

Biomimicry: Patterns, cycles, systems and functions

David Sánchez, PhD
Session 3: Aalto Summer School
Circular Economy and Co-design

Photo: Ximena Curiel

PhD. David Sánchez Ruano



Content

9-10

- Human/Nature
- The language of Nature

10-11

- Bioinspired History
- Contemporary BioArchitecture and BioDesign Examples

11:15-12

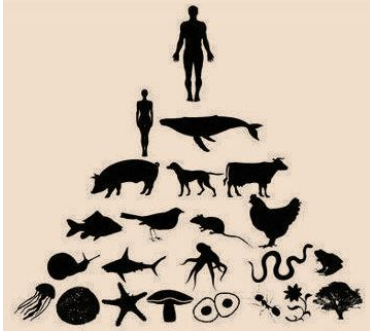
- Biomimicry thinking as a tool
- What can inspire me to create circularity?



Are We a problem? or We have a problem?



Dichotomy. Nature vs. Human



The root of our contemporary environmental crisis lies in our values as human specie because we assume things like:

- 1) A fundamental difference of wanting to separate humans from nature.
- 2) As humans we feel an inherent superiority over the non-human world.
- 3) As people we have the right to exercise control over the natural world, an ethic on the rights of natural elements is not restricted.

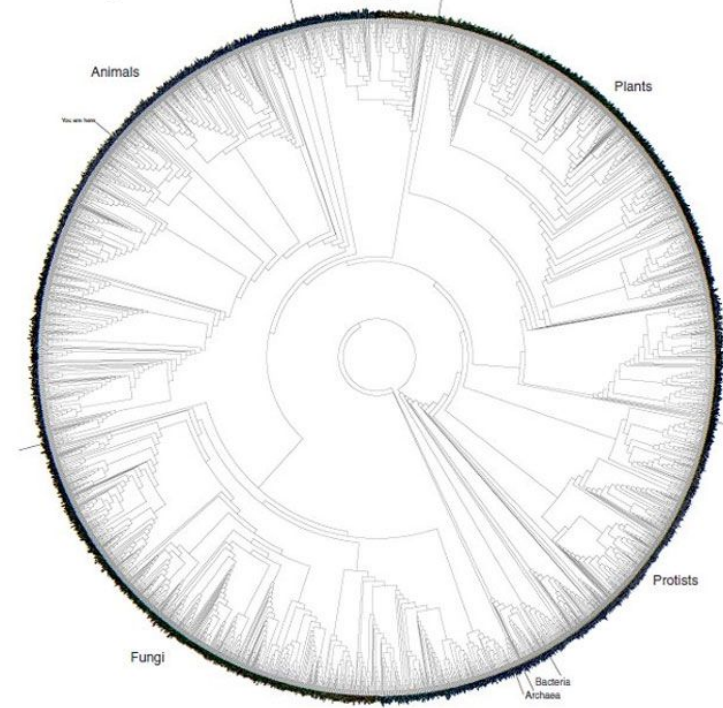
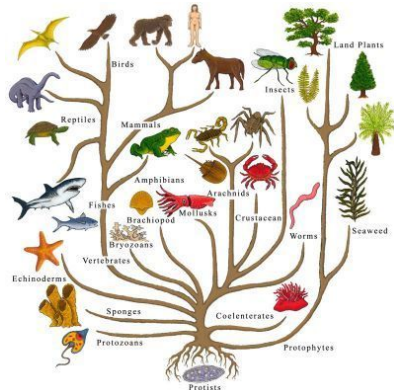
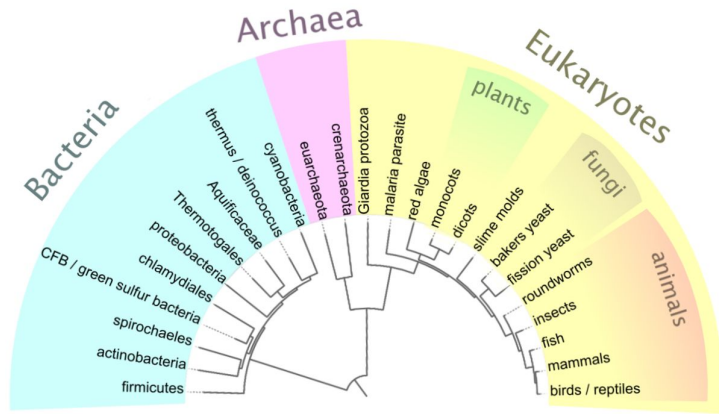
Disconnection: Numbness and Distraction



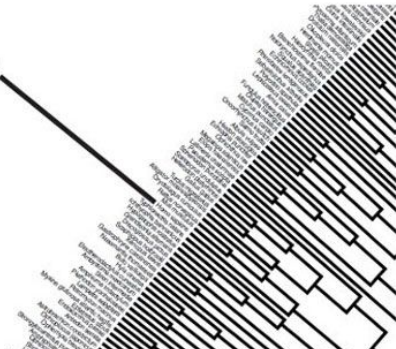
Our generation is the one is facing various crises:

- 1) Our senses are not well stimulated and seemed numb (food, spaces, materials..)
- 2) Perhaps we are oversaturated of information even the availability of wisdom
- 3) Design/Creation need to be constantly questioned and accepted collectively (Co-designed/Co-Created).

We are a young specie



You are here



**What Nature
is telling us?**

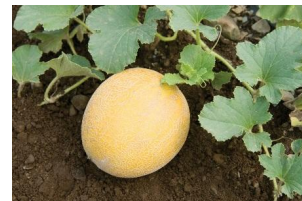




The language of Nature

The frequency of forms

radial, curve, circular, spherical

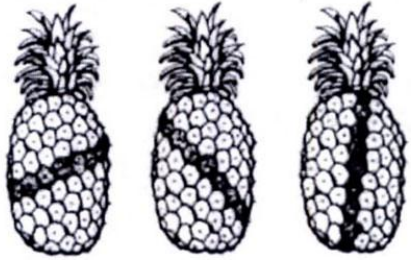


Human Embryonic Development

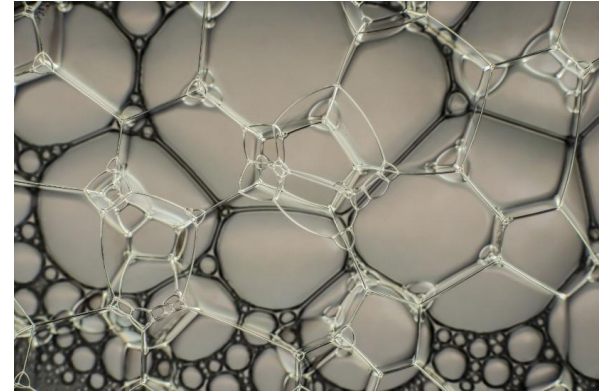


Distribution Principles

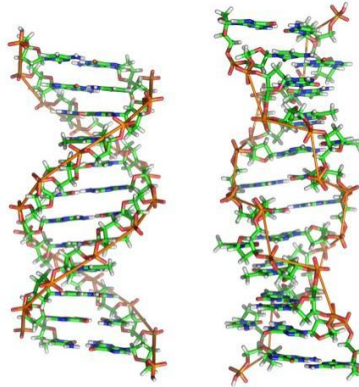
Stacking, packaging, phyllotaxis, bubbles, plateau frontier, voronoi



