urban green | U.S. GREEN BUILDING COUNCIL CHAPTER

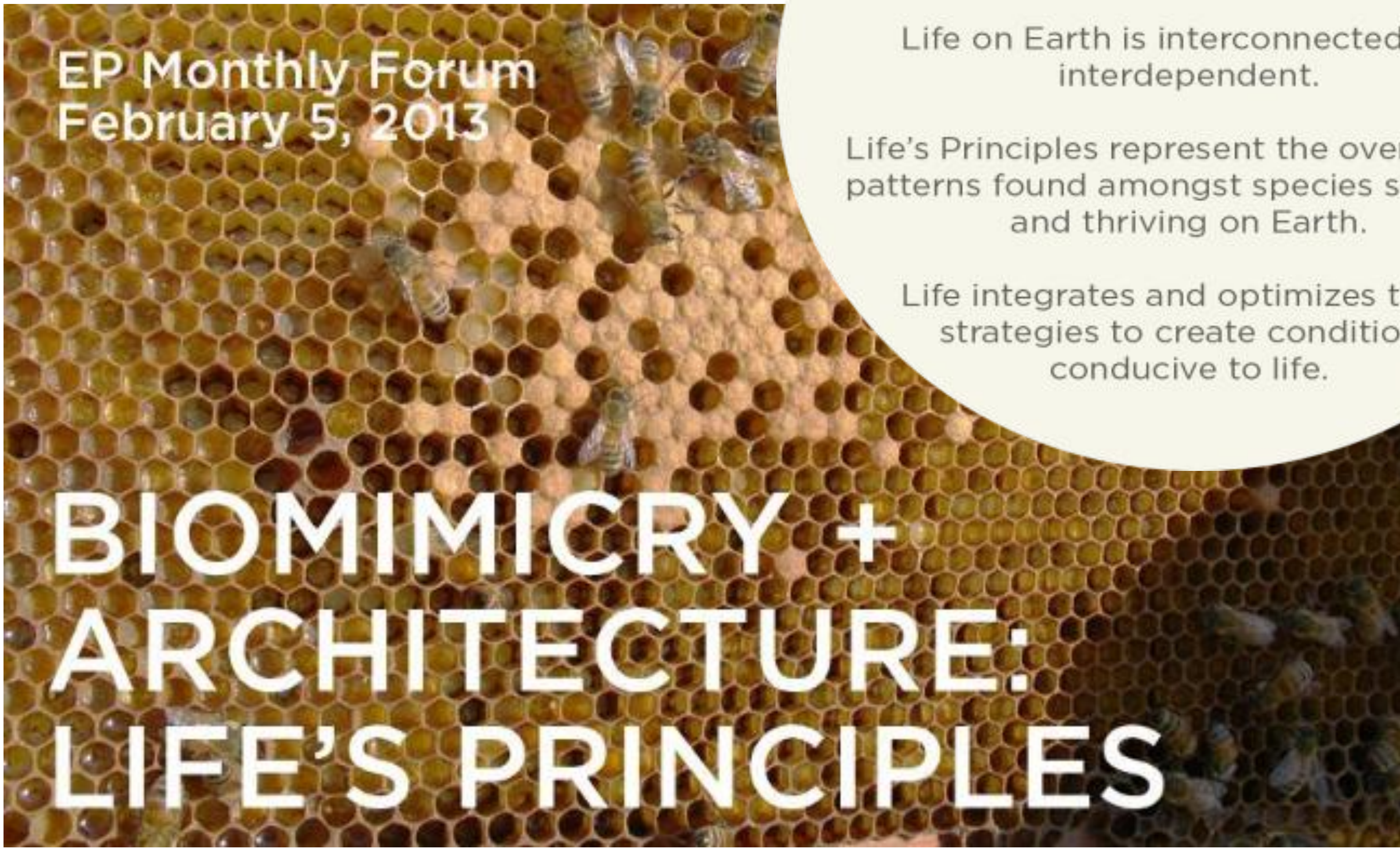
LIFE'S PRINCIPLES

Design Lessons from Nature

Life on Earth is interconnected and interdependent.

Life's Principles represent the overarching patterns found amongst species surviving and thriving on Earth.

Life integrates and optimizes these strategies to create conditions conducive to life.



Learning Objectives

LIFE'S PRINCIPLES
Design Lessons from Nature

Life on Earth is interconnected and interdependent.

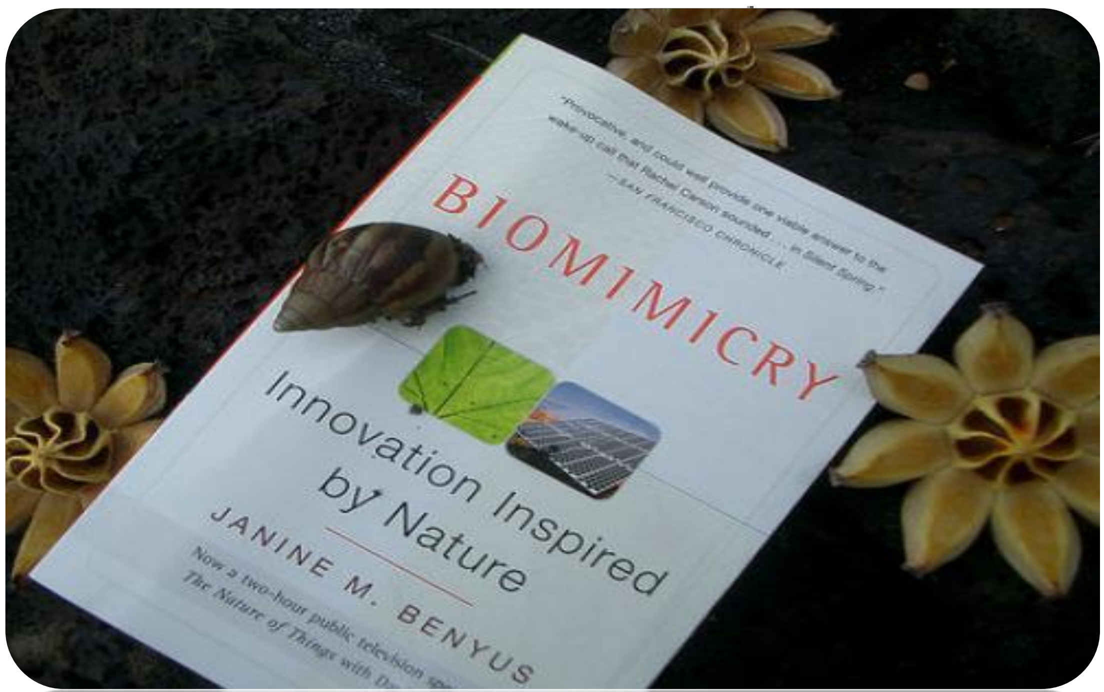
Life's Principles represent the overarching patterns found amongst species surviving and thriving on Earth.

Life integrates and optimizes these strategies to create conditions conducive to life.

1. Define Biomimicry and understand its relationship to sustainable architecture, design, and engineering methodologies such as LEED
2. Understand the underlying "Life's Principles" and Design Lessons from Nature defined in the Biomimicry design process
3. Identify how Life's Principles are applied in many examples of well adapted architectural designs from the built environment
4. Know how to access further resources to learn and apply Biomimicry

What is Biomimicry?

Biomimicry (from Bios meaning Life and Mimesis meaning to imitate) is a design discipline that seeks solutions by emulating nature's time tested patterns, techniques and design strategies to solve human challenges



The Biomimicry Lens

Nature as model, measure & mentor

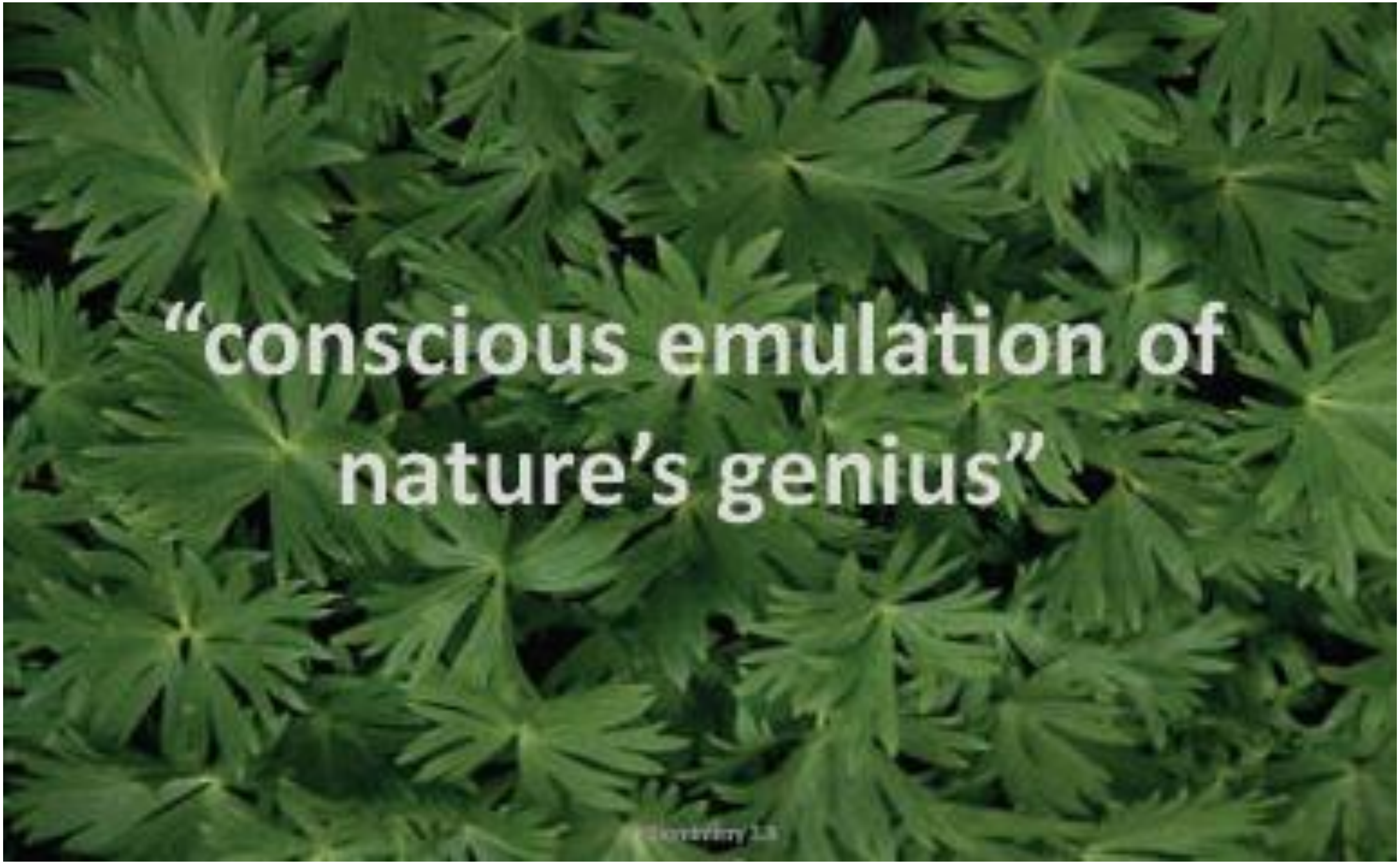
Biomimicry is a new way of viewing and valuing nature, based not on what we can *extract* from the natural world, but on what we can *learn* from it.

biomimicry GUILD

Biomimicry is not:

- Bio Technology- its not microbial bioremediation or genetic engineering
- Bio Assistance- or domestication of organisms to help develop a product
- Bio Utilization- or harvesting natural plants or organisms

