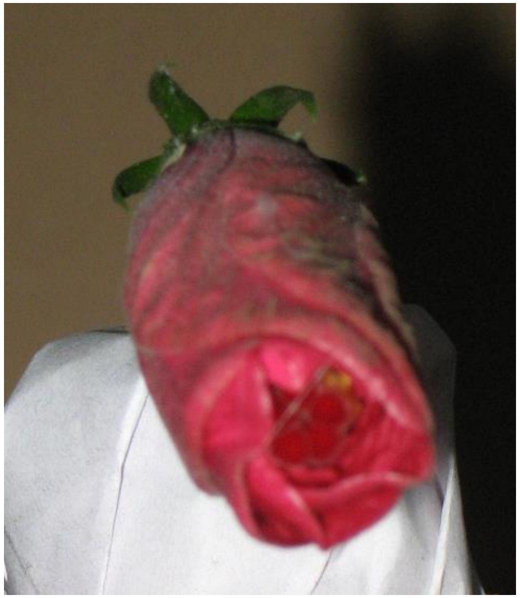
SPECIMEN 1



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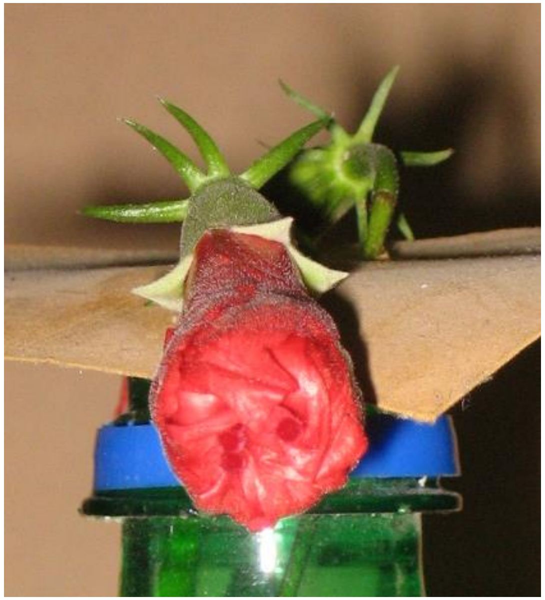

SPECIMEN 3

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SPECIMEN 1

SPECIMEN 2

SPECIMEN 3

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SPECIMEN 1 SPECIMEN 2 SPECIMEN 3

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SPECIMEN 1   SPECIMEN 2   SPECIMEN 3

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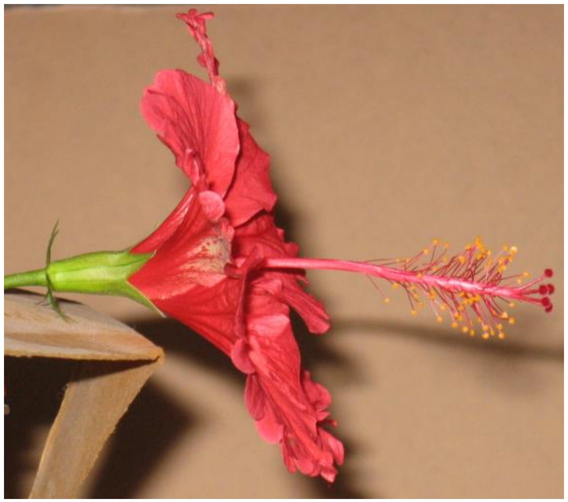


SPECIMEN 1

SPECIMEN 2

SPECIMEN 3

Inferences:

- The petals at the bud stage are entirely inside the sepal. They are small in size.
- The sepal growth stops at one stage, while the petals keep growing.
- At the beginning, they are curved and enveloped with each other.
- Later stages of growth, the area of the petal at the apex increases and the flower petals start opening.
- At one stage, when sufficient lighting and temperature conditions are reached, the turgor pressure increases causing veins to stretch and open the flower.
- The increased water content in petals brings the freshness and beautiful look to the flower.