Spirals on a pineapple rind, image from Livio 'Story' 111

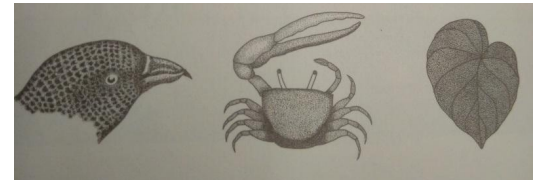
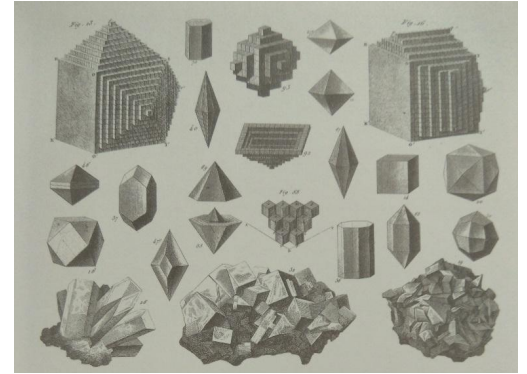
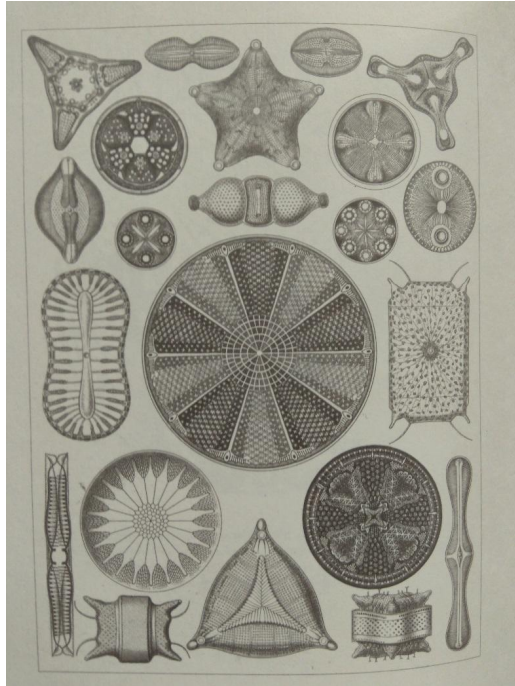


bwc6845851 Barewalls ©



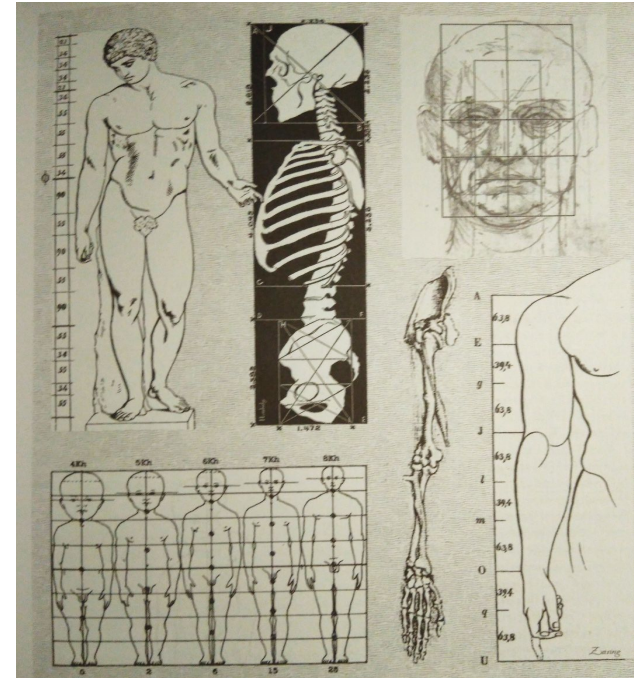
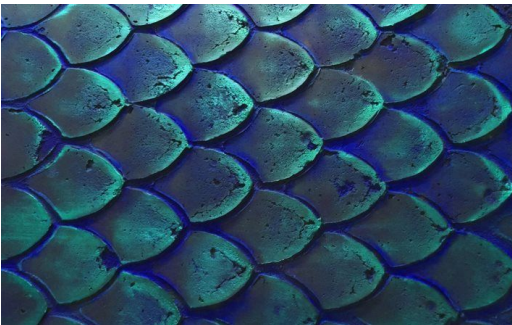
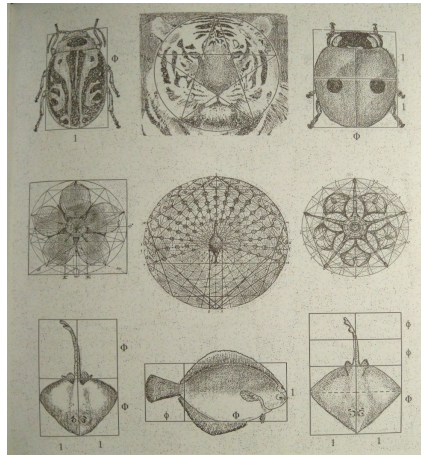
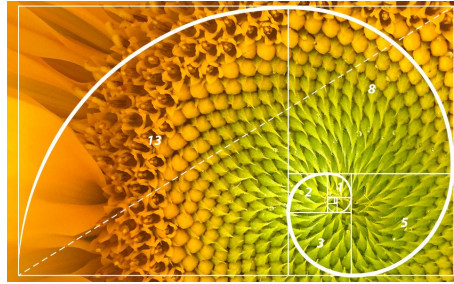
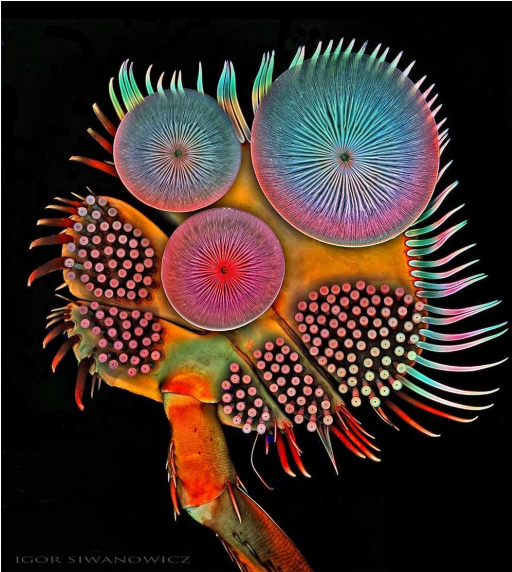
Order

Geometry, phi, crystals, symmetry, dorsiventral, dwarfmorphism, asymmetry



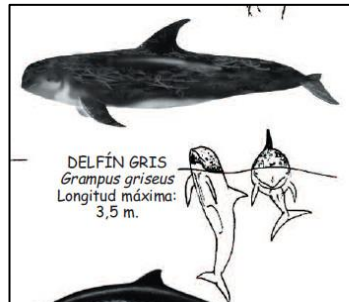
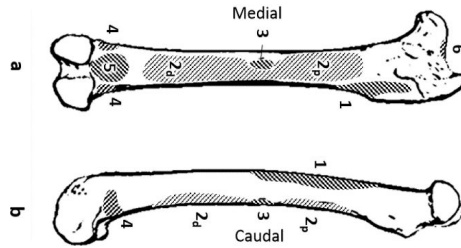
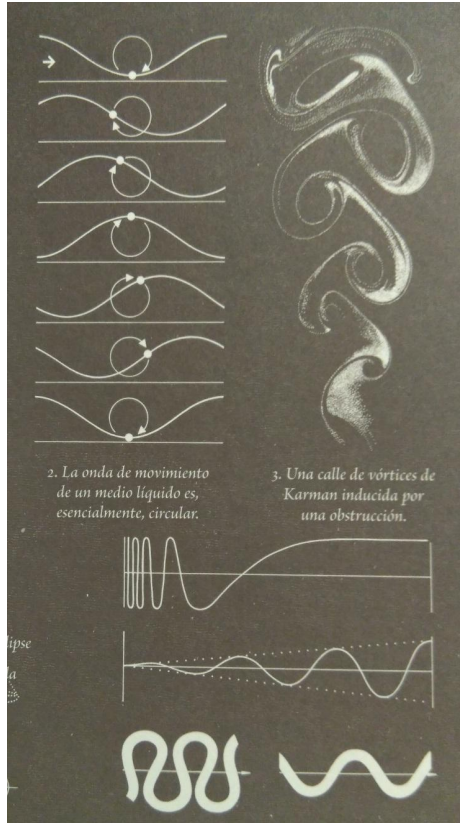
Composition