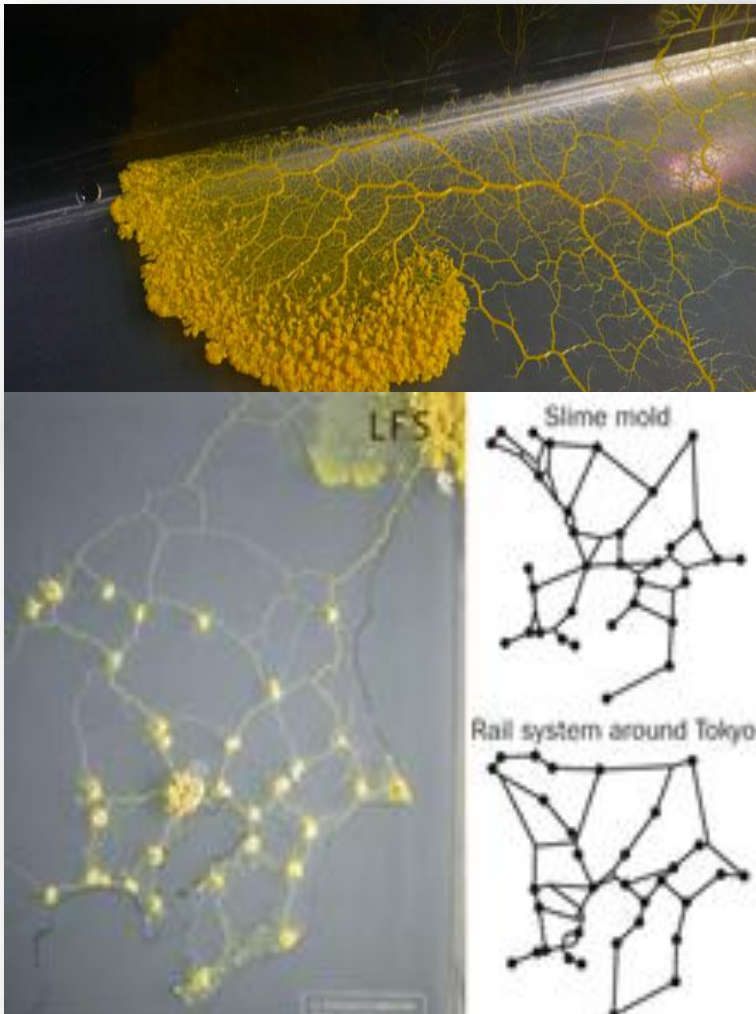
FORM PROCESS SYSTEM



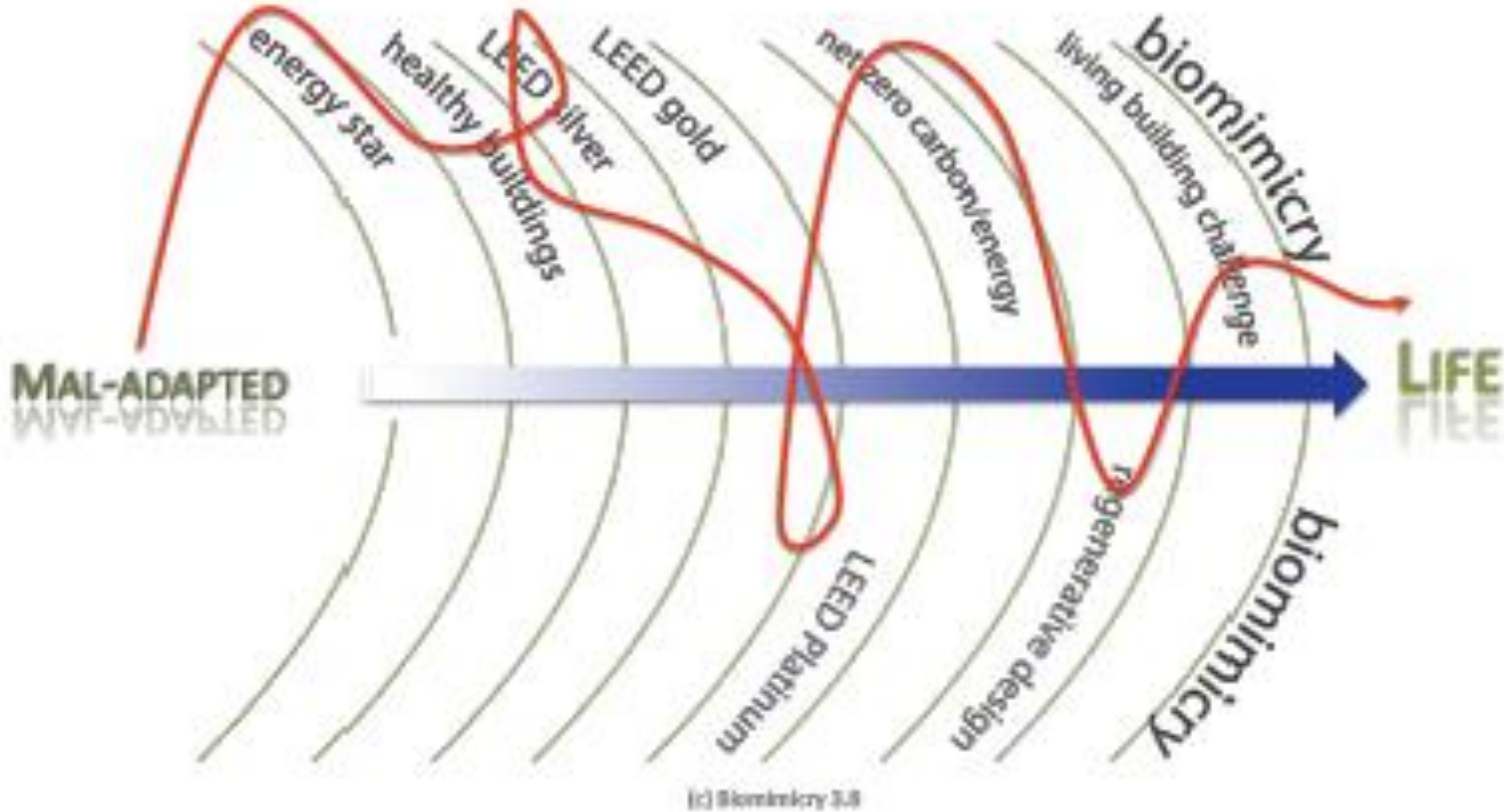
FORM PROCESS SYSTEM

FORM PROCESS SYSTEM

FORM PROCESS SYSTEM



How does Biomimicry fit into Sustainability?



Design Lessons from Nature

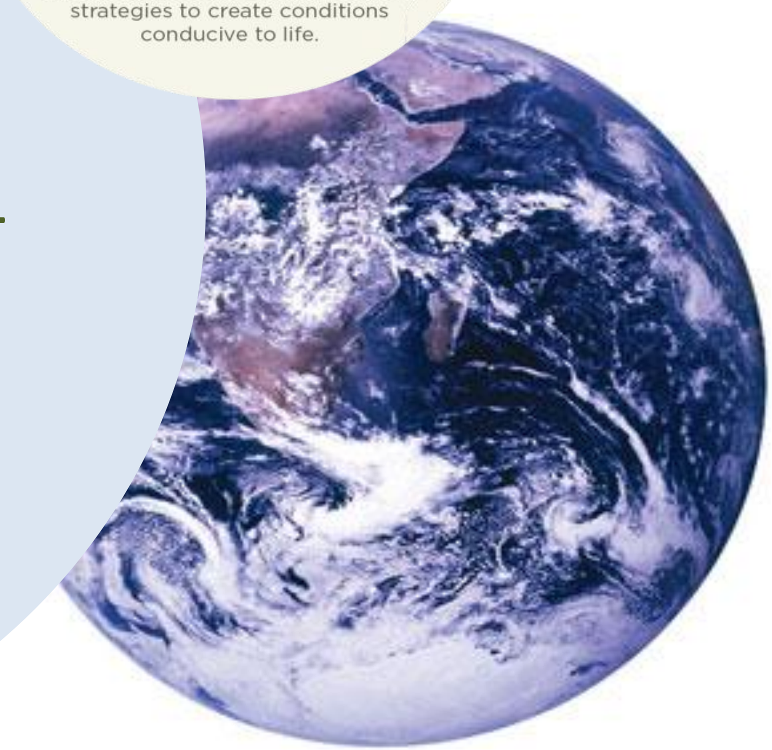
Earths Operating Conditions:

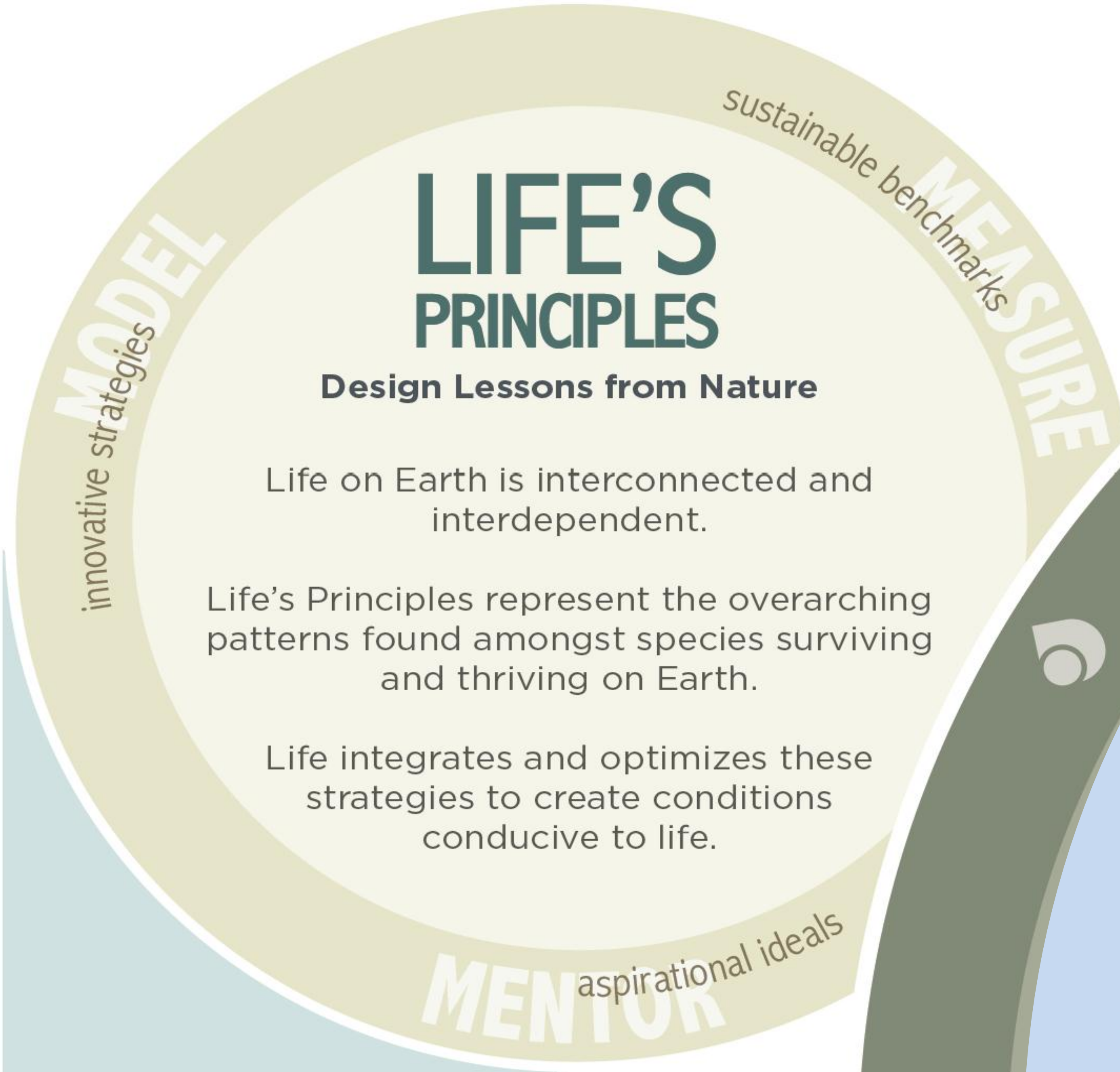
Sunlight - Water

Gravity - Dynamic Non-Equilibrium

Limits + boundaries

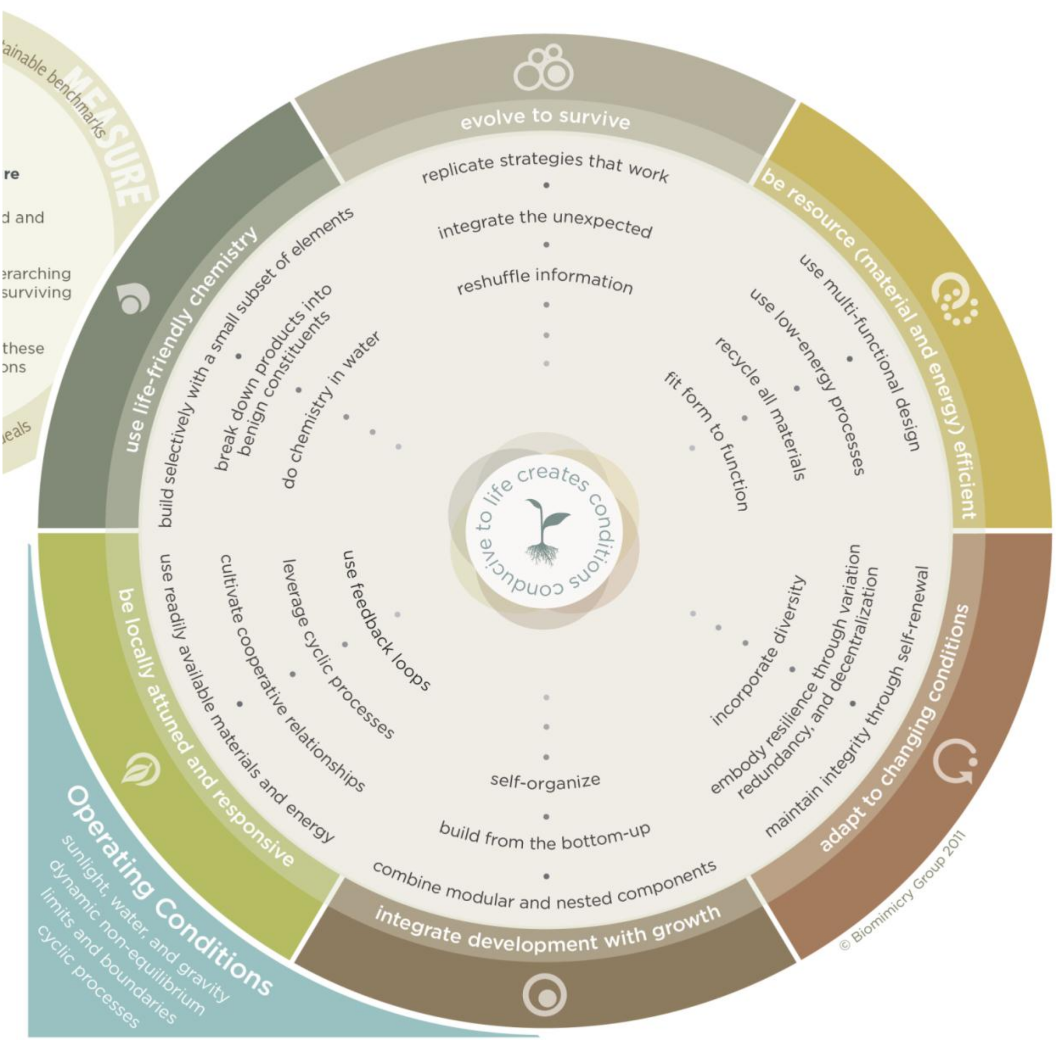
Cyclic processes





- Model
- Measure
- Mentor

Life's Principles-1

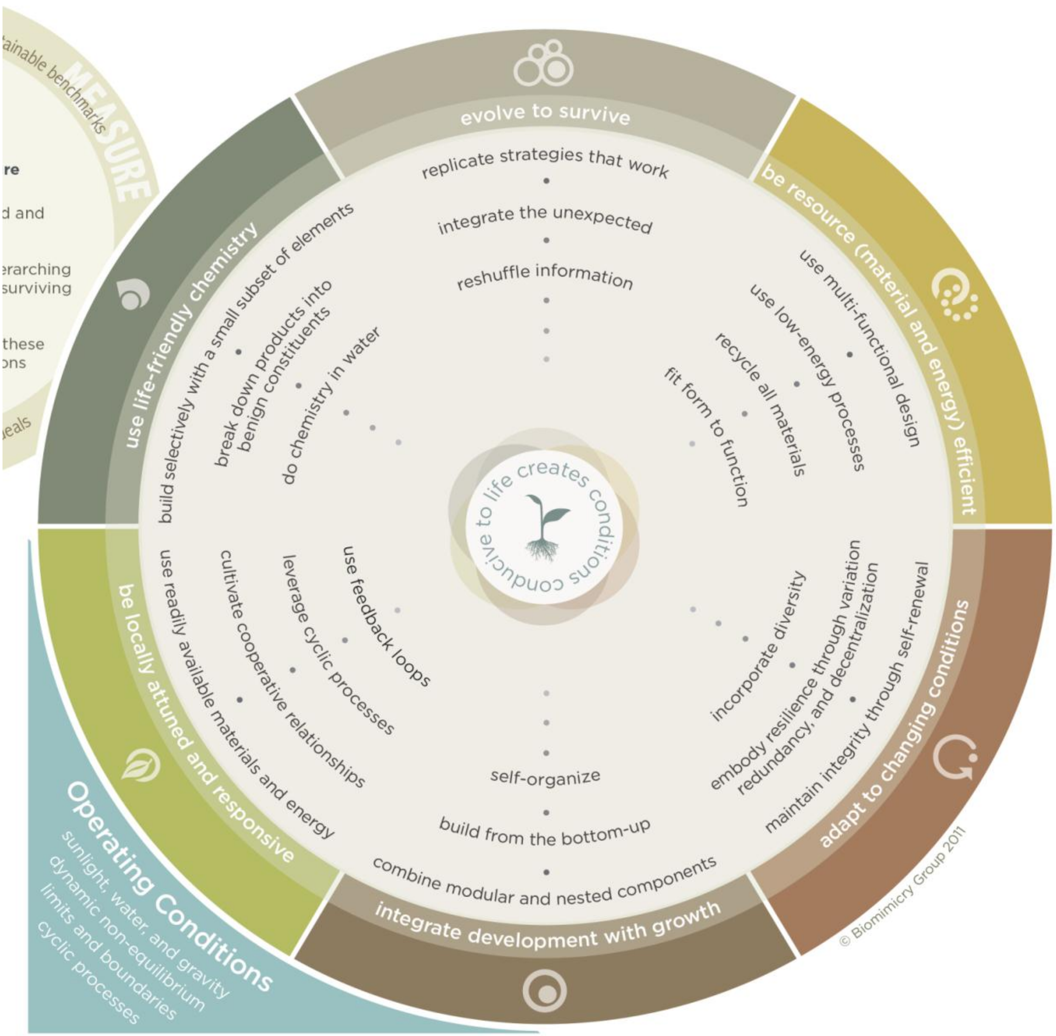


Be resource and material efficient

Use life friendly chemistry

Integrate development with growth

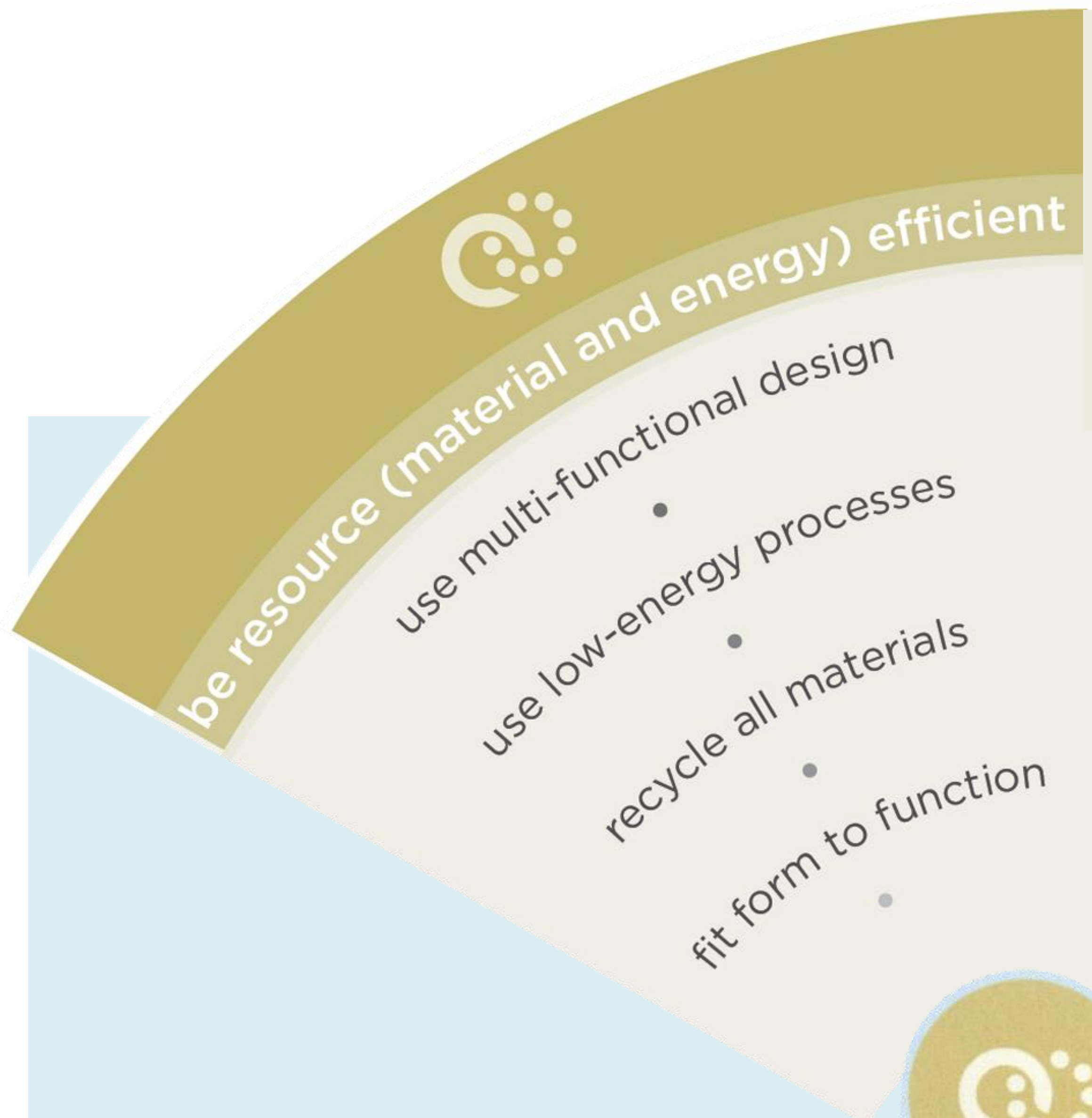
Life's Principles-2



Be locally attuned and responsive

Adapt to changing conditions

Evolve to survive



be resource efficient

Use multi-functional design

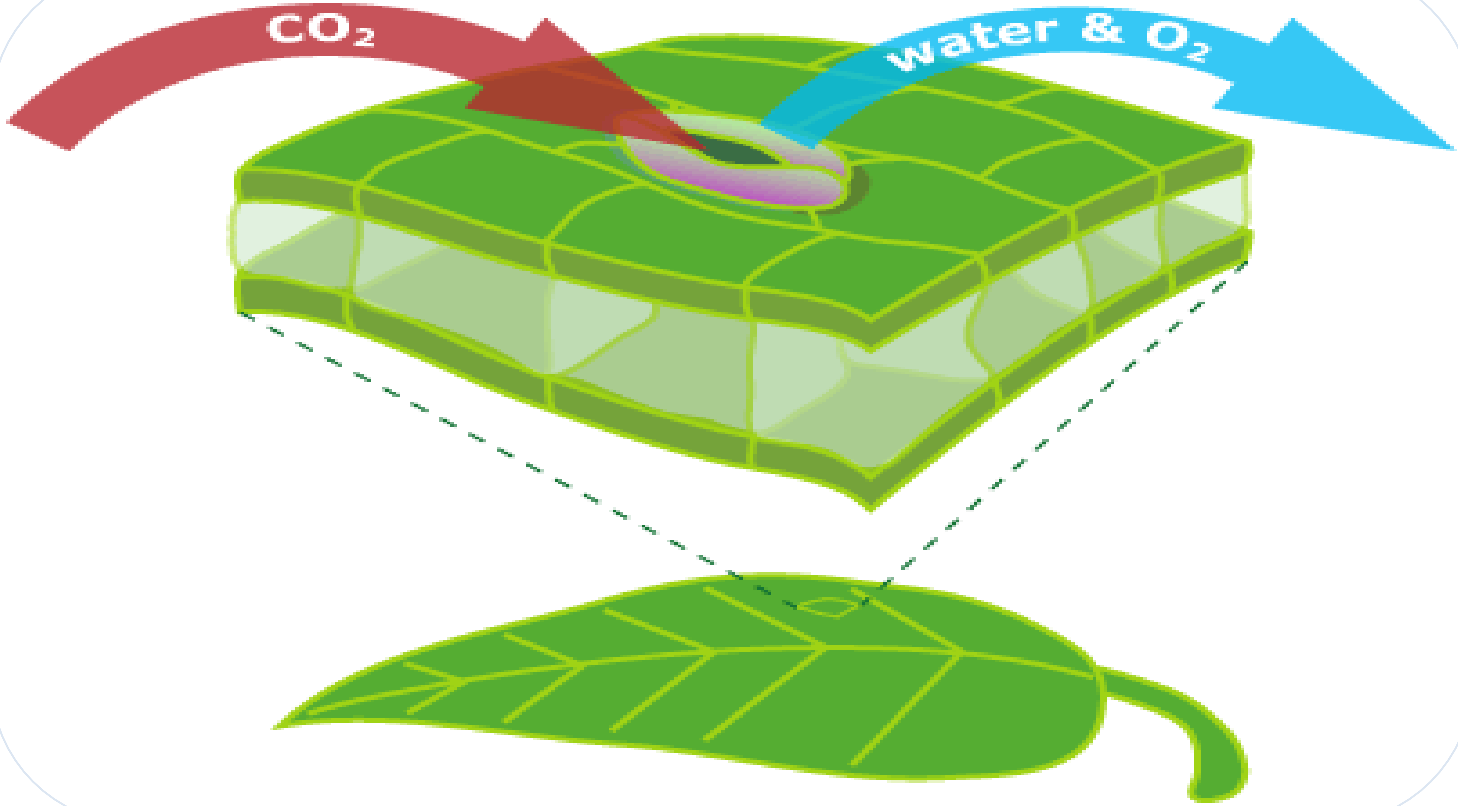
How can the function of leaf stomata inspire an efficient building envelope system that provides many functions?

- protection from elements
- thermal regulation
- ventilation exchange
- modulate daylight

Principle: use multi-functional design

Definition: meet multiple needs with one elegant solution

Biological example: the surface and stomata of a leaf

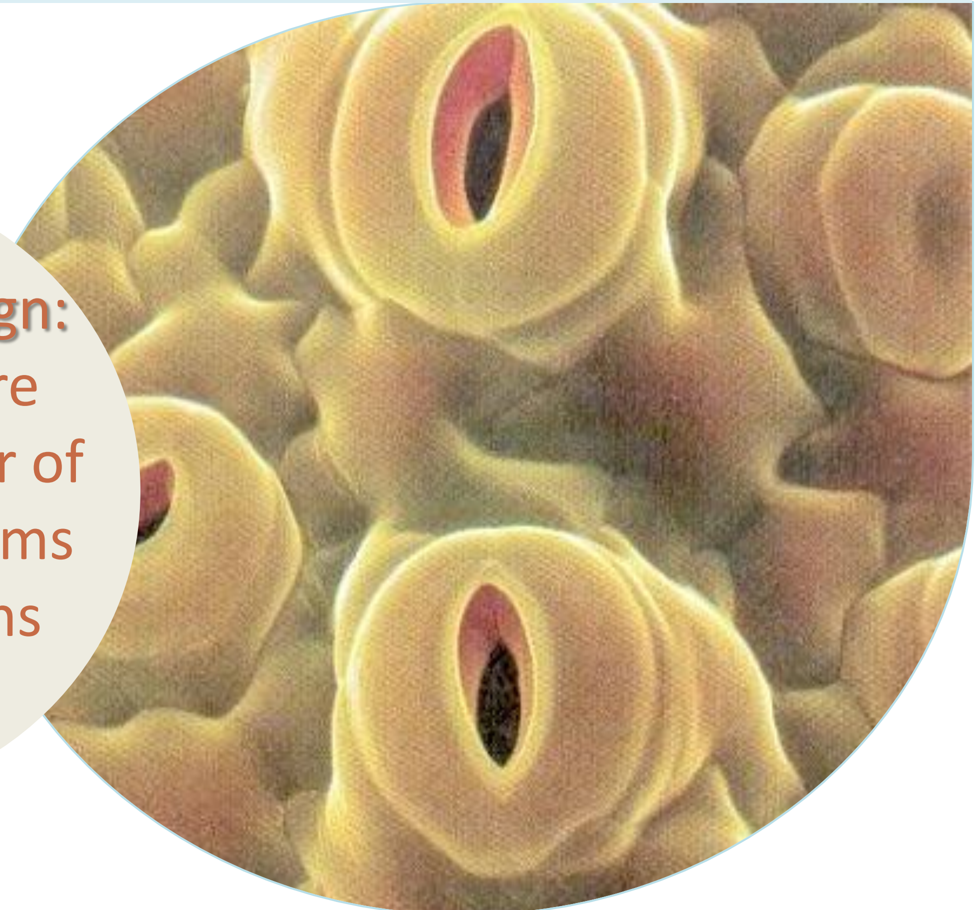


The leaf regulates sunlight and moisture – via stomata that allow gases - carbon dioxide, water vapor, and oxygen to move rapidly into and out of the leaf -thus providing transpiration

Principle: use multi-functional design

Definition: meet multiple needs with one elegant solution

Biological example: the surface and stomata of a leaf



Biology to Design:
Plant leaves are similar to a layer of skin that performs multi- functions

Leaf stomata communicate between internal and external via controlled guard cells that perform photosynthesis- opening for transpiration and closing when dehydrated

Principle: use multi-functional design

Definition: meet multiple needs with one elegant solution

Architectural example: breathable multi-functional building skin

Habitat 2020 - concept building skin opens, closes, breathes and adapts to environment –works like plant stomata; moves with sun, self shading, collects water, light, ventilates, filters, recycles

Principle: use multi-functional design

Definition: meet multiple needs with one elegant solution

Architectural example: breathable multi-functional building skin

Provides individual occupant controls of the quality of light and ventilation

provides thermal regulation and filters outdoor air activated by temperature or light or human touch

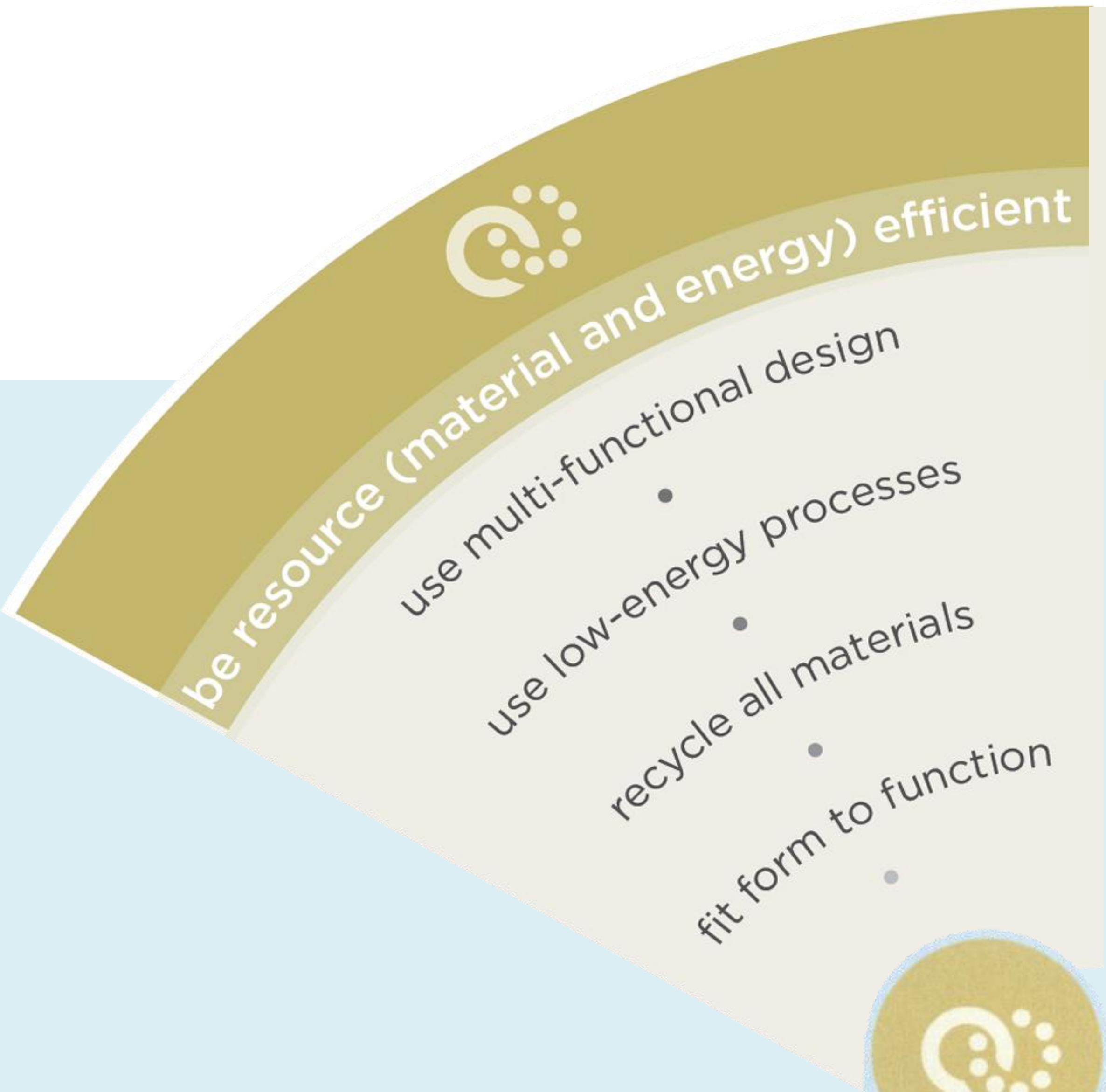
Why don't we design our building skins to perform more functions ?