The following observations were taken of the hibiscus flower from bud to blossom:

1. Petal development:

2. Mechanisms involved:

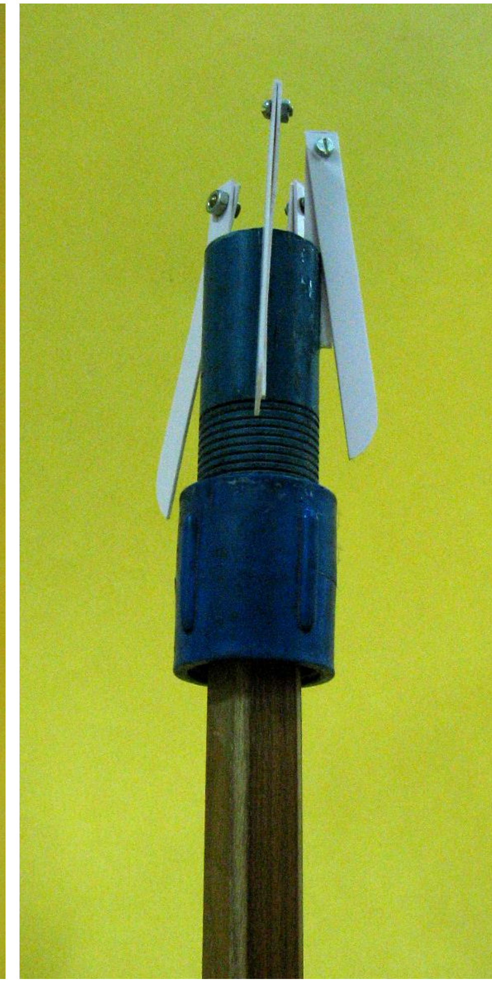
- Twisting and releasing
- Pneumatic coiling/ uncoiling
- Overlapping of petals
- Entwining stands
- Span of petal
- Splitting mechanism
- Cantilever of petal

Mechanism 01

Twisting and releasing

The opening of a flower witnesses the telescopic twisting of the central core to push it upwards and the same action releases the petals that are tucked underneath the style. The spiral motion of the flower aids releasing of each petal, one after the other to bends outwards.