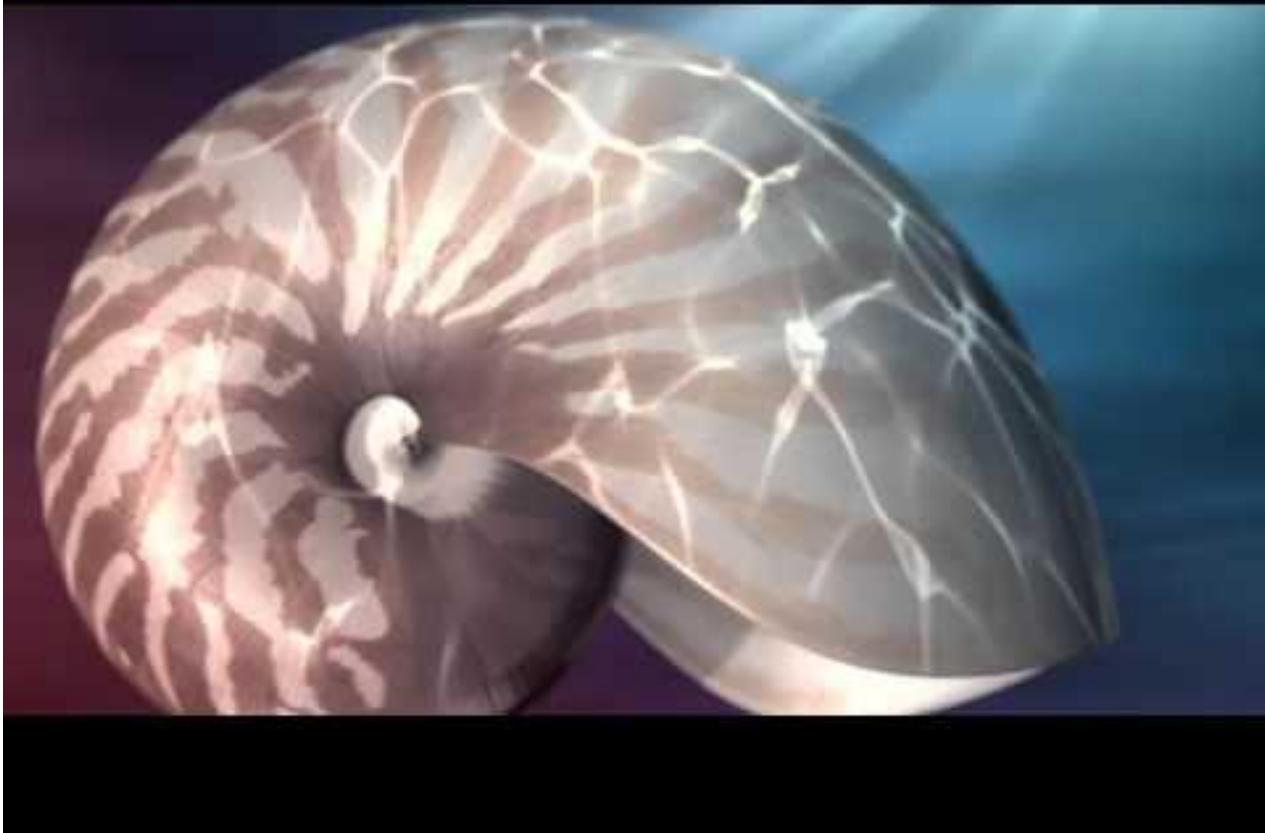
Morphogenesis, fibonacci, repetition, golden ratio, proportion



Natural systems functioning

curves, flocks, textures, propulsion, float, femur, flux, selforganization, fractals





Nature by Numbers by Cristóbal Vila

Recommended videos

Inner Worlds, Outer Worlds

Part 1, 2 and 3.

*To see a World in a Grain of Sand
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your
hand And Eternity in an hour.*

(William Blake)



Activity:

Do you have a favourite plant or animal?

Look for the most representative formal aspects of a chosen organism.

- Geometry ... symmetries, asymmetries,
- Distribution .. Packing, phi, golden ratio
- Composition ... repetition, rhythms, propulsion, sequences
- Functioning ... Textures, movement

Rediscovering Nature



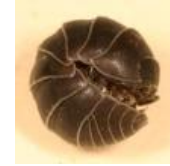
Processes



Functions



Behaviours



Forms

System organisation



Materials



Algorithms



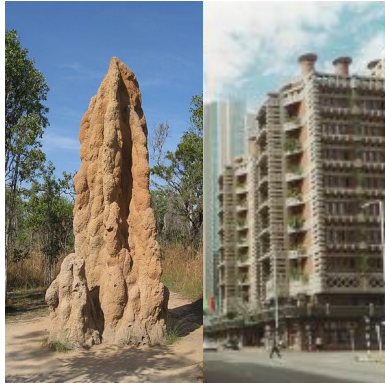
Kingfisher/ Shinkansen Train Japan. (Westra, 2011)



Fractal Coast (Douglas, 2007 cc)



Solar Tree(Ross Lovegroove 2011)



Termite mound/Eastgate Building Harare(Mick Pearce, 1996)



Biomimesis-Biomimicry-Bionics-Biodesign-Biomimetics

(Conscious emulation of nature's genius)



Bio-inspired History

From mimesis to design

Dr. David Sánchez - Tec de Monterrey

μίμησις

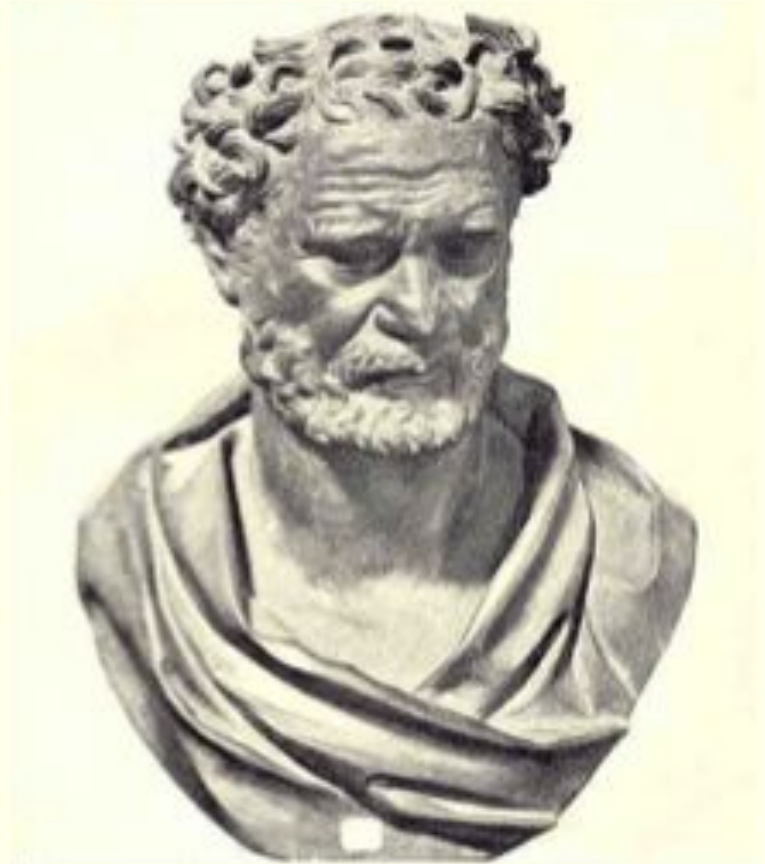
- Probably originated from the Dionysian rituals. Where musical acts and dances were performed.
- This definition of mimesis did not mean reproducing external reality, but internal.

(Tatarkevics, 1987)



'In art we imitate nature:
when we weave we
imitate the spider, when
we build, the swallow,
when we sing, the swan
and the nightingale'

(Plutarco, *De sollert.*, 20.974 A)



Democritus



Total
fidelity



Free
expression

Plato vs. Aristotle

They were referring to copying the appearance of things by referring to painting and sculpture. His theory was for centuries the main theory of the arts.



Orden Corintio



Flor de Acantho



Greece: real envelopment of mimesis

'The elements of nature
and our calculations are
clearly and neatly formed'

(Le Corbusier about Parthenon)

Ancestral Inspiration



Chinese 3,000 years ago first time tried to make **artificial silk**



Capabilities to imitate survival techniques to meet human needs.

Indigenous wisdom vs. primitive



Woorani using curare.



Bovivian artisan in Lake Titicaca.