Design possibilities:

To achieve better resource efficiency, building envelope and wall systems should mimic multifunctional natural biological systems:

- collect energy
- regulate light
- promote natural ventilation
- control moisture
- insulate
- Protect
- shade

be resource efficient



Use low energy processes + materials

How can the function of a Namibian fog basking beetle inspire an efficient water collection system for a building that uses low or no energy, materials, and natural processes?

Principle: use low energy processes + materials

Biological Example : Namibian desert fog basking beetle

The beetle utilizes color and temperature differential:

- collect water overnight on its hydrophilic surface
- creates water in the desert from fog

Principle: use low energy processes + materials

Biological Example: Namibian desert fog basking beetle

Biology to Design: Night time water collection from fog

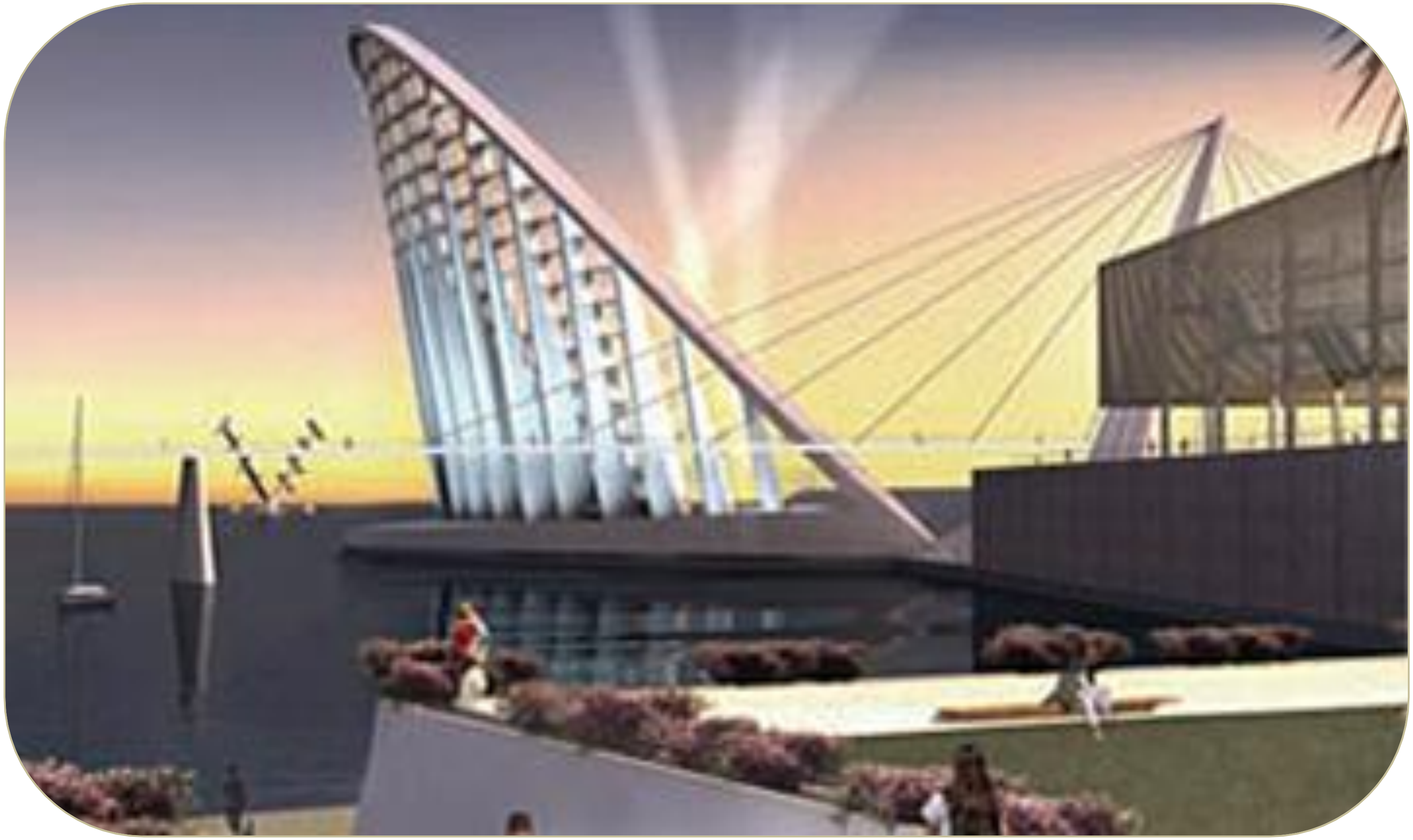
His matte black shell radiates heat to the night sky- becomes cooler than his surroundings- when the wind blows from the sea- water condenses on his bumpy hydrophilic shell

before sunrise he tips his shell up to drink

Principle: use low energy processes

Definition: minimize energy consumption

Architectural Example: Architectural Water Theatre



Las Palmas Water Theatre Canary Islands – Gateway to Las Palmas

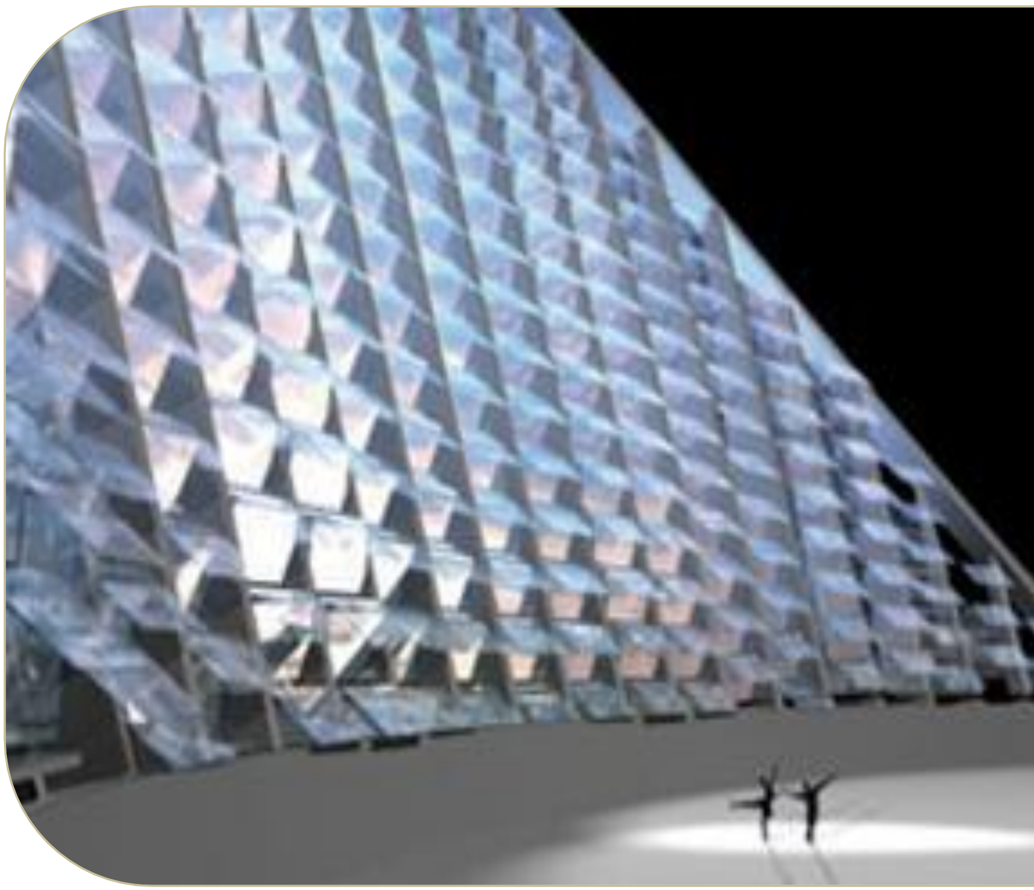
Architect: Grimshaw Architects, London, UK

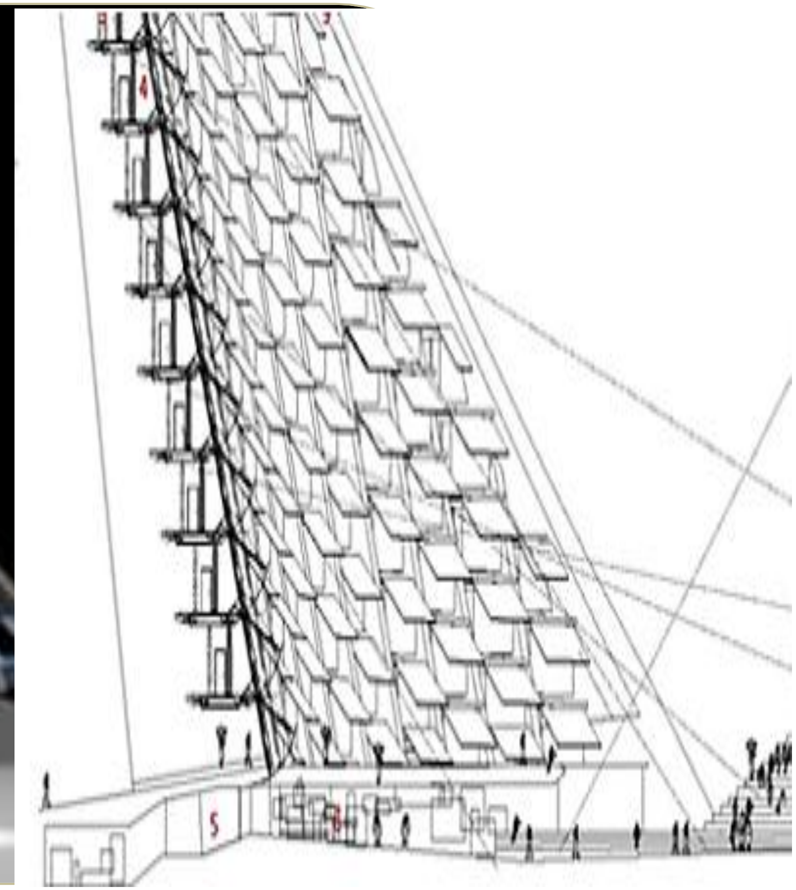
Seawater Technology-inspired by fog basking beetle

Principle: use low energy processes + materials

Definition: minimize energy consumption

Architectural Example: Architectural Water Theatre



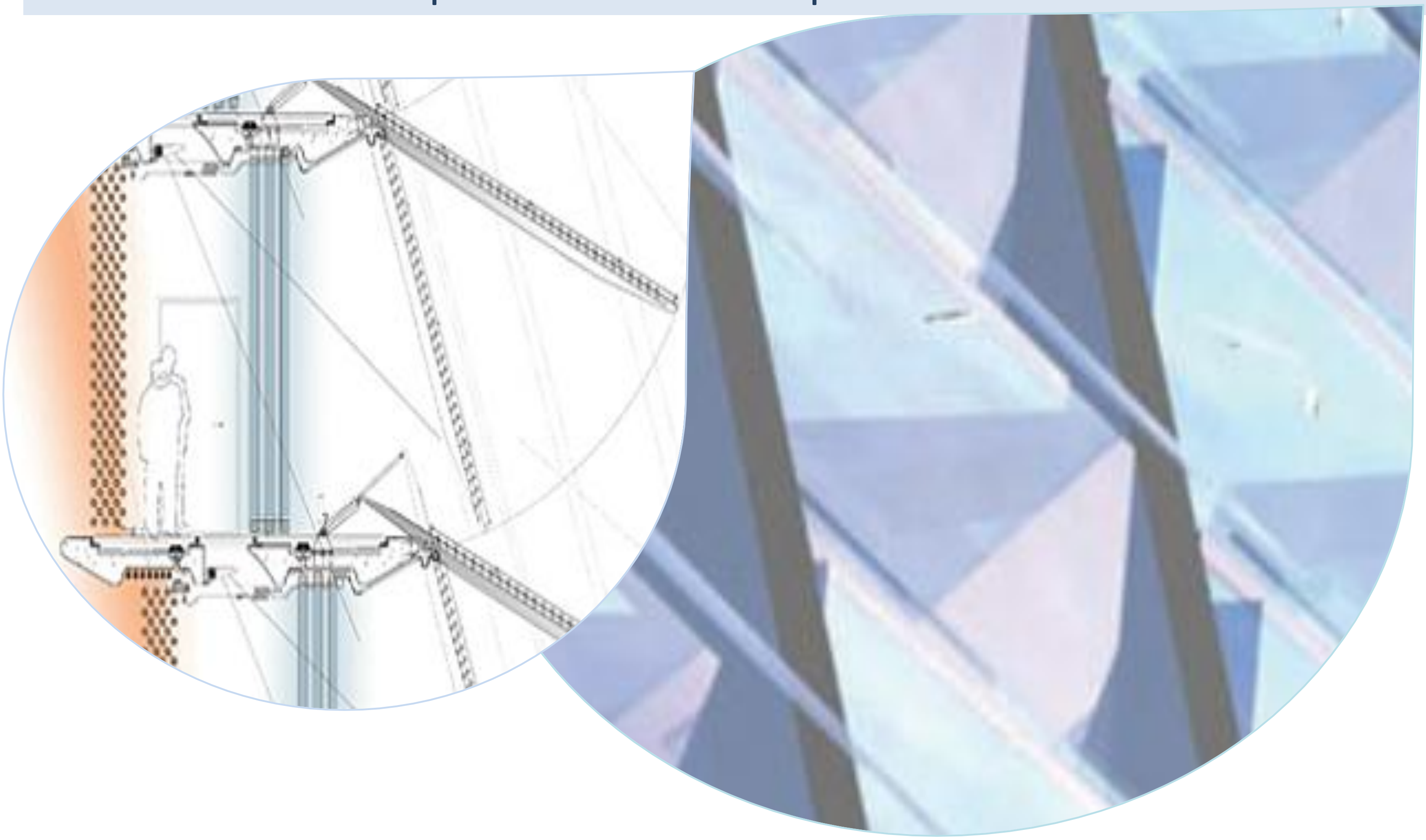


banks of evaporators, condensers, and wind flaps produce distilled water-designed in a sculptural form as a backdrop for an amphitheater