Mechanism 02

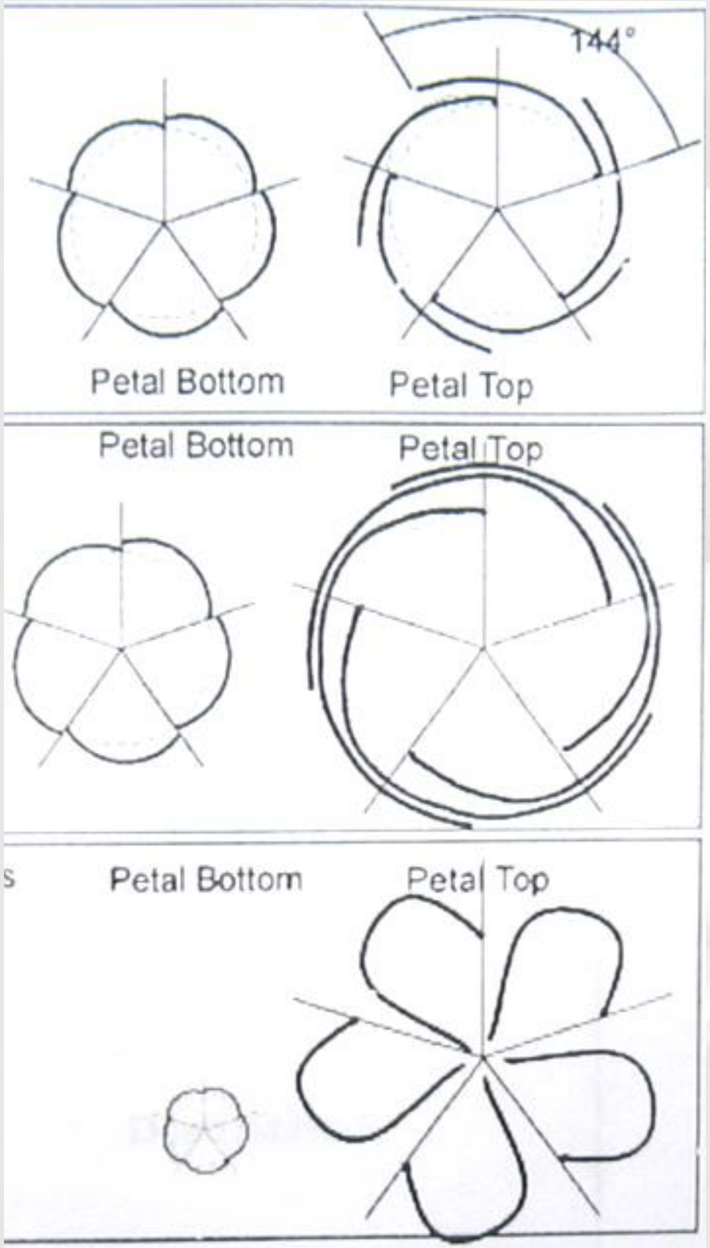
Pneumatic coiling

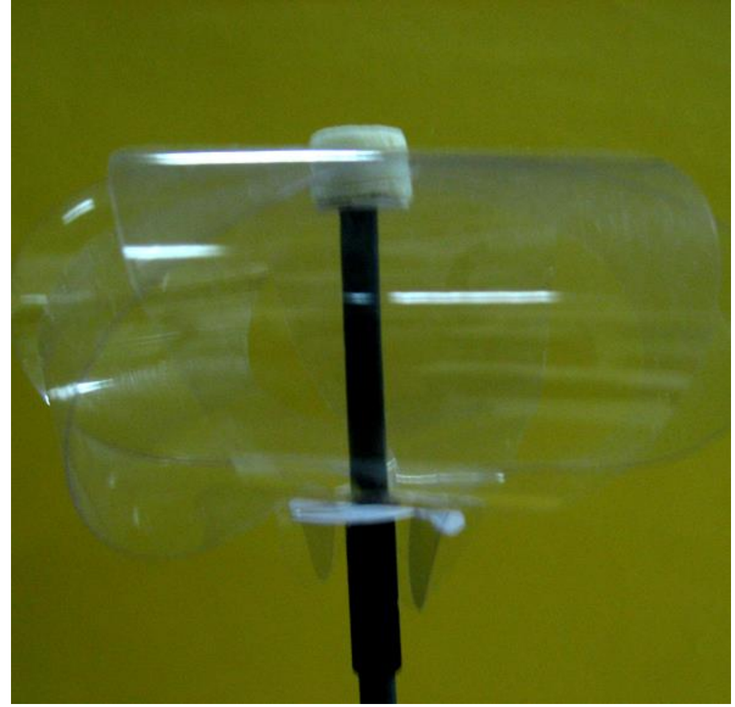
The petals are released from the bud posture and attains the open state by means of hydraulic pressure that build up with in them. The pressure variation forces the flower to open and attain full blossom.

Mechanism 03

Overlapping of Petals

The five petals of hibiscus are arranged on the receptacle in a spiral manner overlapping each other. This helps the bud curl its petals to attain a compact form.

