

ISOFORMOED

FORM OPTIMIZED DESIGN PROCESSES

by DHAVAL JOTANI

PUBLICATION OF INSTITUTE OF MEMBRANE AND SHELL TECHNOLOGIES (IMS e.V.)



dedicated to my family and bhavini

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PUBLISHED IN 2009 BY

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Designed and edited by Bhavini Mistry

Printed in Nairobi, Kenya

CONTENTS:

FOREWORD

INQUIRY	01
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PROLOGUE	03
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NATURE

• RELATION OF NATURE AND FORMS	10
• LINEAR FORMS IN NATURE	13
• PLANAR FORMS IN NATURE	16
• VOLUMETRIC FORMS IN NATURE	20
• NATURAL FORM AND THEIR CHARACTERISTICS	22
• RELATION BETWEEN NATURE AND ITS FORCES	24
• RELATION OF NATURAL FORM, FORCE AND ITS SURROUNDING ENVIRONMENT	29
• NON-LIVING NATURE	30
• LIVING AND NON-LIVING NATURE	30
• LIVING NATURE	31
• NATURE AS PROCESS - THE QUEST	33
• ORGANIZATION PRINCIPLES IN NATURE AFFECTING OPTIMIZATION	36
• SYSTEMS AS OPTIMIZING PARAMETER	36
• STRUCTURE AS OPTIMIZING PARAMETER	37
• GEOMETRY AS OPTIMIZING PARAMETER	37
• PROPORTIONING SYSTEM AS GEOMETRIC PARAMETER	38
• GOLDEN SECTION AS GEOMETRIC PARAMETER	38
• SYMMETRY AS GEOMETRIC PARAMETER	39
• FRACTAL AS GEOMETRIC PARAMETER	39
• ORDER AS OPTIMIZING PARAMETER	40

MAN MADE

• MAN MADE : MATERIAL FORM	42
• RELATION OF MAN AND ECO-SYSTEM	43
• NEED, FORCES AND MATERIAL FORMS	45
• THE WHEEL	46
• THE SAIL	47
• THE BOW AND ARROW	48
• FORM OF SPRING	49
• HISTORY OF FORCES – OPTIMIZATION – BUILT STRUCTURES	49
• A SHIFT	51

FORM-FINDING THEORIES

- **SINGULAR FORMS**
- **COMPOSITE FORMS**

INQUEST

- **THE COLONIA GÜELL CHAPEL, BARCELONA** **76**

EPILOGUE **104**

BIBLIOGRAPHY **112**

ILLUSTRATION CREDITS **116**

ACKNOWLEDGEMENT AND ABOUT AUTHOR

FOREWORD

When I met Dhaval Jotani for the first time at the master course of membrane structures at Dessau in 2008, he was eager to show me some work that he had done as a student in India. He wanted to know what I thought of it and of course he wanted to impress me, and he did.

He showed me a booklet about “ISOFORMOED - an inquiry in to form optimized design processes“ and I was impressed. It reminded me strongly of Frei Otto’s attempt to look deeper into the form finding processes in nature. But what made it most appealing was the fact that it was written in a diagrammatic and easy to understand language, and connected to the historical background of primitive man and his derivation from nature to architecture and not only nature. I had the urge to look it through and to actually read it! My second thought was; what a waste if this was just done for the archive of university study papers in the library. That was the moment when I pursued Dhaval to take up the matter once more, to have a second deeper look into it, with the aim of publication for a wider audience. The first book in the line of publications of the Institute of membrane and Shell Technologies e.V. was on its way.

It is the perfect start for our publications to come leading through nature to the fields of shells and membranes, a perfect reminder of how far Nature is imperative advanced to our technologies and how much we can still learn from Her.

Rewriting took time, as well as the necessary layout. Solving legal questions and all the other obstacles you face when writing a book for publication had to be dealt with. But it is finished and now, my dear reader, you are in for an exciting meeting with long forgotten ideas, reminders and inspirations.

Prof. Dr.-Ing. Robert Off

(Director of IMS e.V.)