Principle: use low energy processes + materials

Definition: minimize energy consumption

Architectural example: desalinization plant



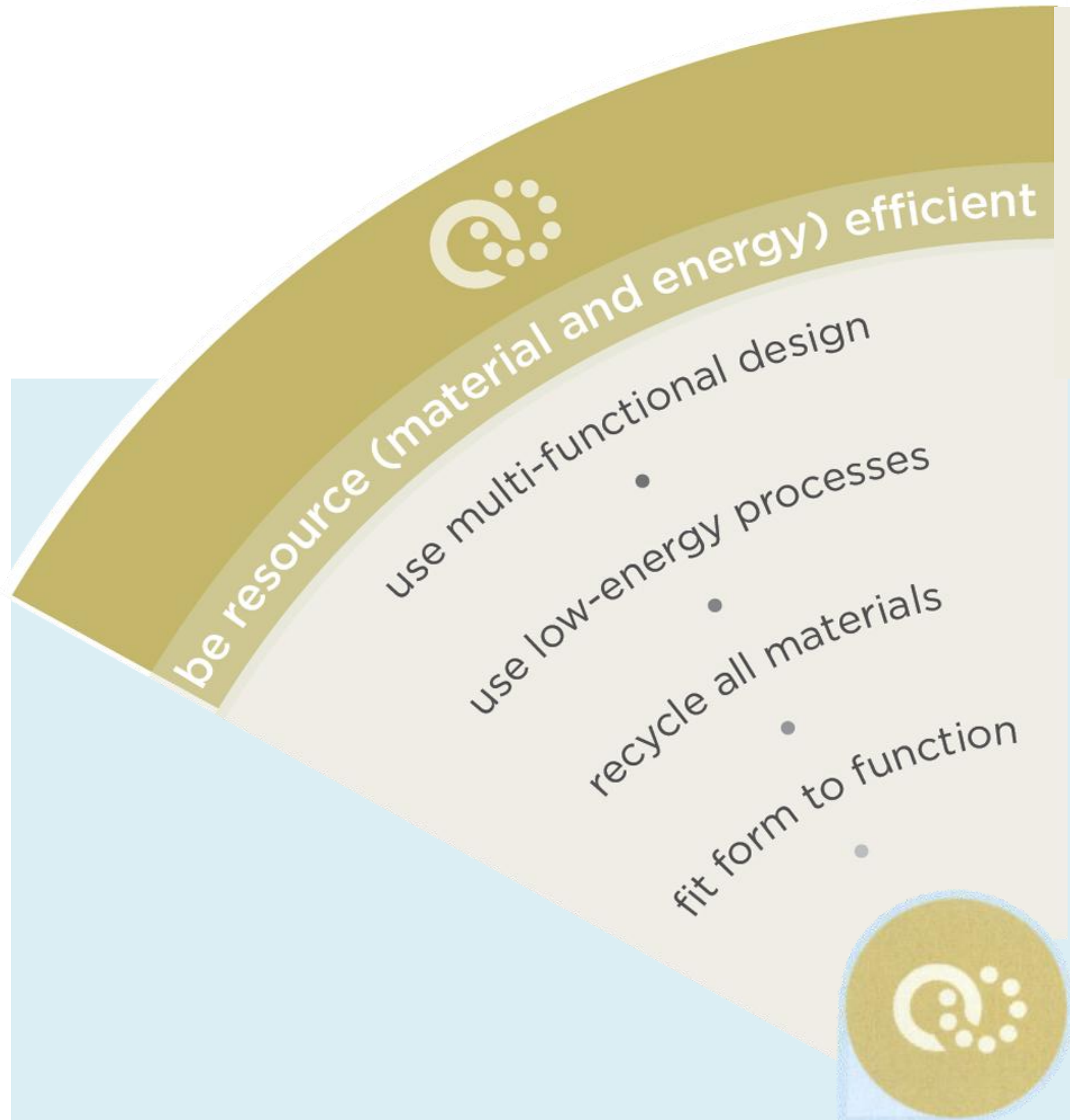
Solar thermal panels heat cold seawater –it passes through evaporators where moisture is condensed by winds

Charlie Paton of Seawater Greenhouse developed the technology

Why don’t we design our buildings to collect + manage water?

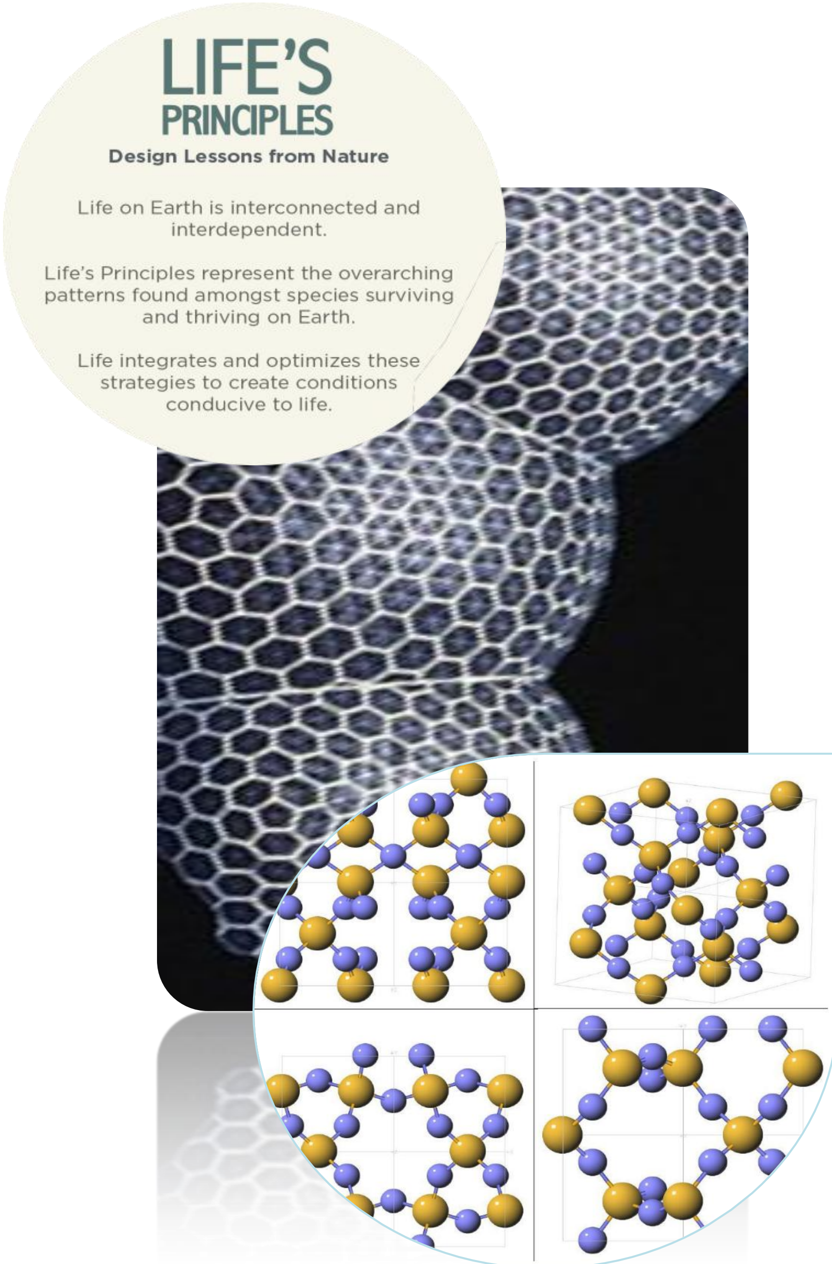
Design possibilities:
Low energy process + materials:

- harvest fresh water from the air, sun, and sea
- offshore breezes blow through a wall of evaporator grilles to create evaporative cooling and desalination



be resource efficient

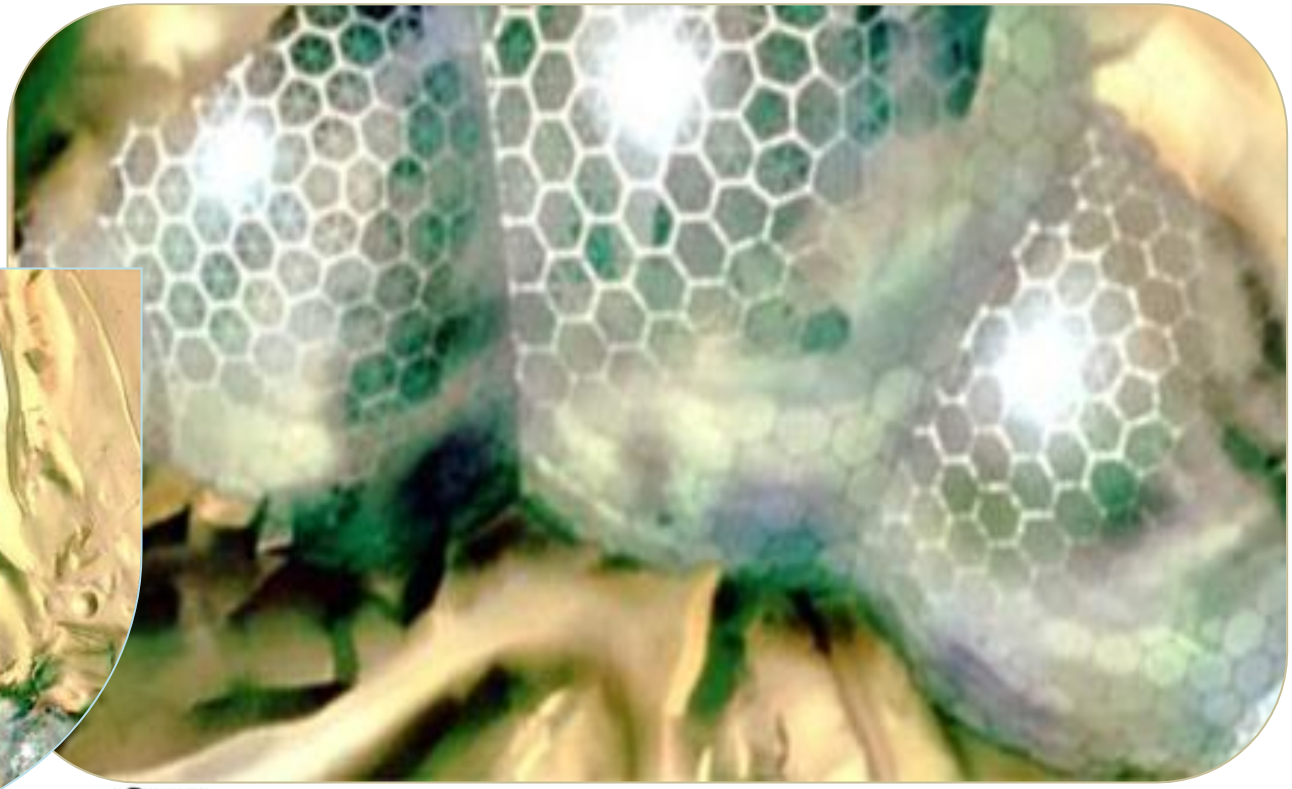
fit form to function

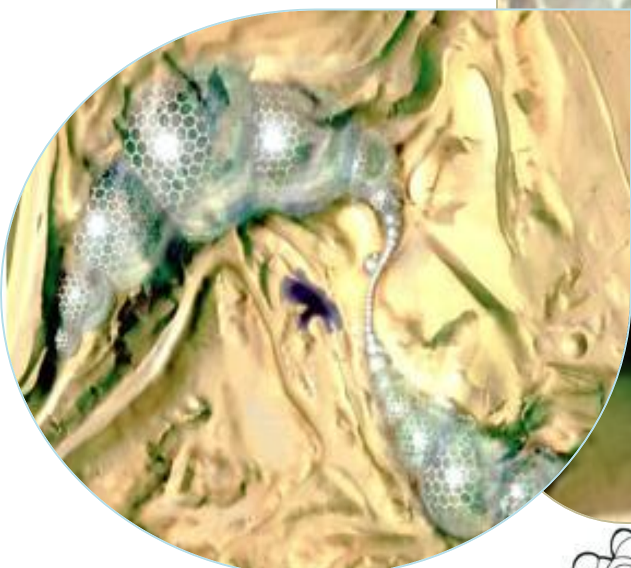


How can cellular structures like pollen dust, radiolarian protozoa, and bubbles inspire the perfect shape for a building to adapt to unknown topography?

Principle: fit form to function

Definition: select for shape or pattern based on need





Biology to design:

"Form Fits Function" is demonstrated by organisms shaped in a way that helps it perform its function(s)

Principle: fit form to function

Definition: select for shape or pattern based on need

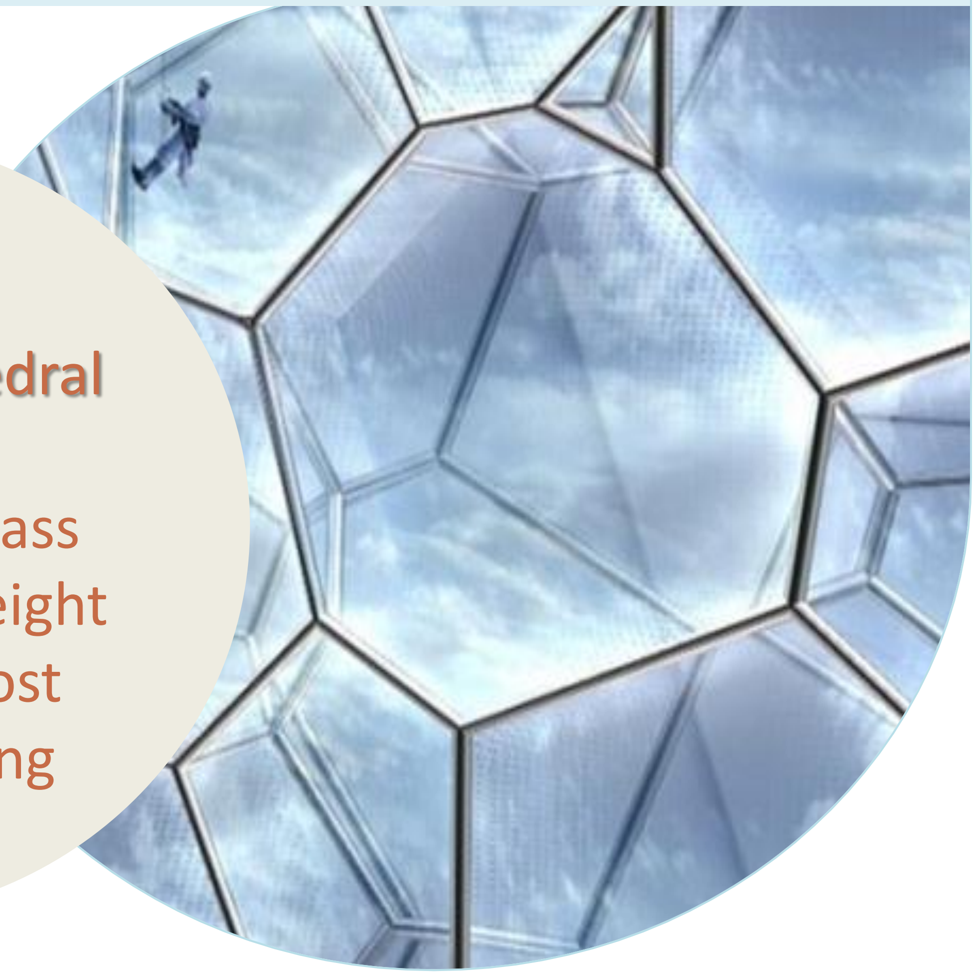
Architectural Example: Eden Project- Grimshaw Architects- Cornwall