Chipewan hunting caribou



Inventio:

from the mimesis of the Middle Ages to the Renaissance

Eternal Beauty

-Middle Ages-

It started with the premises of imitating the invisible, which is much more perfect.

A lot of symbology emerged, a lot of expression of what is thought internally.

(San Buenaventura)



Tomas de Aquino. *ars imitatur naturam*



San Francis of Asisi giving a sermon to the birds. [Giotto](#)'s Fresco



Memento Mori. Worcester Cathedral

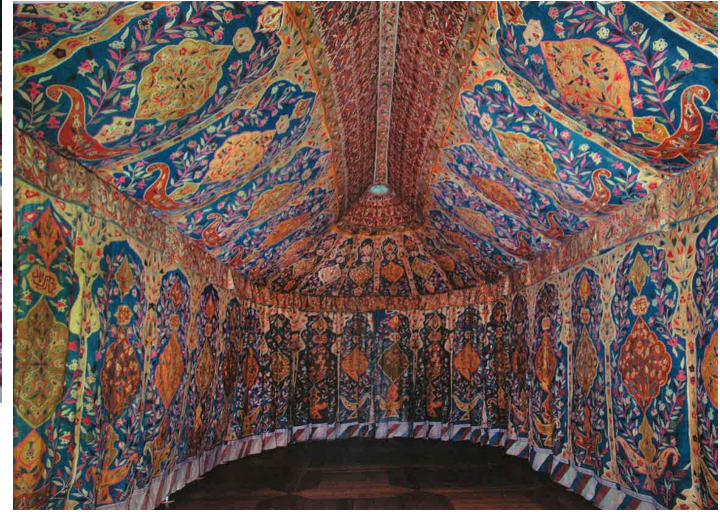
**Humility and simplicity before nature
and
the Transformation of myths in new beliefs.**

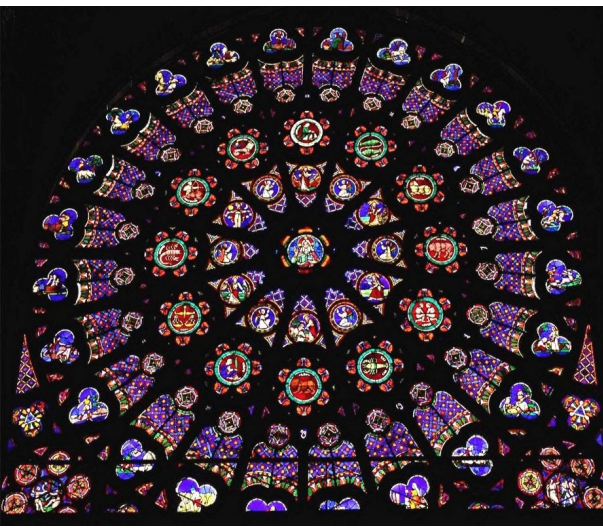
Moving beyond Intuitive Knowledge

Art and design was not a matter for medieval craftsmanship



Turkish Tapestry





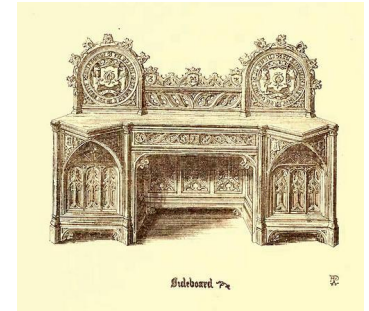
Rosette at St. Denis Basilica



Jerusalem temple construction, Jean Fouquet, painted in 1470



Green Man, Norwich Cathedral



Gothic

Understanding of the world, control, cities and craftsmanship.

Barroque

Between the sublime
and the absolutist



Santa María Tonantzintla, Puebla, Mexico



[Bodegón de caza, hortalizas y frutas](#) (1602), de [Juan Sánchez Cotán](#). [Museo del Prado](#)



[Palacio de Versailles](#), de [Louis Le Vau](#) y [Jules Hardouin-Mansart](#) (1669-1685)

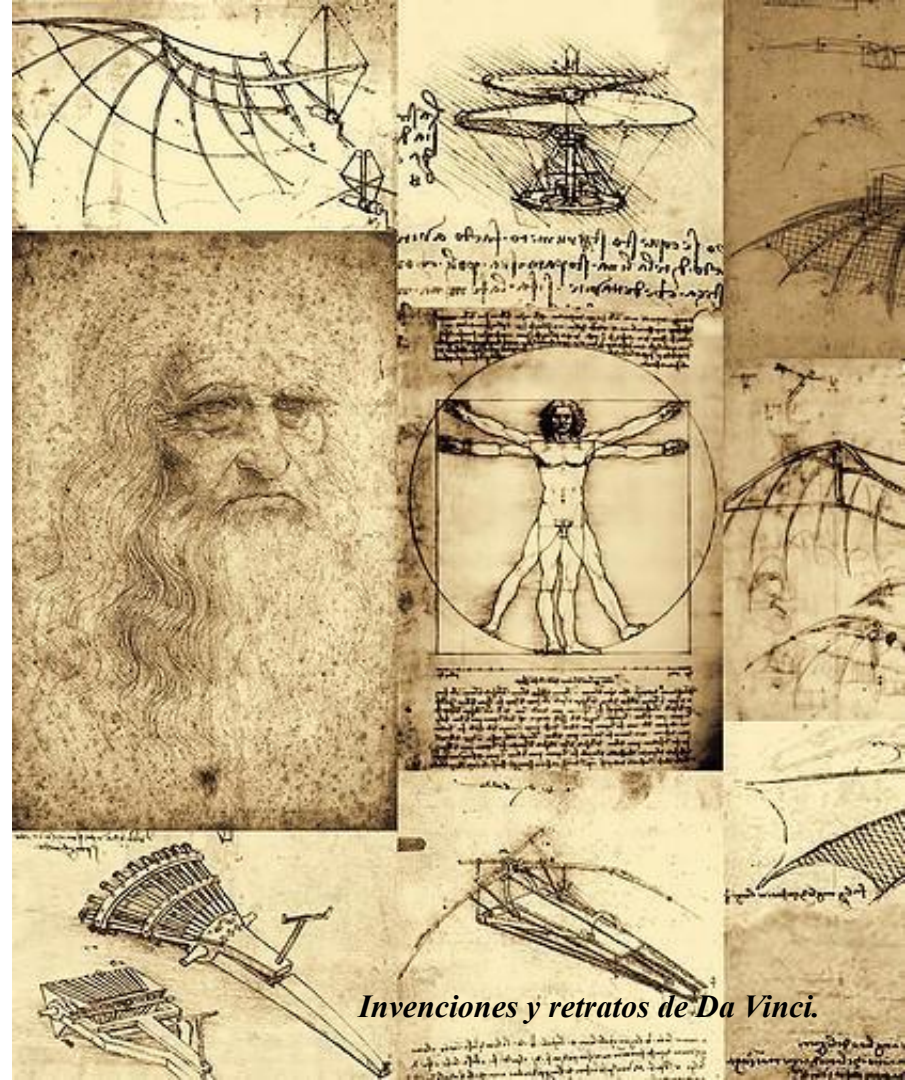


[Cómoda Mazarino](#), de [André-Charles Boulle](#), [Palacio de Vaux-le-Vicomte](#).

Imitatio = Inventio

-Rinassance-

- Leone Battista: 'there is no safer way to beauty than to imitate nature'
- Shakespeare: ... let your tutor be your own discretion: (...) never exceeding the modesty of nature ...
- Dürer: he stressed that imitation was not a passive act: nature has to be 'deciphered' and its content extracted.



Invenções y retratos de Da Vinci.