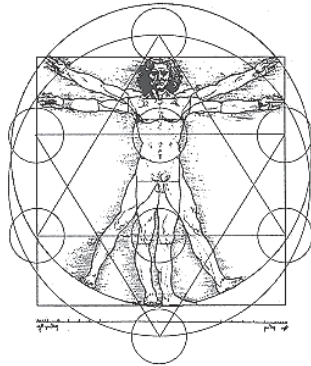
AN INQUIRY

Man observes the various phenomena in Nature's system of which he is a part - cycles of seasons, cycle of day and night, phases of moon, effect of tides and ebbs as ripples on water in ocean, growth and evolutionary forms of living and non-living creatures, where all these effects are experienced as underlying forces which generates harmony in entire system.

Why is nature's vocabulary satiated of various objects and why each is different from another. At the same time each of this too exhibits similar principles composed in them. Yet they appear distinct. Each has its unique quality and expresses distinct characteristics. These objects are what we refer to 'natural forms'. So the question here is - why these forms are distinctly diverse in many aspects?

What is the underlying order which gives them the sense of uniqueness? We also can sense the intrinsic harmony which this governing factors acts upon. This governing factor can be termed as 'force' which brings in a sense of coherence in this natural world and its elements. So if these forces exist on forms how do we understand its existence? What are these types of forces and how they play role in shaping each form differently? And how have human nature since ages been inspired from it in its various activities?

After understanding the effects of forces on natural forms one achieves a power to analyze the most evident principles in it. The resultant of which is evident in man's endeavors through interpretation of these Nature's inspiration into built forms. Depending on these interpretations of forces over forms many theories are developed which generates man-made structure authentically.



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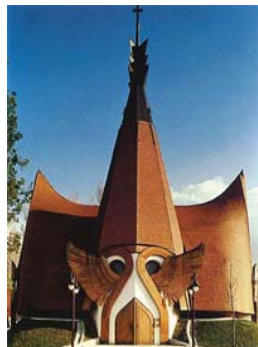


3.

1. image shows the sketch of the Roman Vitruvius by Leonardo Da Vinci - 'human body' as a modular construction through geometric representation as a form of nature's unity. 2. Image shows interpretation of nature in form of astrologically based zodiacal sign as referred to Islamic way of expressing nature and culture. 3. Image shows diagram of Yin-Yang as a theory of balance derived from nature's integral balanced system as applied in ancient times.



4.



5.



6.

4. Image shows The Colonia Guell chapel in Barcelona by Antonio Gaudi in 1870, an abstract interpretation of natural forms and forces. The elements of the interior space shows the cohesive construction of elements as similar to a system in nature. This system consist of elements such as slant pillars, vault made of numerous catenary arches resulting into a parabolic profile. 5. Image shows Siofok Lutheran church, 1986-90 by an Hungarian architect Makovecz Imri, a metaphorical interpretation of wing and eye of the bird as various elements of space. These elements though do not play a functional role but are jestures created from nature. 6. Image of Church of Saint Mary, The Virgin, is a classic example of Art Nouvea which shows ornamental interpretation as expression of nature in space.

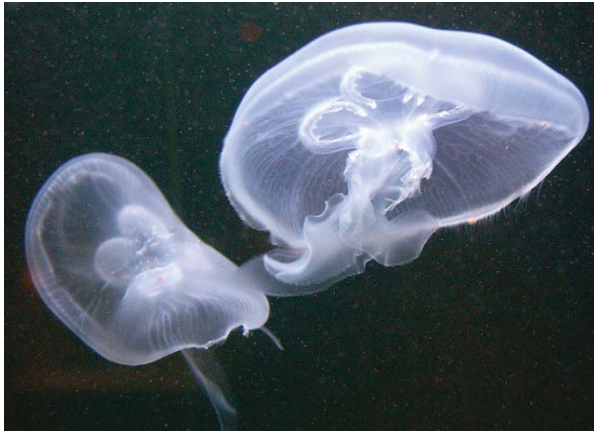
PROLOGUE

“We do not seek to imitate nature, but rather to find the principals she uses”