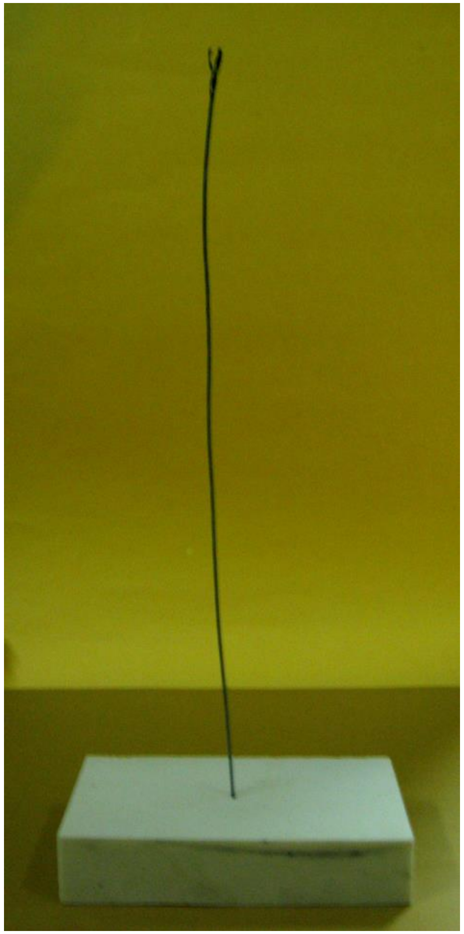


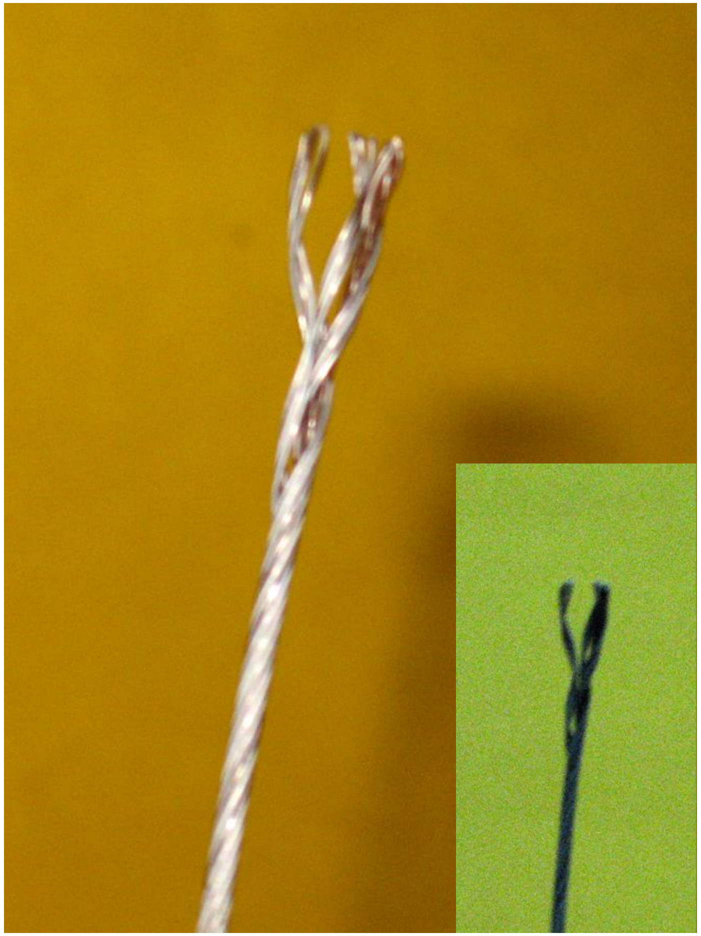



Mechanism 04

Entwining strands

Hibiscus is a bisexual flower in which the androecium entwines over the gynoecium. The stamens entwine in a spiral manner around the pistil with the style, which is a conduit. The thin member stands on itself because of the structural stability attained through this form.





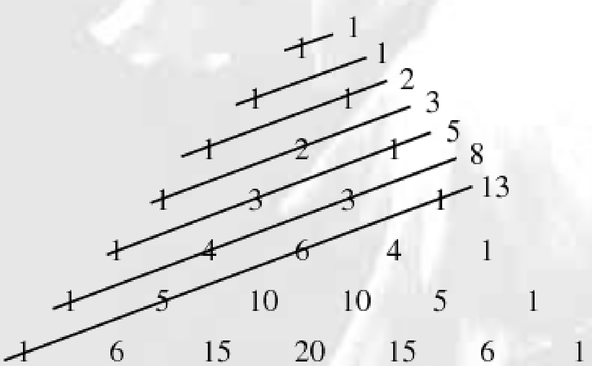
Mechanism 05

Span of petal

In mathematics, the **Fibonacci numbers** form a sequence defined recursively by:

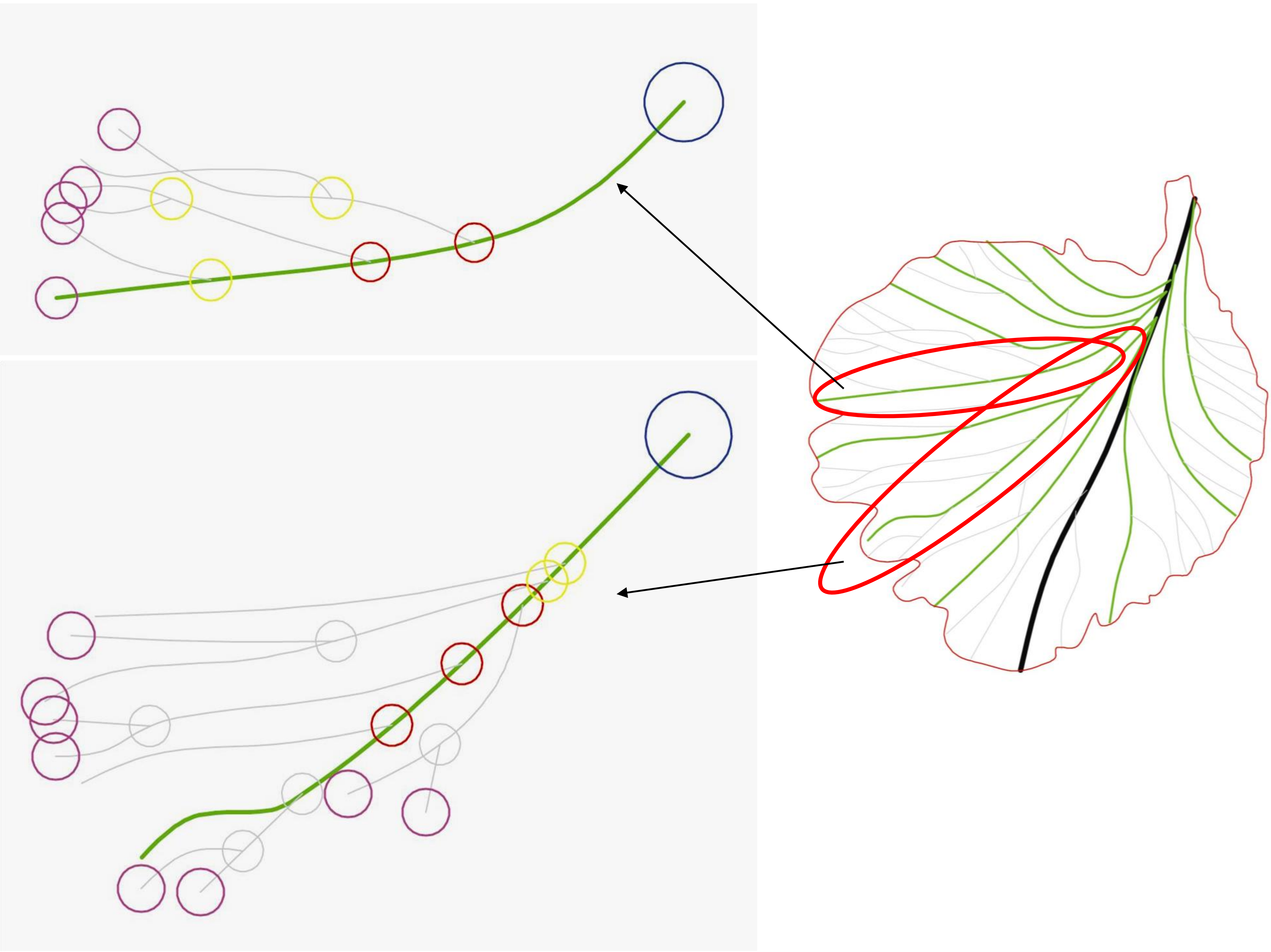
$$F(n) := \begin{cases} 0 & \text{if } n = 0; \\ 1 & \text{if } n = 1; \\ F(n-1) + F(n-2) & \text{if } n > 1. \end{cases}$$