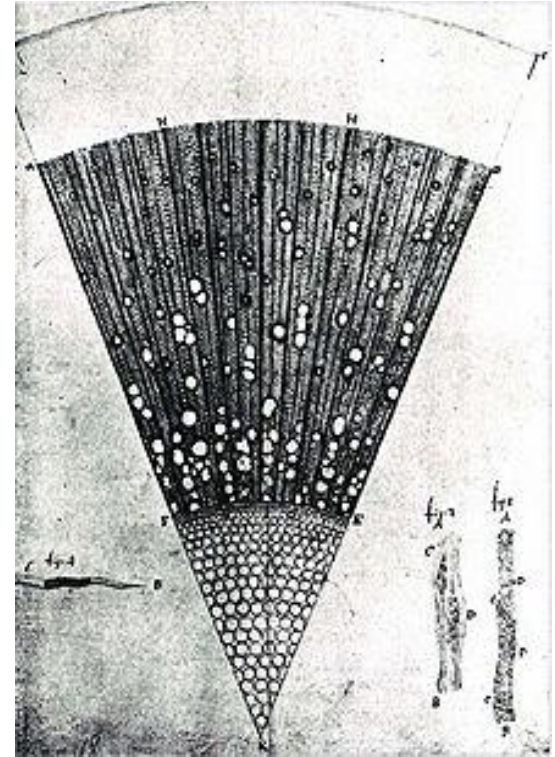


Galileo using his telescopic devices.

Scientific Revolution s. XVII-XIX

Quick accumulation of knowledge

- Bacon
- Newton
- Leeuwenhoek



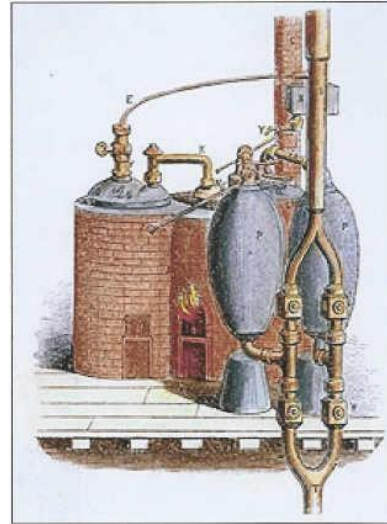
A microscopic section of a one-year-old [ash tree](#) (*Fraxinus*) wood, drawing made by Antoine van Leeuwenhoek

Age of Enlightenment

- The mechanical philosophy
- Institutionalization
- Biology and Medicine
- Calculating devices
- Industrial machines



French [Academy of Sciences](#) was established in 1666.

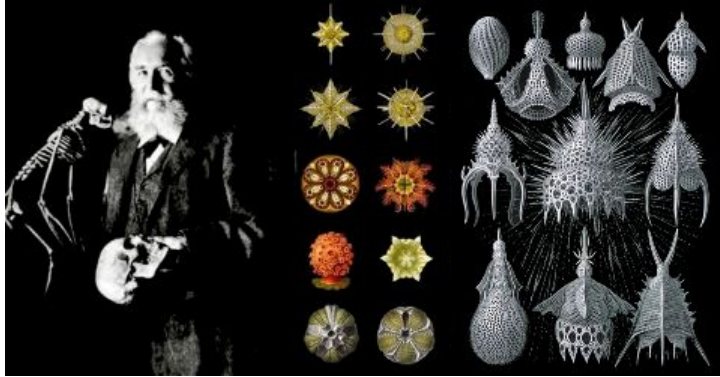


The 1698 [Savery Engine](#) was the first successful [steam engine](#)

Evolution & the Arts and Crafts



Realism / Naturalism



Ernst Haeckel (Scientist)

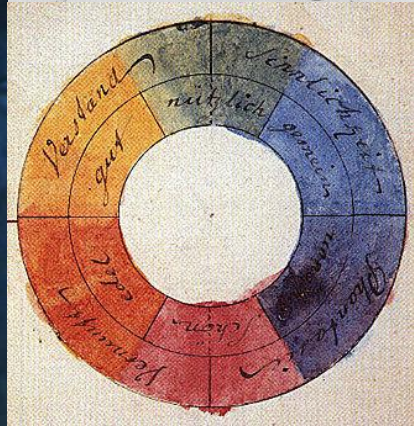
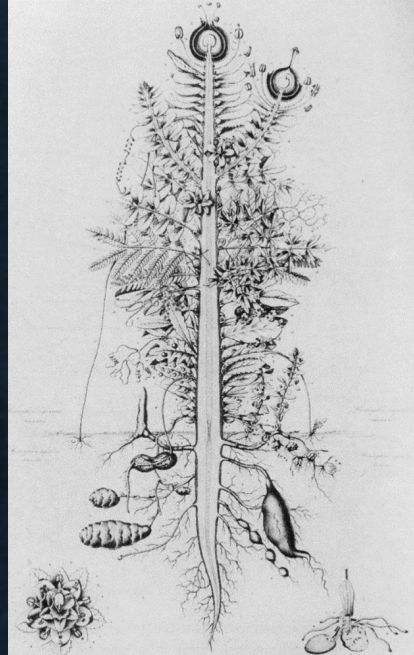


Rene Binet (Artist)

- In the XVIII-XIX the principle of fidelity to nature was underlined. The 'naturalism' was generated by the scientific study of phenomena and people. (Zola)

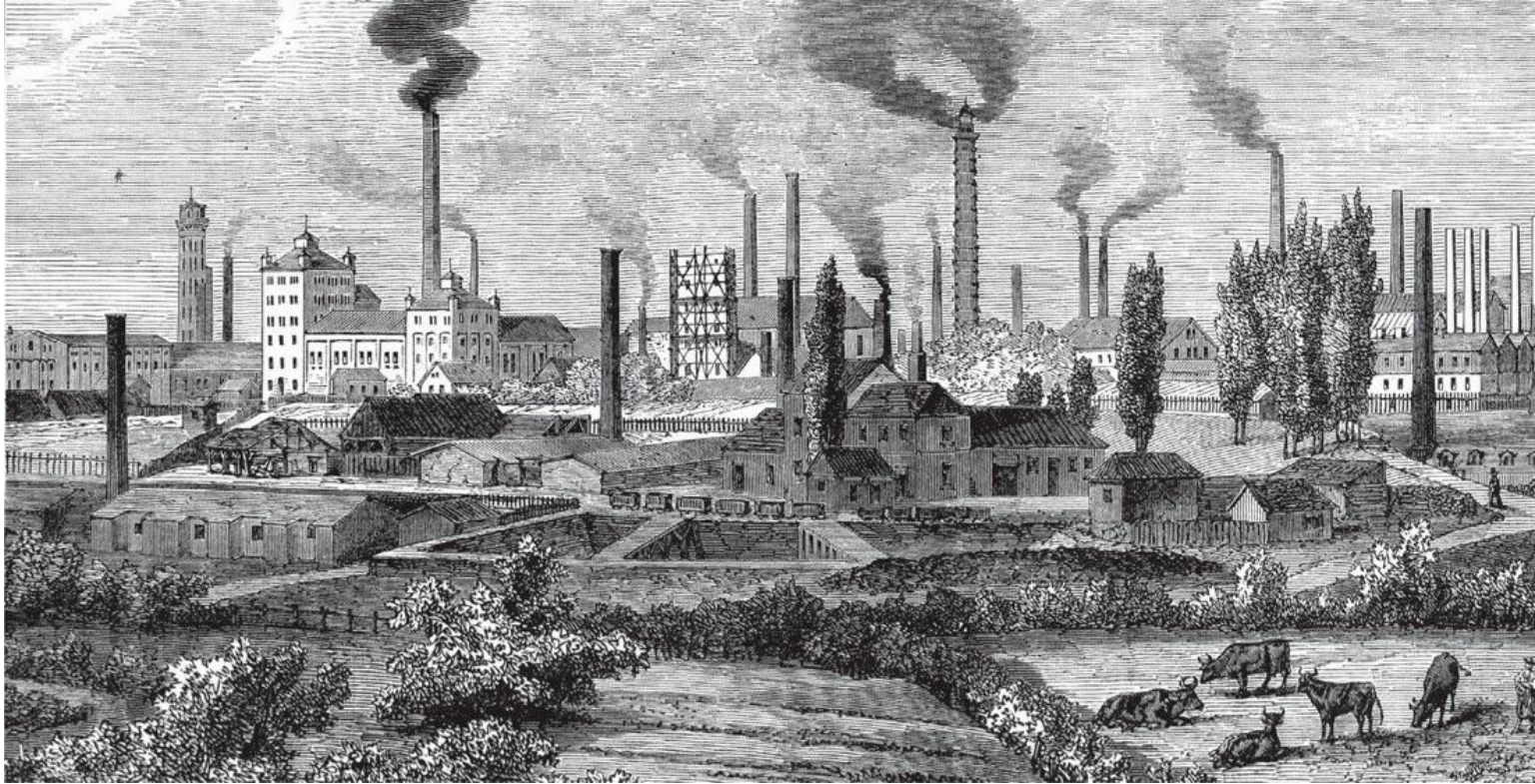
Johann Wolfgang Von
Goethe (1749-1832)