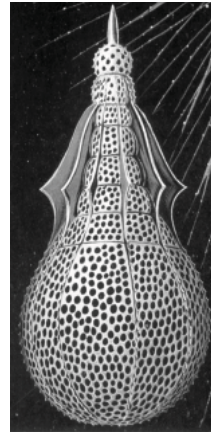
-Buckminster Fuller

Ever since the man's existence it has tied a unique relationship with Nature and has drawn various inspirations which have led him make many discoveries and invention. It has been immediate source, which knowing or unknowingly is part of man's creative Endeavours and pursuits. This relationship has many gives and takes such as need, dependency, adaptation and acquaintance to achieve coexistence with Nature. Through this journey of drawing inspiration from Nature, many designers have interpreted through imitation, replication, simulation and abstraction. It has a long and celebrated history, from Ancient Greece to Art Nouveau. Long before these designers, interpretation are also evident in civilizations and cultures where they have studied Nature in various ways to live in harmony with it. “Egyptian and Ancient Greek civilizations studied natural forms and the human body and abstracted them as geometry”. Emphasizing beauty and harmony, its free-flowing curves and expressive forms are sympathetic to the human body, mind, and spirit. The Roman, Vitruvius, agreed with his forebears that the human body, with its modular construction, is the ideal expression of nature's unity. His homo quadrates - the figure of a man, with extended arms and feet, fits neatly into what were considered the most perfect geometrical figures - the square and circle. Patterns and forms in nature, such as the spiral and fractal, are products of internal laws of growth and of the action of external forces, such as sun, wind, and water. Architects learn to use natural forms from observing living structures: trees, bones, shells, wings,

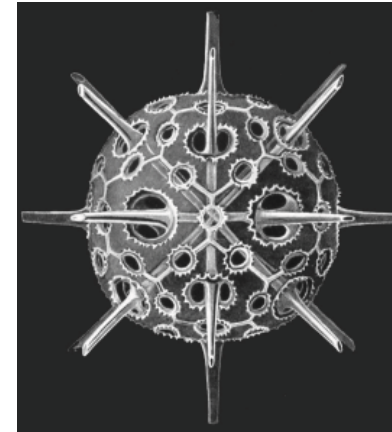
*“ The grandeur, the vastness, the inexhaustibility of nature are in man, and the sensitiveness and mystic impenetrability of the soul lies also in the blossom of nature”
- Dr. D. T. Suzuki*



7.



8.



9.

webs, eyes, petals, scales, and microscopic creatures - as illustrated in the following pages. They are the very forms of life and growth and have been key inspirations in architectural spaces, whether for ornament, as in Art Nouveau, structure, as with Gaudí, or metaphor, as with Makovecz.

The Pioneering students of nature's forms, whose influences are still felt today, included Johann Wolfgang von Goethe (1749<1832), Ernst Haeckel (1834<1919), and D'Arcy Wentworth Thompson (1860<1948). Goethe studied natural forms and coined the term morphologie. He also applied ideas of metamorphosis to art and architecture, the active dynamism of form in all living organisms, whereby an orderly and cyclic transformation can be traced in all plant forms from seed to calyx to blossom to fruit (and to seed again) - a concept central to the development of organic architecture.

Biologist and zoologist Ernst Haeckel studied Radiolaria (plankton) and was captivated by their exquisite geometrical forms and complex patterns. He is best known for his work *Art Forms in Nature* with its magnificent illustrated plates by lithographer Adolf Giltsch. Such stunning illustrations had an immediate impact on Art Nouveau and the work of Hermann Obrist, August Endell, and Louis Comfort Tiffany. Architect René Binet not only produced a book of ornament based on Haeckel's illustrations, but also designed the monumental entrance gate to the 1900 Paris World Exposition, as a vast radiolarian. Haeckel, himself, used beautiful jellyfish forms as ceiling decoration in his former home, the "Villa Medusa".

7. Image shows form of underwater creature, jelly fish which is studied by many biologist and transform their exquisite geometrical forms in to the built spaces. 8 & 9. Images are sketch of radiolarian, different types of under water micro creatures, studied and sketched by Biologist and zoologist Ernst Haeckel. He studied various geometical forms and distinct complex patterns on their surface and its appearance.

"Look deep, deep into nature and then you will understand everything better"
- Albert Einstein

4 PROLOGUE

Industrial age reflects the man-made materialistic values which have been dominating the modern life, gradually increasing the gap between man and its natural world. Nature is credited with providing elements, but it is man's fantasy which is responsible for taking over the elements and recombining them into novel patterns of his own creations. Man has just not altered the surroundings and systems of nature but resulted into even more challenging situation for its existence. There is a sudden call of the crisis for human existence where many designers have grounded foundations to abstract concepts from nature. The re-emergence of nature's interpretation, represents a new freedom of thought; an expression of hope for the future. Man understood these elements as living nature and non-living nature. Through his pursuits in process of inventions he has failed to adapt with nature and rather have moved far away. On the other hand man has tried to alter the surrounding for his comfort.