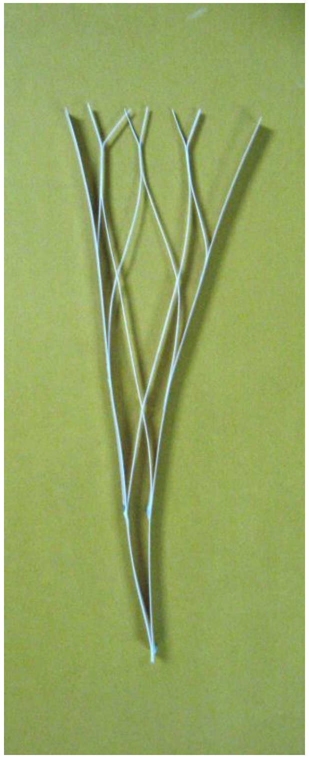
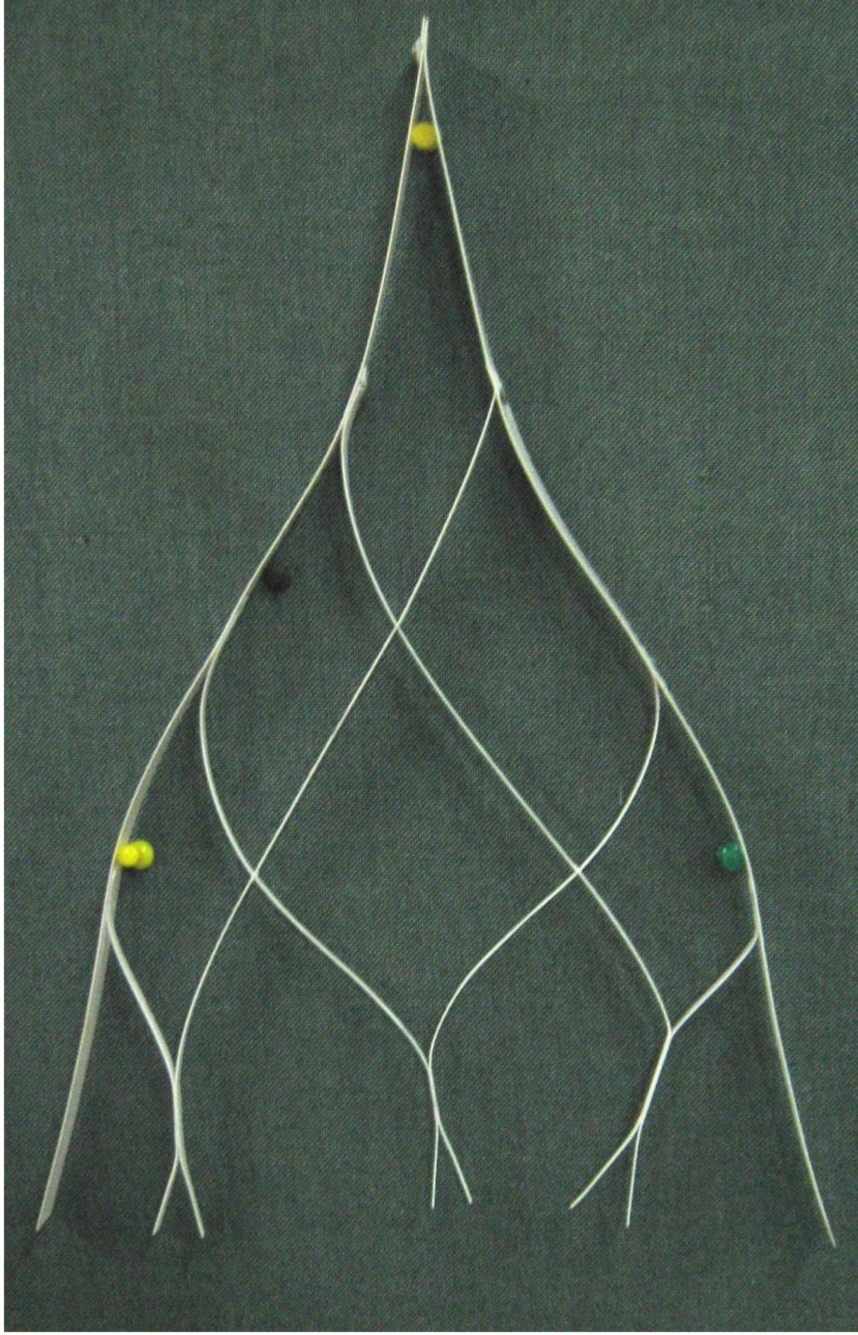
That is, after two starting values,each number is the sum of the two preceding numbers. The first Fibonacci numbers , also denoted as F_n, for $n = 0, 1, \ldots$, are: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987, 1597, 2584, 4181, 6765, 10946, 17711, 28657.



The petals attain the span by means of veins that spread through the petal and support it. The petals of hibiscus by means of its particular vein arrangement attains a frill pattern across the edges. The veins branches to follow the fibonacci series which allows the required multiplication of the veins across the span, which in turn allows the petal to attain the furled edges.





Mechanism 06

Splitting mechanism

The sepals that protect the petals partially during the bud stage bursts open at the time of flowering due to the hydraulic pressure built up. This explosion is continued by the whirling mechanism of growth.

Mechanism 07

Cantilever of petal

Each petal is supported at the base where it is relatively narrow and thick. Further from the base, the petals are broad and thin. This variation in cross section helps the petal to cantilever from the base. The surface behavior of the petal, which by virtue of the doubly curved surface is strengthened by the veins in the lateral direction.