A work of art is: 'a
supreme work of nature
executed by man in
accordance with the
laws of nature'





Industrialization
and the aesthetic
implementation of
bioinspiration in
the s. XX



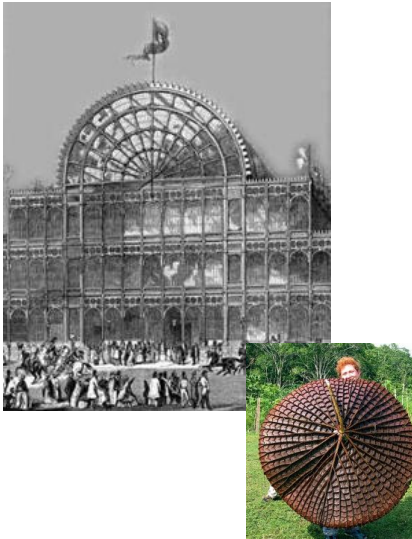
Industrial Revolution: Humanity and Machines

- Nostalgia for the countryside
- Separation areas of knowledge and specialization
- Machines decried craft skills

Arts and Crafts

*"The tree which moves some tears of joy is in the eyes of others only a Green thing that stands in the way. Some see Nature all ridicule and deformit...& some scarce see Nature at all. But to the eyes of a the man of imagination, **Nature is imagination itself**"*

William Blake



Joseph Paxtons Crystal Palace



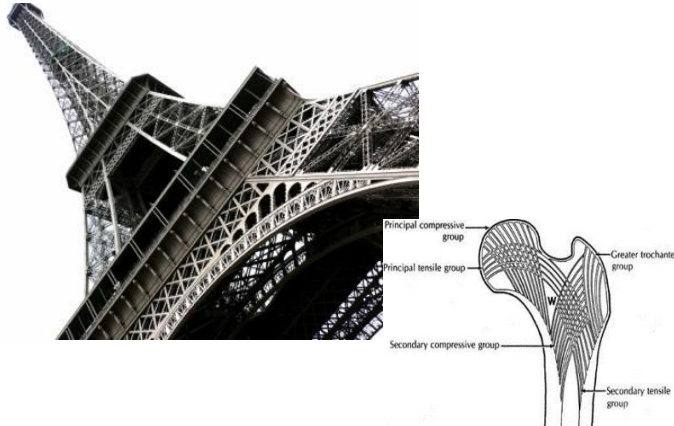
John Ruskin Illustrations



Sevill Chaire by William Morris

Art Nouveau = Biodesign = Bioinspiration

In the 20th century finds in **Art Nouveau** the introduction to a key concept “**Biodesign**”. **Vegetables shapes** were used in industrial mass production, all in a search for **lightness and elegance**.



Modernism: *The clean spirit of Nature*

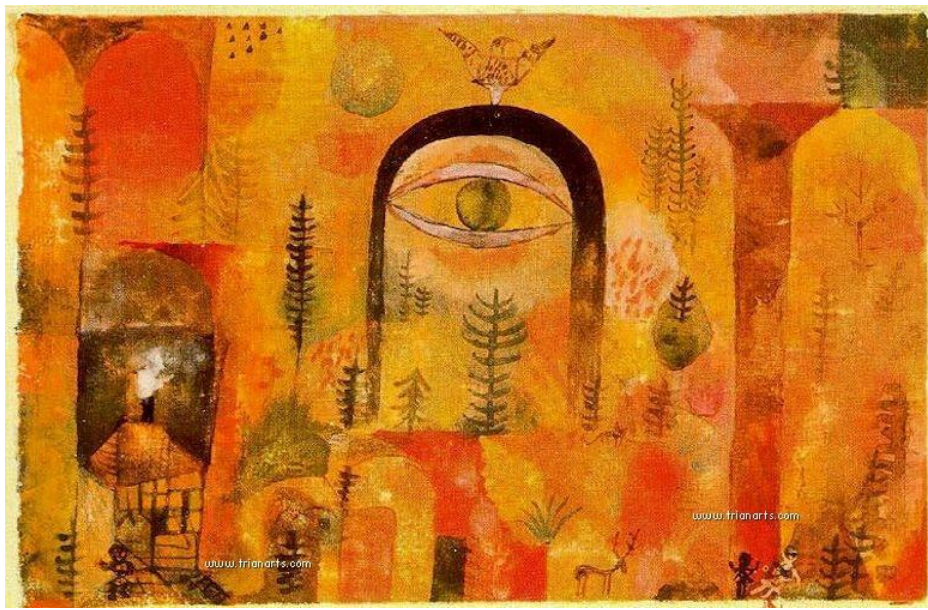
- New objectivism: no escape from industrialized society
- Bauhaus: Laszlo-Moholy Nagy "the laws of life must guarantee an organic development"



Savoy vase by Alvar Aalto



Leaf bowl by Tapio Wirkkala



Pintura de Paul Klee

How do we understand fidelity, the truth that nature expresses?

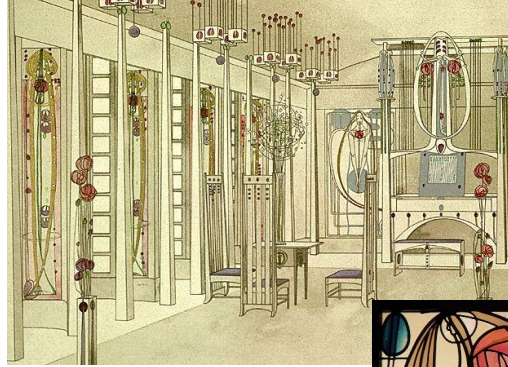
Gogol expressed that we are inclined to understand imitation in the original sense as Democritus did, the **mimetic-expressive**.

Mondrian and Paul Klee expressed 'we do not want to copy nature or imitate it, what we want is to be **able to configure something as nature shapes a fruit**'

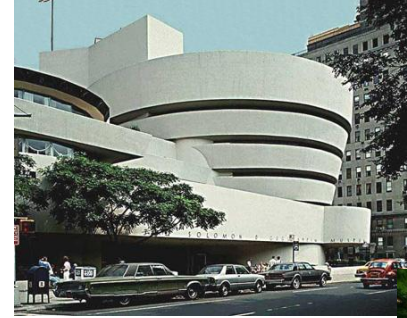
Organic Architecture and Design



Diseño de Antonio Gaudí



Rennie Mackintosh interiores



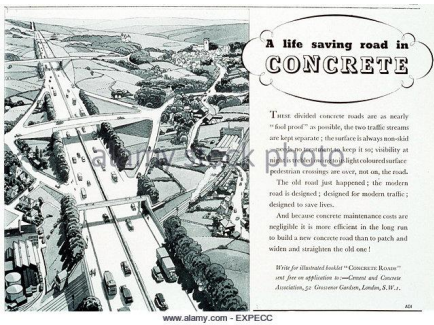
Form follows function
Frank Lloyd Wright and Louis
Sullivan



The new landscape and the new ecology (1950-60)



Modern life!



A life saving road in CONCRETE

These divided concrete roads are as nearly "fail proof" as possible, the two traffic streams are kept separate, the surface is always non-slip and the road surface is kept in its stability as light-colored surface polymer treatments are ever, not on, the road. The old road just happened; the modern road is designed, designed for modern traffic; designed to save lives.

And because concrete maintenance costs are negligible it is more efficient in the long run to build a new concrete road than to patch and widen and straighten the old one!

Write for illustrated booklet "Concrete Roads" and for an application to Concrete and Concrete Association, 25 Grosvenor Gardens, London, S.W. 1.