This relationship is just not restricted to co-exist, rather understand the way nature functions with variety of forms its growth, evolution and decay. It researches deep into reasoning the existence of particular forms in nature. The study focuses those aspects of nature takes part in the formation of any object such as form, forces acting on it which shapes its structure and geometry and the material. It's an urge to understand why in nature 'every form and its structure are optimized'? Every thing in nature is with its purpose, which is why it achieves optimization and becomes context specific. Man perceives the underlying forces of nature in different phenomena on innumerable forms which are related to specific discoveries in particular examples. This can be studied as many specific examples of the same kind which allows to observe similarities within them. These commonalities are the essence of the natural forms and become the principle or law. These principles and laws are perceived in diverse phenomena and expressions in nature, stating that they are limited and spell diverse forms and therefore are understood as an underlying basis in nature.

"The form of an object is a diagram of forces".

D'Arcy Wentworth Thompson

Nature is always changing, and yet it is balanced. This is because nature grows. The energy of life is present in it and the growth is governed by creation itself, which gives rise to the internal structure. We are trying to understand the processes which give rise to form at every stage of growth and thus led to balance.

Optimum material has been observed in the structures of natural forms where by it achieves maximum structural strength and can take care of the stress and tension created by the forces acting on it.

Applying the similar structures in nature one can just not achieve material efficiency but can also reduce the usage of energy and resources for the making of any space. Using less material it can achieve more strength and can too generate large spaces.

Various biologists, mathematicians, artist and designers have studied in detail many principles and formed methods to interpret in tangible forms. Many researchers and designers have adopted to work with this realm of taking inspiration from nature and interpret in built forms. Various methods have been discovered from these scientific studies on nature which have helped deriving optimization aspect. These spaces are interpreted with reference of order, geometry, structure and systems. Amongst these category of form finding methods to interpret nature with respect of self-organized and optimization are catenaries, gridshells, geodesics, tensegrity, hyperbolic, parabolic.

Spaces with such structural forms generate light weight structure which can span large spaces. It expresses dynamic spatial quality which also defines tectonic character of spaces. The lightweight timber gridshell, for example, is simple, economical, and strong, and uses sustainable materials. Like the catenary structures derived by Gaudí from his hanging models, the thin wooden laths of the gridshell act like chains to take up optimum structural forms. Pioneered in the 1970s by Frei Otto for Germany's Mannheim Garden Festival, the gridshell has been chosen by Edward Cullinan Architects, working with Büro Happold, for the undulating tunnel structure of the Weald & Downland Open Air Museum, Sussex, England. Elsewhere, Philippe Samyn has evolved "harmonic" double curved structures, using fractals, which are low-cost, lightweight, and easy to erect, Shoji Yoh uses local craftsmen to "weave" organic bamboo grids, and Santiago Calatrava has engineered sculptural bridges, roofs, and towers with great panache and elegance.

These branches of nature's interpretations were perceived by many designers in form of forces, which are regulated and abstracted into organized processes of translating into built spaces to achieve the desired forms of space. These spaces carry specific properties and principles of nature. The way these understanding are generated, they are also carry forwarded into the space making elements where its base is not so obvious. These forces and parameters affecting the formation of nature's objects are unveiled in other creations and experiences. So these abstractions of nature are systematically transformed to achieve optimized man-made built forms and its structure. In nature everything that exists is integrated within each other and through their performance in their function it achieves 'an aesthetic expression' through their inherent qualities. The intension is here to search 'Can man made forms also be developed similarly?' What are those constants and variables that make nature so unique at each and every node? Can we also achieve conceptually optimized man made form? Optimization of structure, geometry, organization, material.

This is affecting most fields of design from products and furniture, lighting and textile design to architecture, landscape architecture, and interior design. There is an upsurge in interest in nature's designs spurred on by modern science and mathematics and particularly amongst engineers, who are using new computer-modelling technology to twist, fold, and curve shapes to support stresses more elegantly. As science sees further into the microscopic world of matter and uncovers more about the remarkable structures of living things, nature continues to surprise us and teach us how we might build more cleverly, economically, subtly, and ecologically.