The structural shape needed to respond to a china clay pit mine where final ground levels were in flux – mold to fit any landform- high light transmission

Principle: fit form to function

Definition: select for shape or pattern based on need

Architectural Example: Eden Project- Grimshaw Architects- Cornwall



ETFE-
efficient icosahedral membrane

1% weight of glass
400 x its own weight
25-70% less cost
Better insulating

Supremely efficient form enclosed with ETFE-insulated polymer membrane that is 1% the weight of glass- largely self heated - passive solar design

Principle: Be material and energy efficient

Definition: Fit form to function

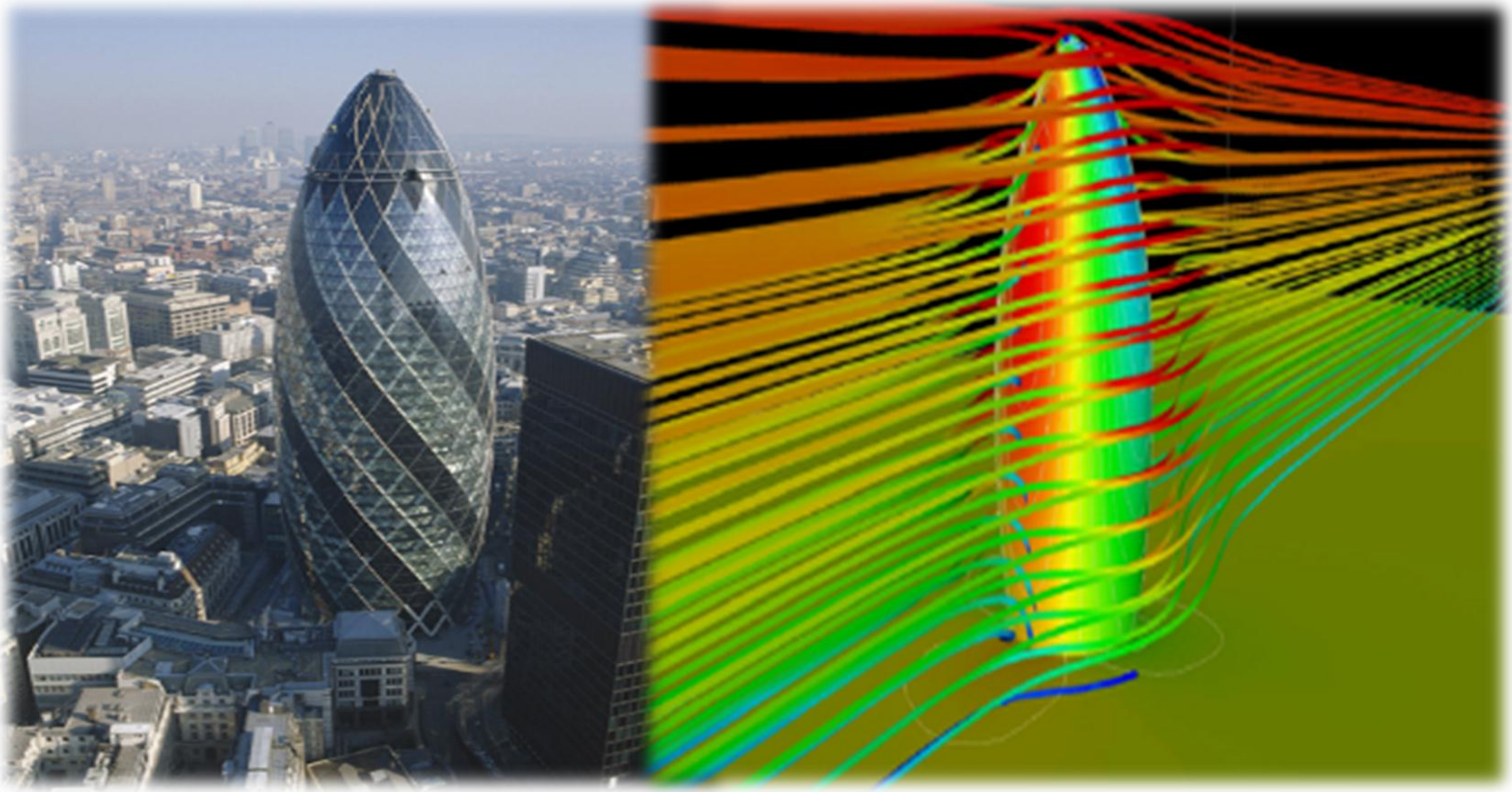
Architectural example: Gherkin Tower- Sir Norman Foster

Sir Norman Foster's Gherkin Tower is very well known- its famous hexagonal skin was inspired by the Venus Flower Basket Sponge

Principle: Be material and energy efficient

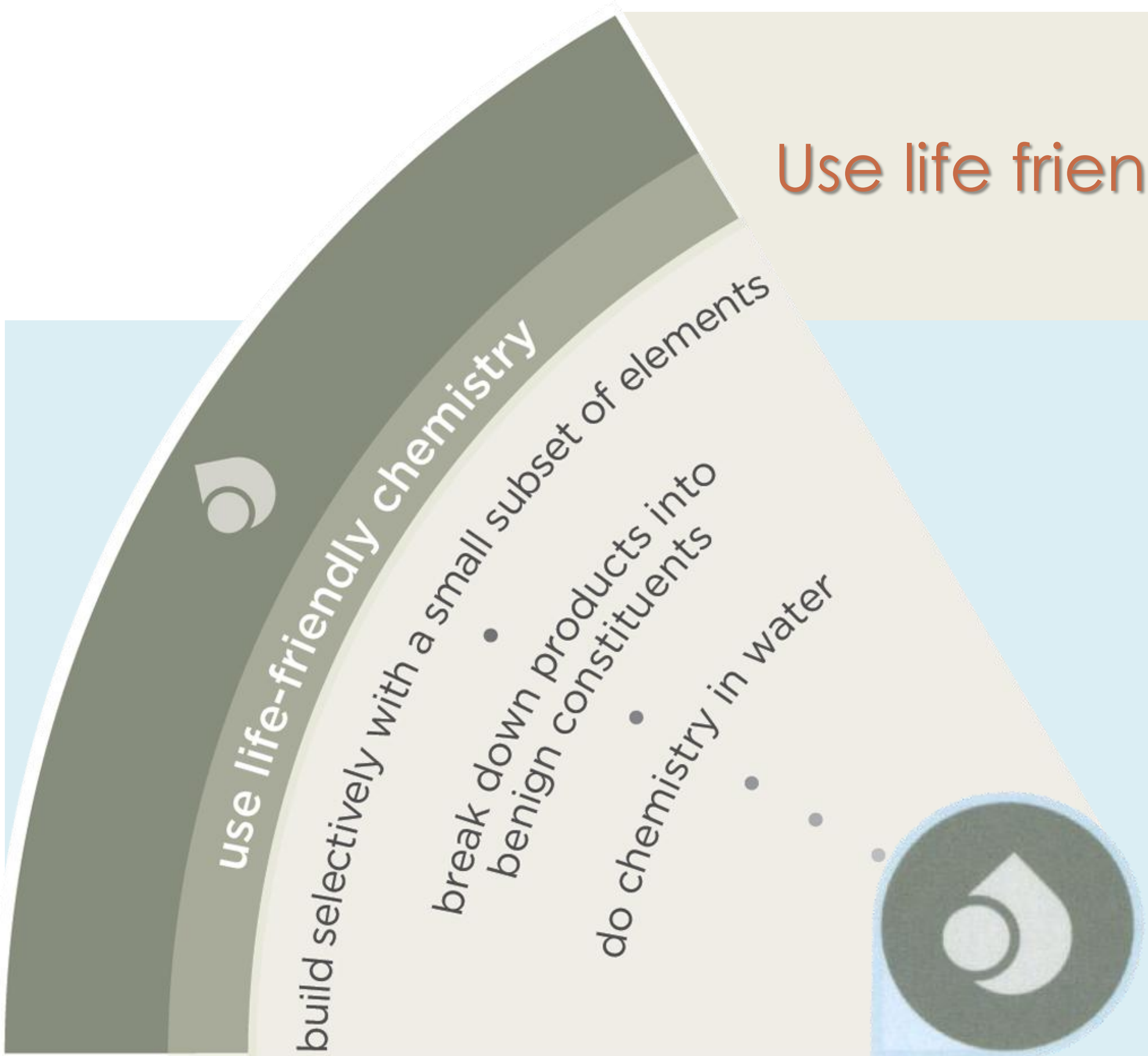
Definition: Fit form to function

Architectural example: Gherkin Tower- Sir Norman Foster



lattice-like exoskeleton helps to disperse stresses on the organism and its shape reduces forces of strong water currents- both of which were applied to Foster's design

Use life friendly chemistry



Build selectively with a small subset of elements

LIFE'S PRINCIPLES

Design Lessons from Nature

Life on Earth is interconnected and interdependent.

Life's Principles represent the overarching patterns found amongst species surviving and thriving on Earth.

Life integrates and optimizes these strategies to create conditions conducive to life.

How do coral reefs and shellfish like abalone inspire concrete building products grown in seawater that can sequester CO2 greenhouse gasses?

Principle: build selectively - small subset of elements

Definition: assemble relatively few elements in elegant ways

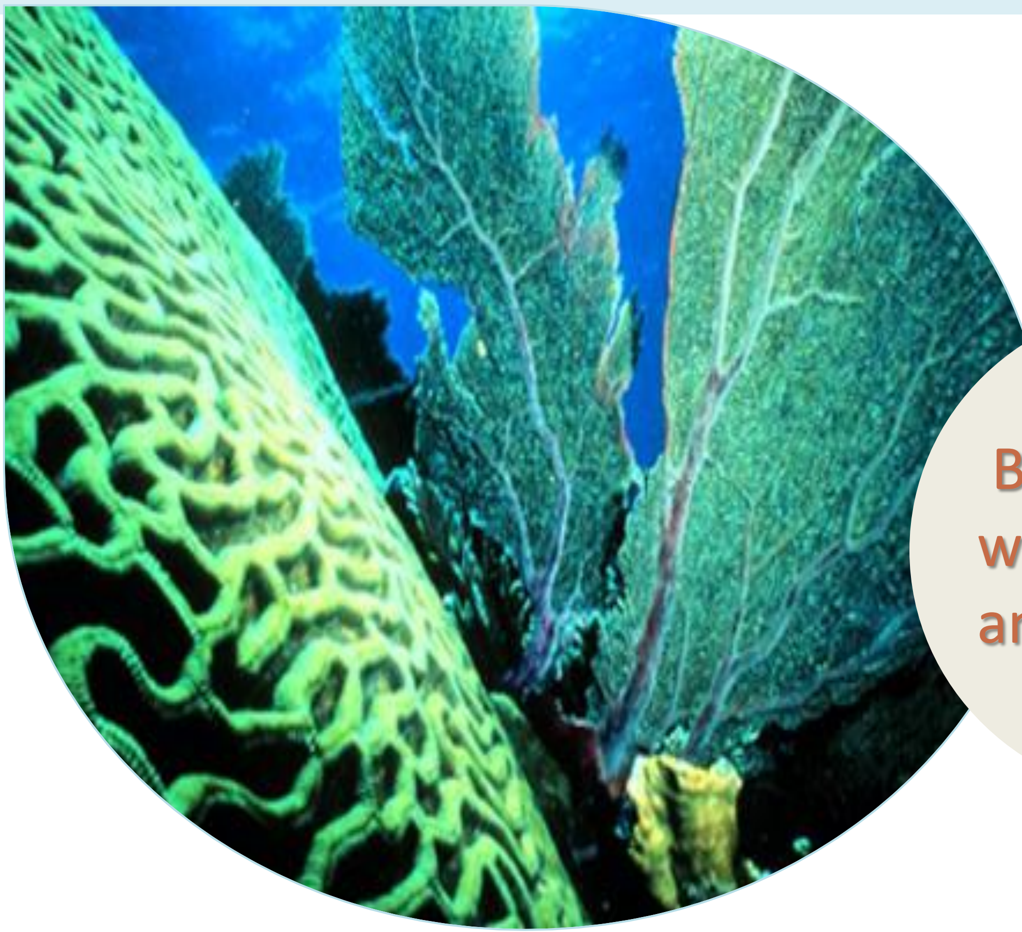
Biological example: coral reefs and shellfish, abalone, oysters

Using the chemistry of a few elements ; calcium carbonate and magnesium - the shell is grown in seawater nourished by sunlight

Principle: build selectively - small subset of elements

Definition: assemble relatively few elements in elegant ways

Biological example: coral reefs and shellfish, abalone, oysters



Built in water with calcium and carbonate

Coral crystallizes out of seawater from algae polyps that secrete calcium carbonate or natural limestone that forms an exoskeleton or shell and grows from this limestone as the algae polyps leave behind structure

Principle: build selectively - small subset of elements

Definition: assemble relatively few elements in elegant ways

Architectural example: Calera cement mimics marine creatures

Calera Cement Process: Flue gas from coal, steel, or natural gas plants plus seawater for calcium & Magnesium = Cement + Clean Water + Cleaner Air + Sequesters CO_2