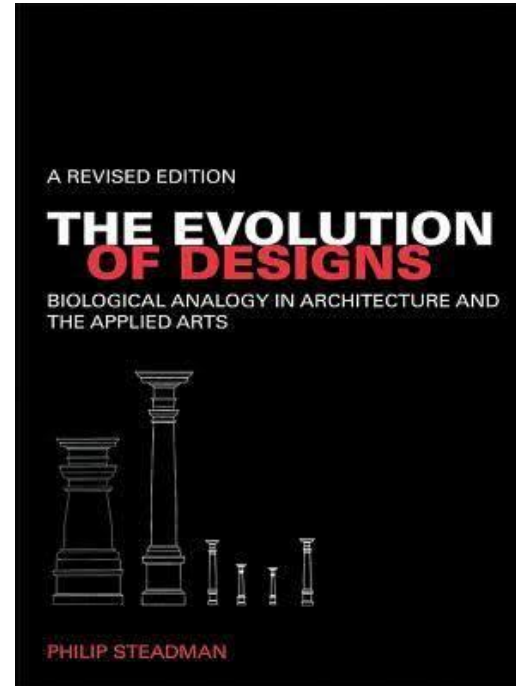
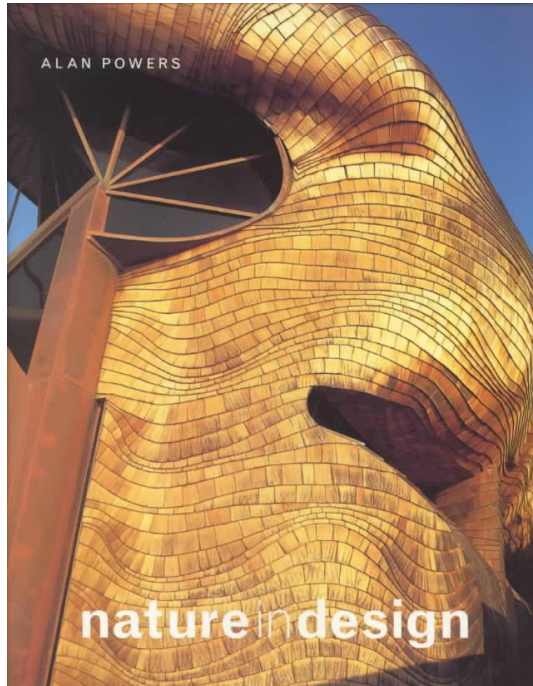
Georgy Kepes - New Landscape exhibition MIT 1951



Rachel Carson and Buckminster Fuller in the 60s



Recommended books





Gardens by the bay. Singapore

Biomimetic Design and Architecture Contemporary Examples

BioArquitecture



Caracol House, Mexico
By Javier Senosiain
Model: Snakes, sea shells



Munich Olympic Park,
By Frei Otto
Models: Tensegrity



Ciutat de les arts i les ciències
By Santiago Calatrava
Model: Human body/bones



Eden Project, Cornwall
By Nicholas Grimshaw
Model: Bubbles/Beehive



Yellow Tree House, NZ
By Fock Associates
Model: Chrysalis, Trees



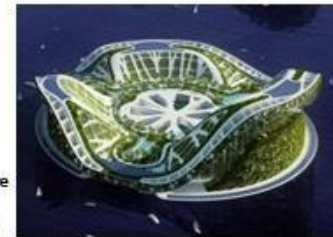
Gardens by the Bay, Singapore
By Wilkinson Eyre
Model: Trees, sea shells, etc.



Eastgate Building, Zimbabwe
By Mick Pearce
Model: Termite mounds



Research Pavilion
By ICT/ITKE Research
Model: Water Spider



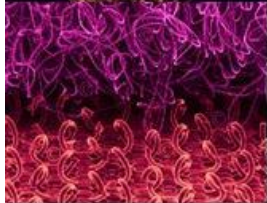
Floating Ecopolis
By Vincent Callebout
Mmodel: lillypad



Evolutionary Architecture
By Eugene Tsui
Models: Birds, various sources



Velcro
By 3M
Model: spiky seeds



Bacteria repels surface
By Sharklet
Model: Shark skin



Entropy Carpet
By Interface Inc.
Model: forest floor



Organic jewelry
By Nervous System
Model: Leaf, Radiolarians, etc



Color-reflective textile
By Morphotex
Model: Morpho butterfly



Self-regulating Textile
By University of Bath
Model: Pinecone



Ooho! water packaging
By Skipping Rocks Lab
Model: Natural membranes



Fastskin textile
By Speedo
Model: Shark skin



Impact safe glass
By Ornilux
Model: Spider wet

Textiles and Biomaterials

Interior/ Environmental Design



Lotus Effect Paint
By STO
Model: Lotus plant



Solar/wind facade
By Smit. Grow
Model: Ivy Plant



Place based interiors
By NatScape
Model: Desert Biome



Bioluminescent instalations
By Loop Ph
Model: Bioluminescent fish



HermitCrab House
By FNP Architects
Model: Hermit Crab



Laren Building facade
By Monk Architects
Model: Boar Fur



Flower Pavilion
By London Design Fest
Model: Flower petals



Parasite House
Korteknie Architects
By: Parasitic Mushroom





Bone Chair
By Joris Laarman
Model: Tree growth



Pax Volute water Pump
By Pax Scientific
Model: Vortex, Spirals

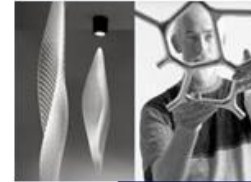
Product Design



Franco Lodato Design
By Franco Lodato
Model: Various



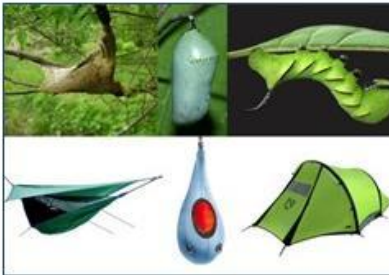
Sonar-Enabled Cane
By UltraCane
Model: Bat's Sonar



BioOrganic Designs
By Ross Lovegrove
Models: Various



BioInspired processes
By Nery Oxman/MIT
Model: Various



Cocoon Tents
By Various designers
Model: Cocoons,
Chrysalis



Invisible street light
By Jongoh Lee
Model: Tree branche



Owl Fan
By Silent Fan
Model: Owl
feathers



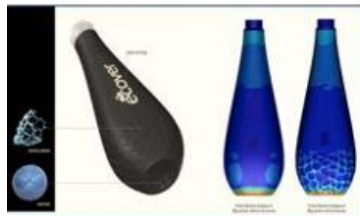
Luminaries 3Dp
By FOC
Models: Varios
botanics