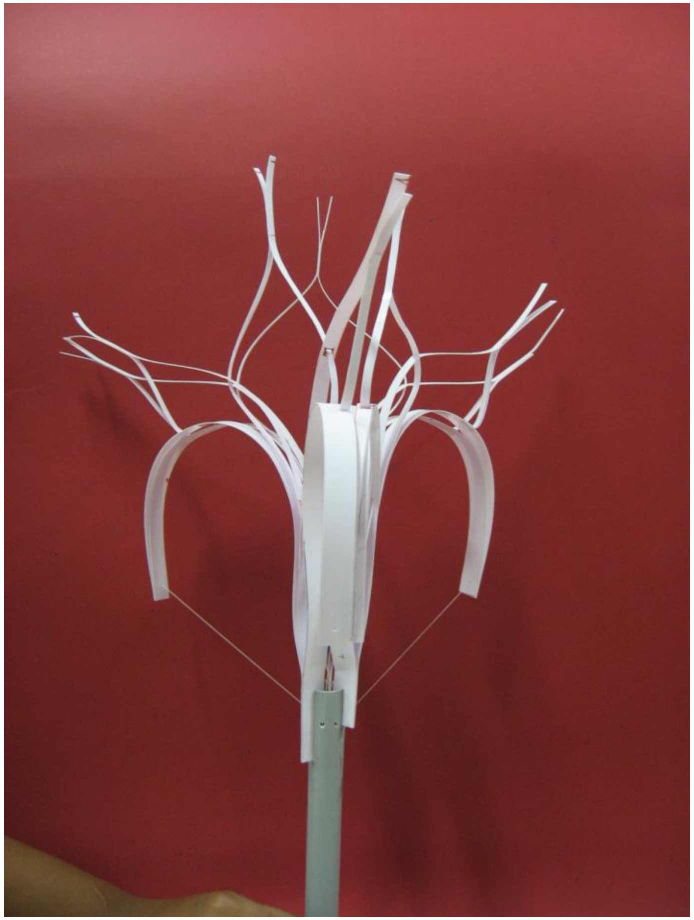
PART THREE

SYNTHESIS

PHYSICAL INTERPRETATION

MODEL1

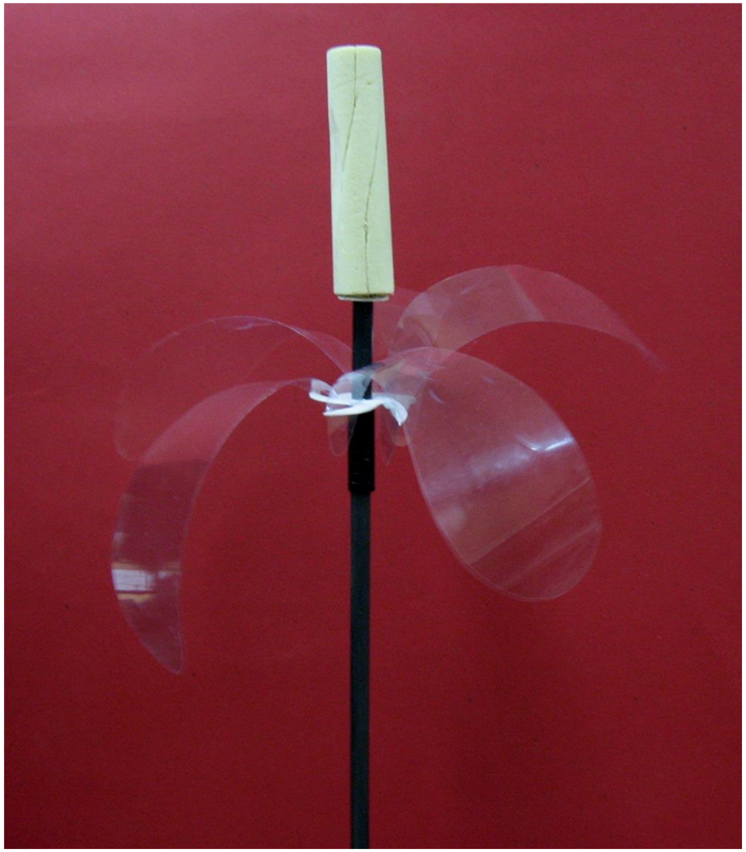
The flower is interpreted as an extension of Mechanism 5 , which is the Span of the Petal. The members have been multiplied along the central axis to form a full blossom flower when opened.



PHYSICAL INTERPRETATION

MODEL2

The flower is interpreted from Mechanism 3 to form the Overlapping of the petals entangled in a spiral manner at the Bud stage. This twists along the central core to release each petal one by one to acquire the fully curved profile which is observed during the full blossom.



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