Principle: build selectively - small subset of elements

Definition: assemble relatively few elements in elegant ways

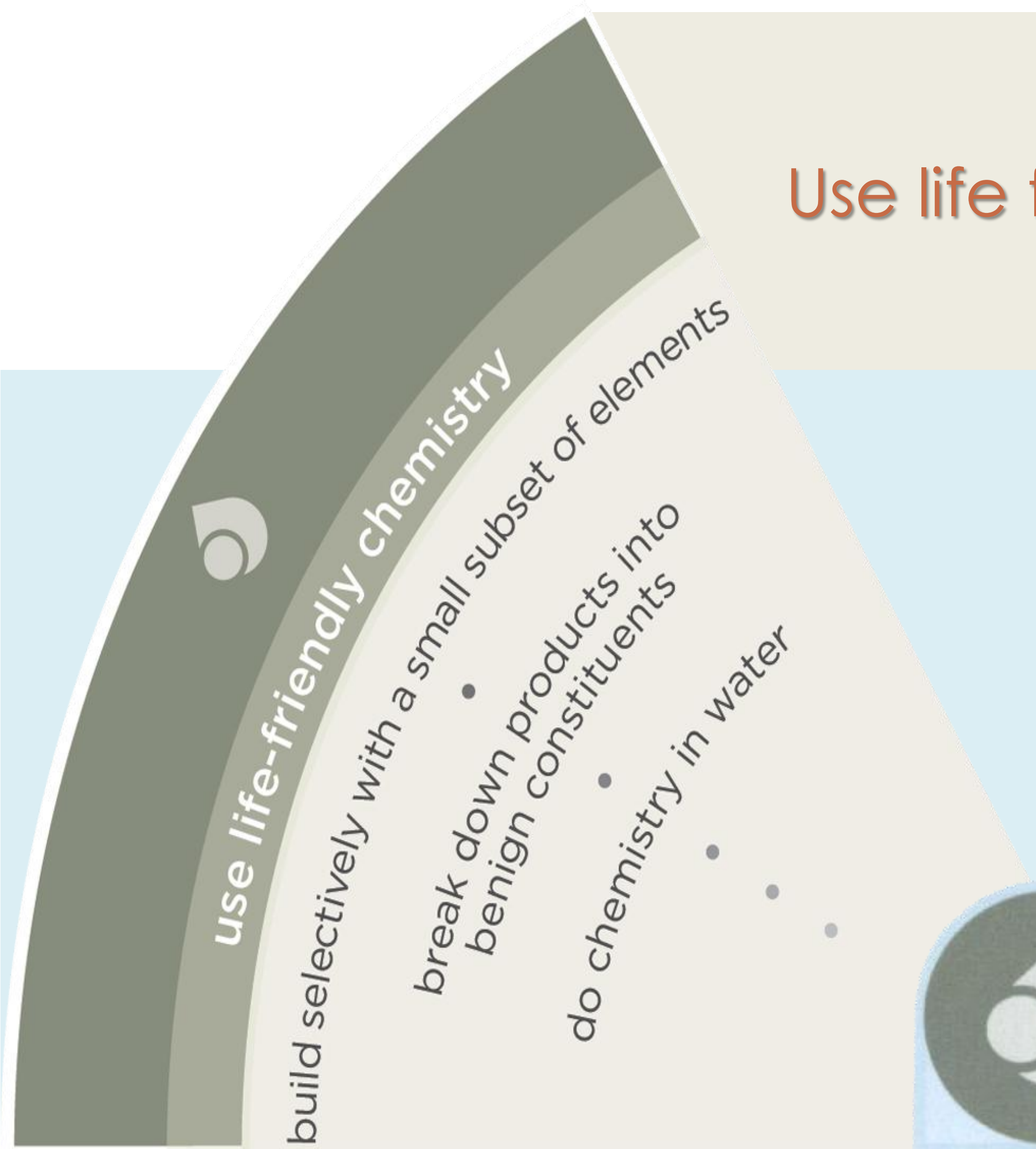
Architectural example: Calera cement mimics marine creatures

Build materials with elements of nature

Low energy electrochemical process [vs. heat, beat and treat] bubbles CO2 emissions through seawater to produce a pre-curser for synthetic concrete

Cement is 3rd largest source of greenhouse gas pollution!

Use life friendly chemistry



Do chemistry in water

Principle: do chemistry in water

Definition: use water as a solvent- non toxic and bio-degradable

Example: non-toxic No VOC adhesives inspired by blue mussels

How does nature adhere? blue mussel creates a unique amino acid that formulates a sticky thread- connecting it to rocks in the ocean- mussel *glue* is created at ambient temperatures , pressures in water

Principle: do chemistry in water

Definition: use water as a solvent- non toxic and bio-degradable

Example: non-toxic No VOC adhesives inspired by oysters

Columbia Forest Products -Pure Bond – emulation - soy-based formaldehyde-free adhesive in hardwood plywood products

Principle: do chemistry in water

Definition: use water as a solvent- non toxic and bio-degradable

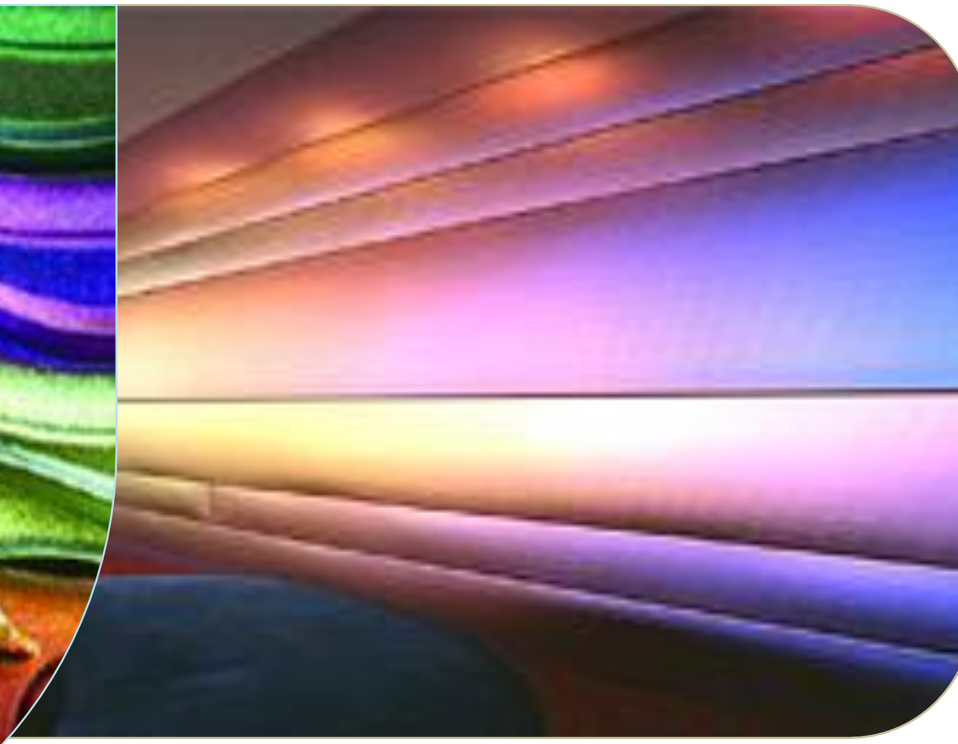
Example: structural color minimizes dyes, pigments, and solvents

Organisms use structural color that makes tropical butterflies, peacocks, and hummingbirds so gorgeous.

Principle: do chemistry in water

Definition: use water as a solvent- non toxic and bio-degradable

Example: structural color minimizes dyes, pigments, and solvents



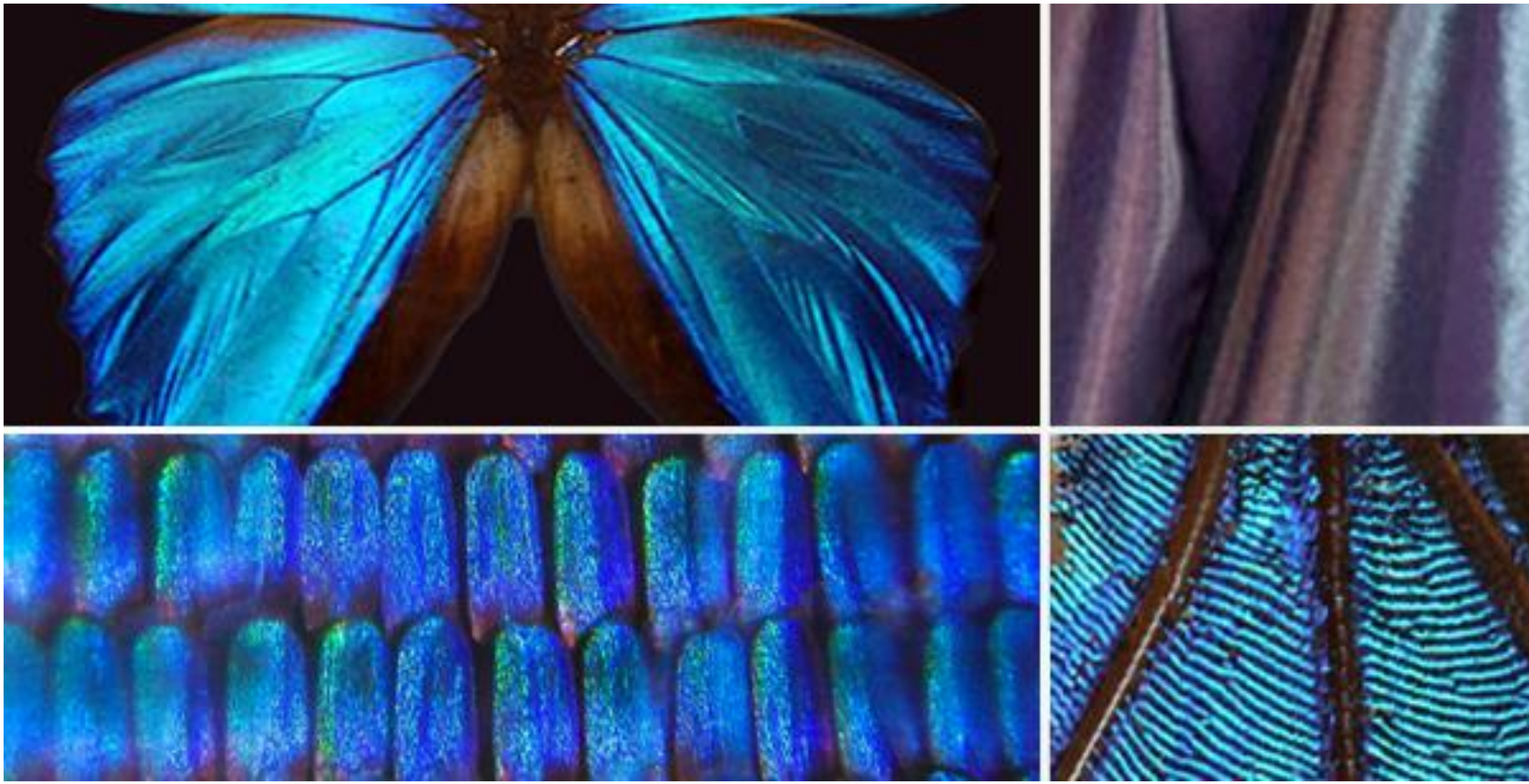
JDSU Color Shift light-interference and light-diffractive pigments made of magnesium fluoride coated aluminum pigment

Spectra Flair® pigments- Micro flakes- optical thin film technology

Principle: do chemistry in water

Definition: use water as a solvent- non toxic and bio-degradable

Example: structural color minimizes dyes, pigments, and solvents



Morpho butterfly scales are layers of proteins that refract light in different ways- play of light on nanostructures-creates color

Teijin Fibers Limited of Japan – Morphotex ® fibers

Principle: do chemistry in water

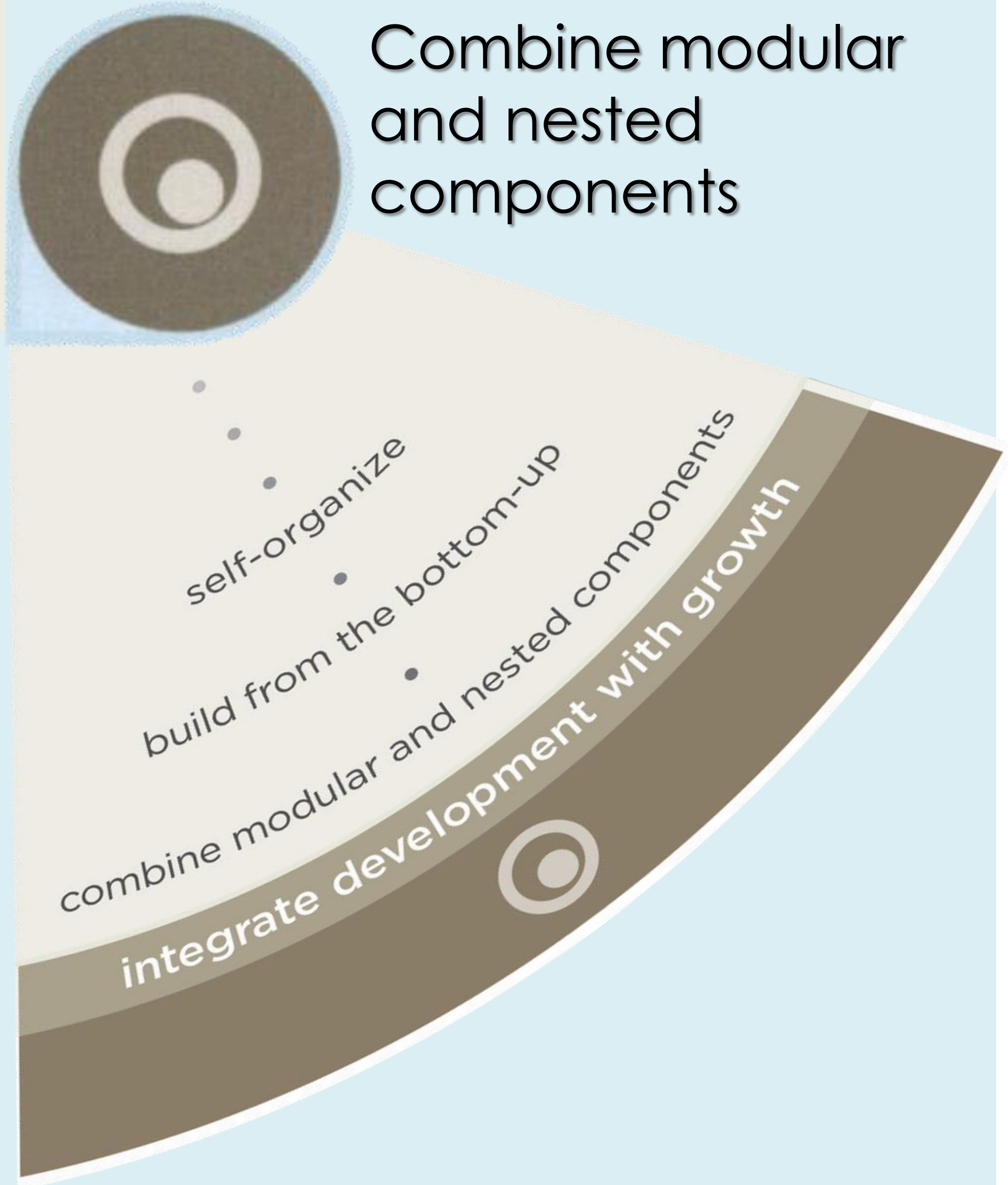
Definition: use water as a solvent- non toxic and bio-degradable

Example: structural color minimizes dyes, pigments, and solvents

Iridigm in San Francisco used structural color ideas from tropical butterflies to create a PDA screen that can be easily read in sunlight.