Graphic design and Packaging



Brandiversity | by Koert Van Mensvort | Model: Various



Soap packaging | by Logoplaste | Model: Radiolarins



Fruit packaging | by Naoko Fukasawa | Model: Fruit skin texture

Transportation Design



Sinkansen Train | by Eiji Nakatsu | Model: Kingfisher beak



Bionic Car | Mercedes-Benz | box fish

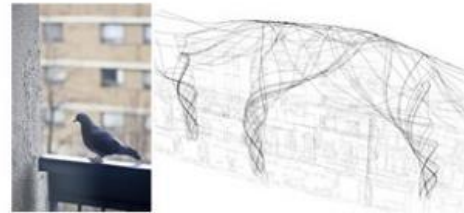


Zepp-Dirigible | by Jean-Marie Massaud | Whale

Interaction design



Self-driving systems | by Nissan | Model: School of fish/flocks



Envision Pigeon | by Carla Gould | Model: Pigeon-city interaction



Flower console game | by Thegamecompany | Plant polination

Engineering, Medicine and other areas



Flexible Solar panels | Model: leaves



Pest-Resistant Crops | Grasslands



Non toxic strong glues | Model: mussel



Sonar technologies | Model: Bat echolocation



Wind turbines | Model: whale fin



Anti reflexive screens | Model; Moth eyes



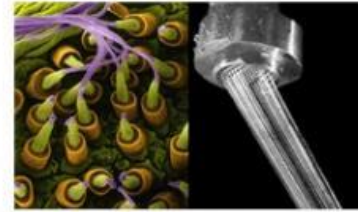
Strong Adhesives | Gecko's foot



Festo Bionics | Models: Marine and Aerial Organisms



Cancer treatment medication | Model: Chimpanzee's diet



Kevlar extrusion Spinneret | Spider's spinneret



Biomatrix Regeneration systems | Model: Aquatic ecosystems



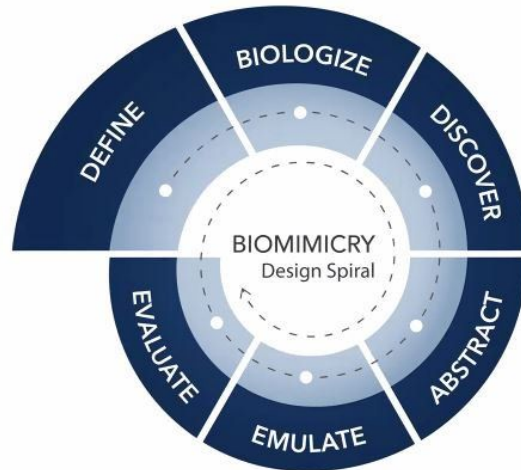
NovaLabs Vaccine Stabilization | Model: Water Bear

Biomimicry

Thinking as a Tool

Biomimicry Design Spiral

- **DEFINE** function and context
- **BIOLOGIZE** the challenge
- **DISCOVER** biological models
- **ABSTRACT** strategies
- **EMULATE** strategies
- **EVALUATE** fitness



Dayna Baumeister
Biomimicry Design Spiral
1997



Janine Benyus
Biomimicry Design Spiral
1997

Life's Principles

- “orks with sunlight
- Use only the energy needed
- form follows function
- recycle everything
- reward for cooperation
- Protect diversity
- Demand local expertise
- Removes excess
- Touch the power of limits
-



BIOTRIZ CONTRADICTION MATRIX

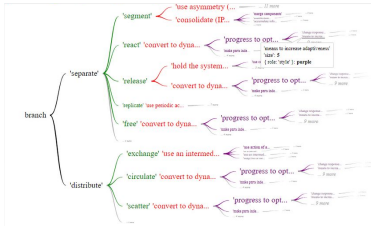
BIOTRIZ

JULIAN VINCENT- NIKOLAY Y OLGA BOGATYREV



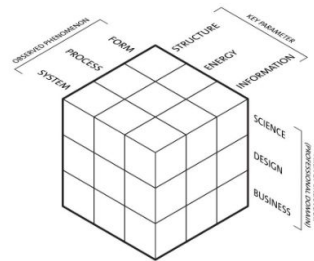
BIO DISEÑO

JANITZIO ÉGIDO VILLAREAL



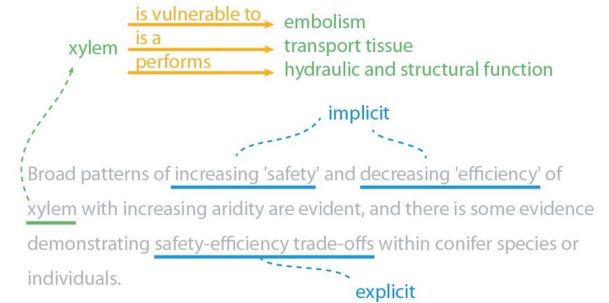
E2B THESAURUS

JAQUELINE NAGEL



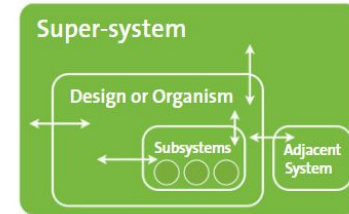
BIO-DESIGN CUBE

TOM MCKEAG



CROSS-DOMAIN ANALOGIES AND KEYWORDS

UNIVERSIDAD DE TORONTO



SYSTEM EXPLORER

CURT MCNAMARA

Biomimicry Institute



BIOMIMICRY

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It's time to ask nature.

AskNature.org

Interest in biomimicry has skyrocketed over the past decade, and there are now thousands of resources—including books, articles, videos, lesson plans, groups, training programs, and more—available to folks who want to learn, teach, and practice.

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The Biomimicry Toolbox

The toolbox provides an orientation to biomimicry and introduces a set of tools and core concepts that can help problem-solvers from any discipline begin to incorporate insights from nature into their solutions.

Get started with this free resource [here](#).

Strategies Behind Recent Innovations

+

BIOLOGICAL STRATEGY

Adhesive Is Both Strong and Flexible

Eastern oyster

BIOLOGICAL STRATEGY

Leaf Pores Draw Water Through Plants

Plants

BIOLOGICAL STRATEGY

Chemicals in Oregano Act as Fungicide

Oregano

BIOLOGICAL STRATEGY

Wing Scales Cause Light to Diffract and Interfere

Morpho butterfly

FUNCTION:

Move in/on Liquids

+

[Explore Function](#)

BIOLOGICAL STRATEGY

Why Fish Scales Aren't Such a Drag

Fish

BIOLOGICAL STRATEGY

The Beak That Inspired a Bullet Train

Kingfishers

BIOLOGICAL STRATEGY

Fin Movements Aid in Swimming Backward and Forward

African freshwater electric eel

BIOLOGICAL STRATEGY

Foot Aids Underwater Movement

Snails and slugs

What can
Inspire me to
create
circularity?

Our local landscapes



Biomaterials



Nature is our best teacher



The Department of Seaweed at the Victoria and Albert Museum, 2013

Julia Lohmann

Upcycling, recycling, reuse ----> Grow, slow, less <---- ancient, primitive, local



reddot

Roberto Mendez



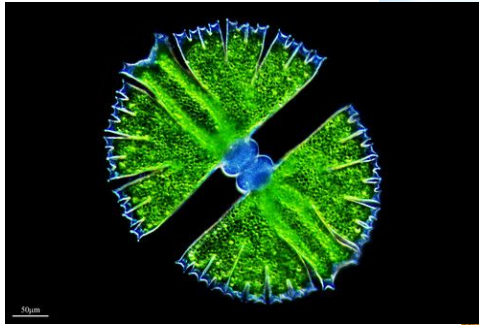
Julia Lohmann



Zapotec bowls

Living in an age of Enlivenment (*Andreas Webber*)

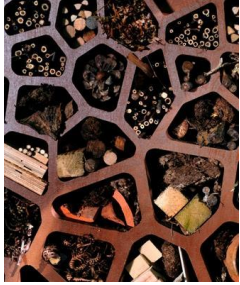




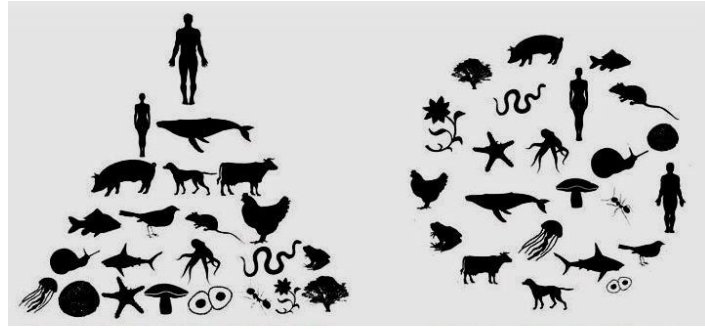
Which is the life cycle that we want to contribute for?

What mentors will be guiding you to generate design that continue the conditions of life?

FINAL ADVICE



Biodiversity bridge Netherlands cc)



Ego vs Eco (cc, 2012)



Treehouse forrest(concept)



Bug hotel, ArupAse

Biomatrix Living machine, Manila



Gardens by the bay, Singapore



Bee and flower in symbiosis (cc, 2012)

Symbiotic Design and Regeneration as key for a circular economy and Codesign



Thinking like a tree/bird/forest provides us with ethical behavior and a creative lens to solve problems.

The ability to recognize the patterns of nature and apply them is today fundamental

We all have the ability to re-imagine the intentions of our living planet.



Shanghai 2100. (Luc Schuiten, 2009)

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