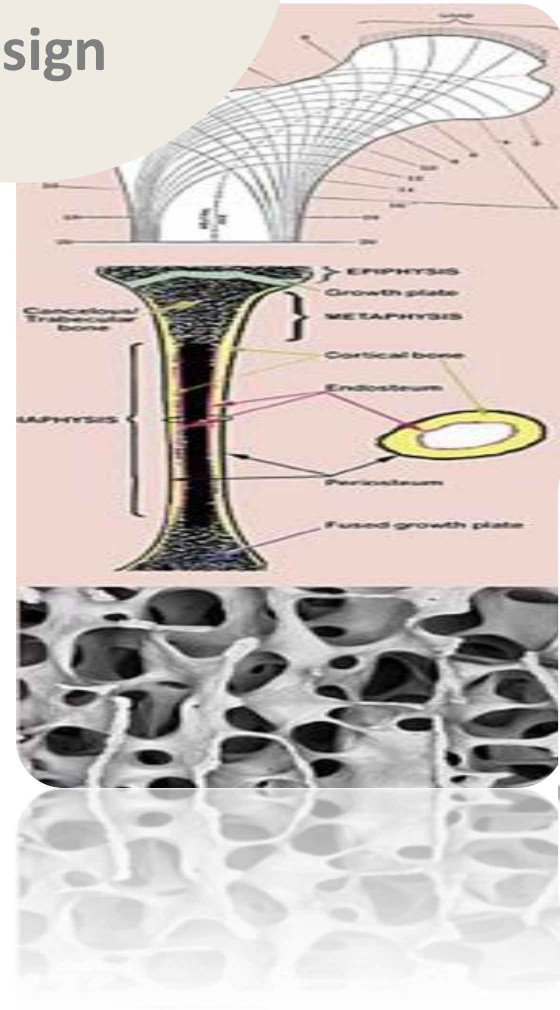
Integrate development with growth

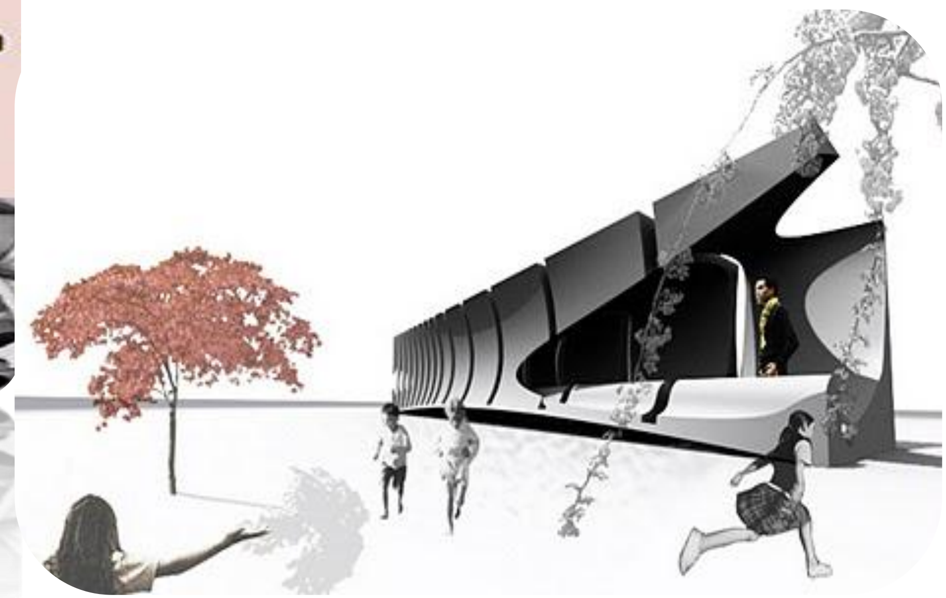
Combine modular and nested components



Performance based structural design

How can the human skeleton inspire a structural system for seismic adaptation that integrates performance based design?





Principle: Integrate development with growth

Definition: Combine modular and nested components

Biological : human bone and tendon structural system

Many bones are supported internally by a latticework of trabeculae [Latin: "little beams“]

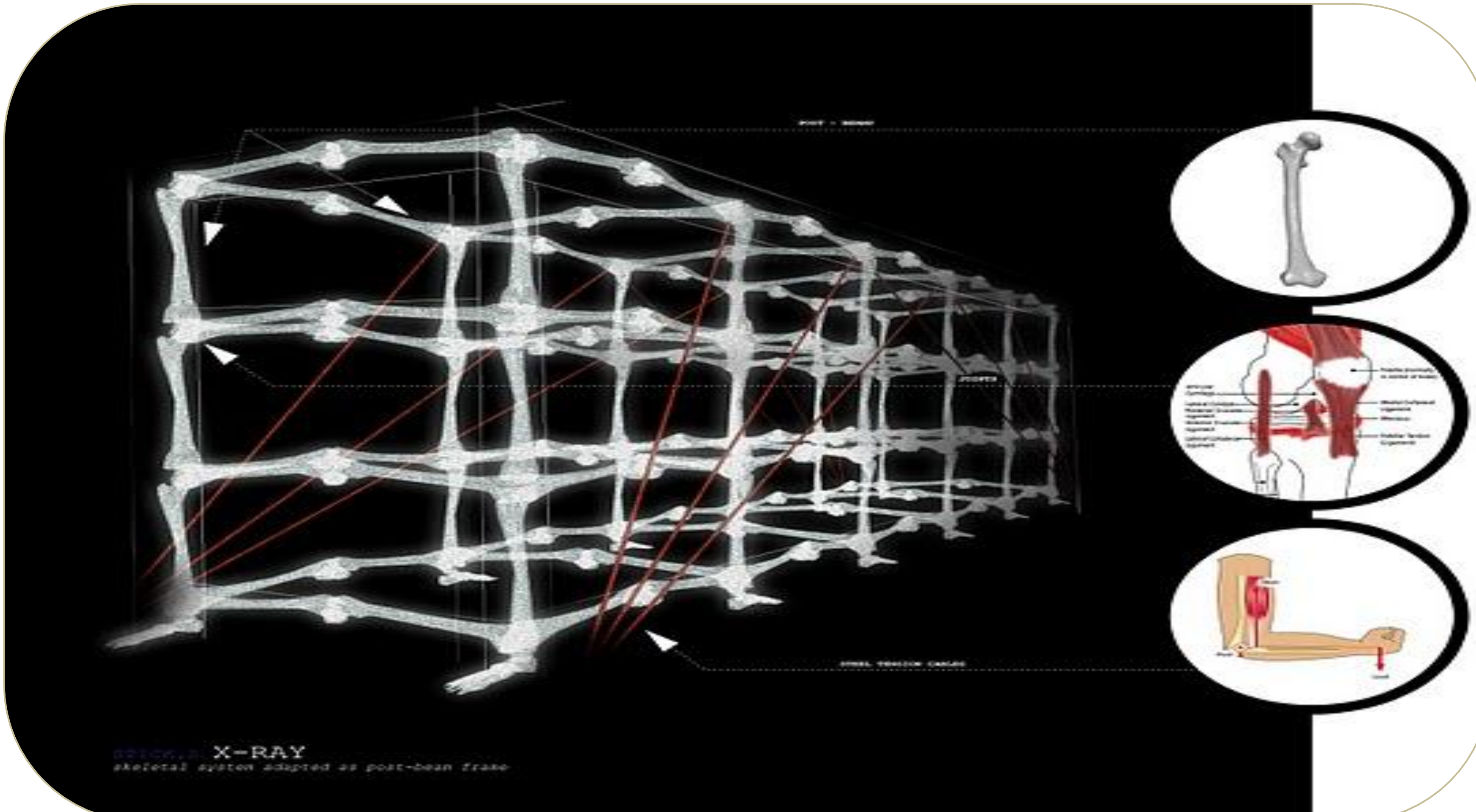
bone +tendon system both modular and nested- more resource efficient structure - puts mass where it is needed for seismic loads

Based on Wolff’s Law solution of Bone Morphology

Principle: Integrate development with growth

Definition: Combine modular and nested components

Biological : human bone and tendon structural system

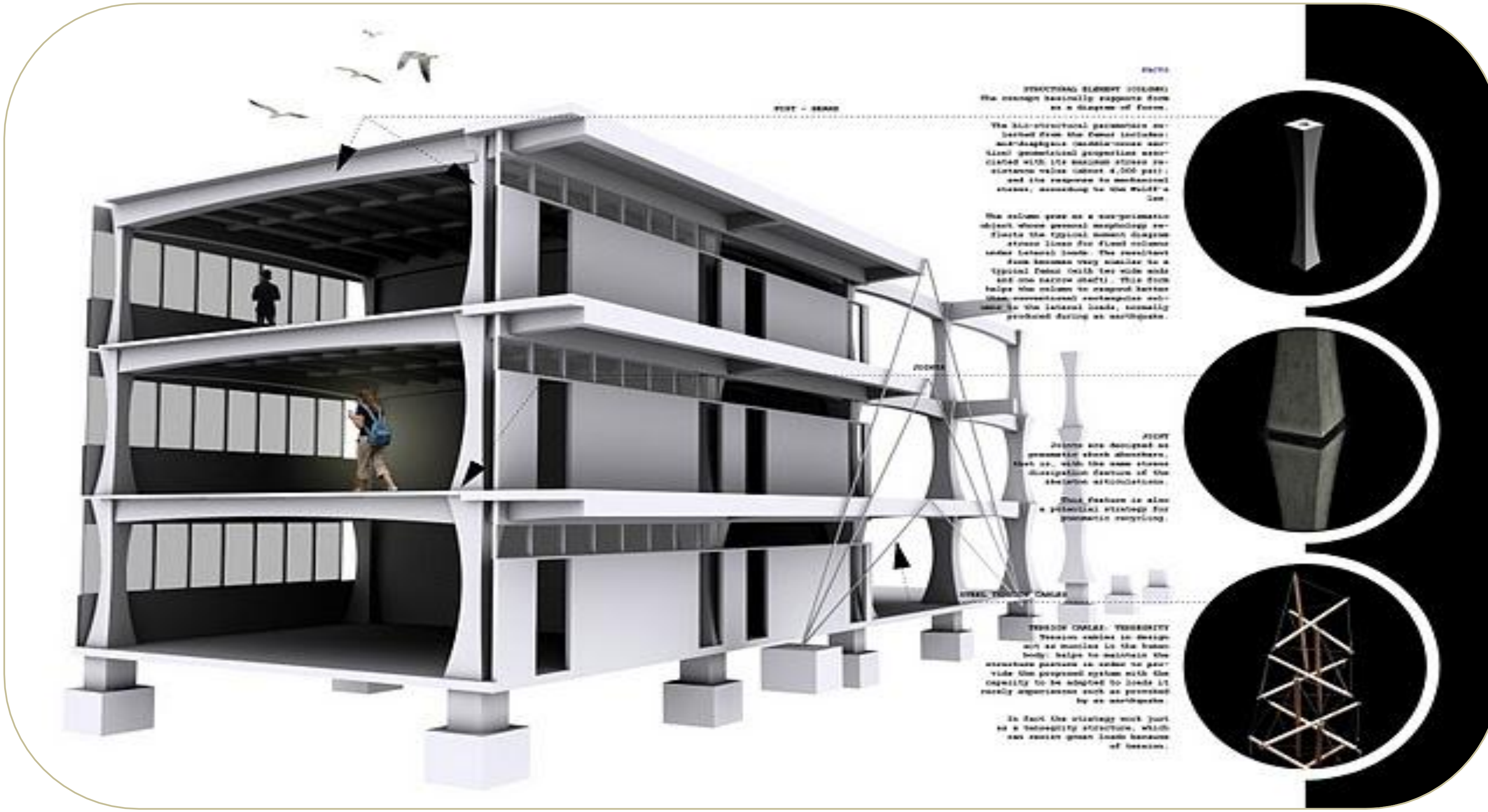


STICK.S mimics the bone morphology to minimize material use

Principle: Integrate development with growth

Definition: Combine modular and nested components

Architectural example: STICK.S TECTONICA structural system



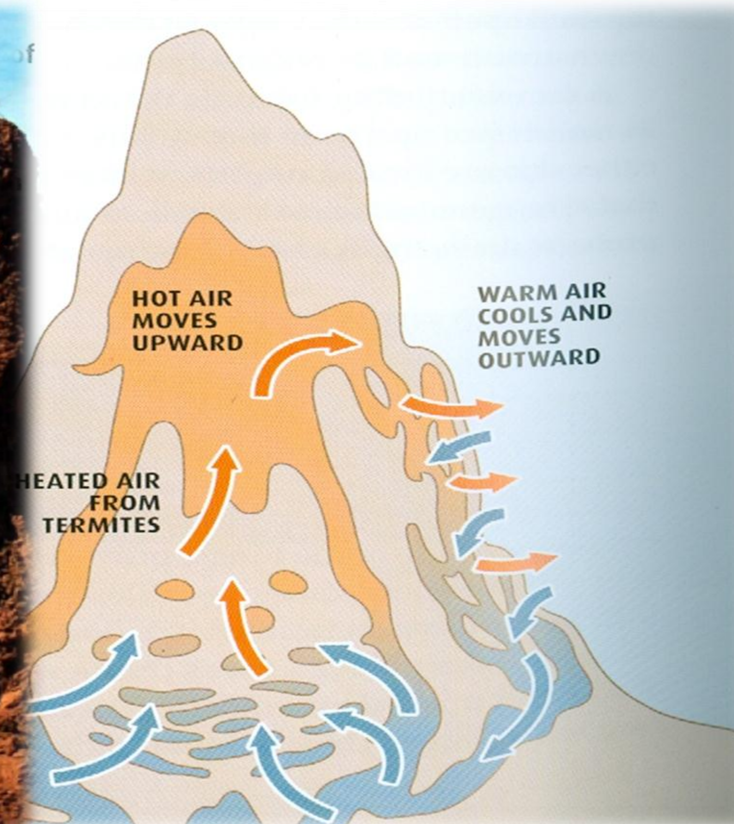
Puerto Rican Architect, Wilfredo Mendez subtracts up to 30% of the concrete use for each component -Special Moment Resisting Frame

How can buildings learn from organisms that practice heat exchange and leverage cyclic processes of sun and earth to heat and cool?

Principle: locally attuned + responsive

Definition: use readily available materials and energy

Biological : termite mound-driving heat regulation with rising hot air



termite mound - insects create heat –moves up through central vertical channels and dissipates outwards and down illustrating thermal buoyancy - free convection loop -heat regulation - 87 degrees- natural air conditioning by termite standards

Principle: locally attuned and responsive

Definition: use readily available materials and energy

Eastgate Centre Office Building, Zimbabwe - Mike Pierce + Arup

Passive cooling chimneys and floor slabs -self-regulating ventilation design uses 90% less energy to heat and cool and saved 10% on initial costs by not purchasing air conditioning system

Use readily available materials + energy

Be locally attuned + responsive

How does photosynthesis energy processes of green leaves and the piezoelectric energy response of eels can inform a hybrid energy collection system for buildings?

Principle: locally attuned and responsive

Definition: readily available materials + energy

Biological example: photosynthesis in leaves and leaf movement

the electric eel has three abdominal pairs of organs made of electrocytes where current flows through producing piezoelectric electricity

Principle: locally attuned and responsive

Definition: readily available materials + energy

Architectural product example: GROW Solar Ivy

SMIT Co. in Brooklyn, NY GROW Solar Ivy: due to its light weight - 4 x7 foot strip of Solar Ivy is capable of generating 85 watts of solar power.

Principle: locally attuned and responsive

Definition: readily available materials + energy

Architectural product example: GROW Solar Ivy

Left: Concept design of Solar Ivy on a home.

Below: Solar Ivy prototype up close. Cells can be any colour.

layer of thin-film material on top of recycled polyethylene on the "front" of the leaves-PVs capture sunlight and generate electricity on the back side are piezoelectric generators that generate power from leaf movement in the wind

Adapt to change

Embody resilience: through variation, redundancy and decentralization

How could a touch sensitive plant inspire a dynamic solar shading system for buildings?

Principle: Adapt to change

Definition: Embody resilience, redundancy+ decentralization

Biological example: thigmomorpho-genesis touching response

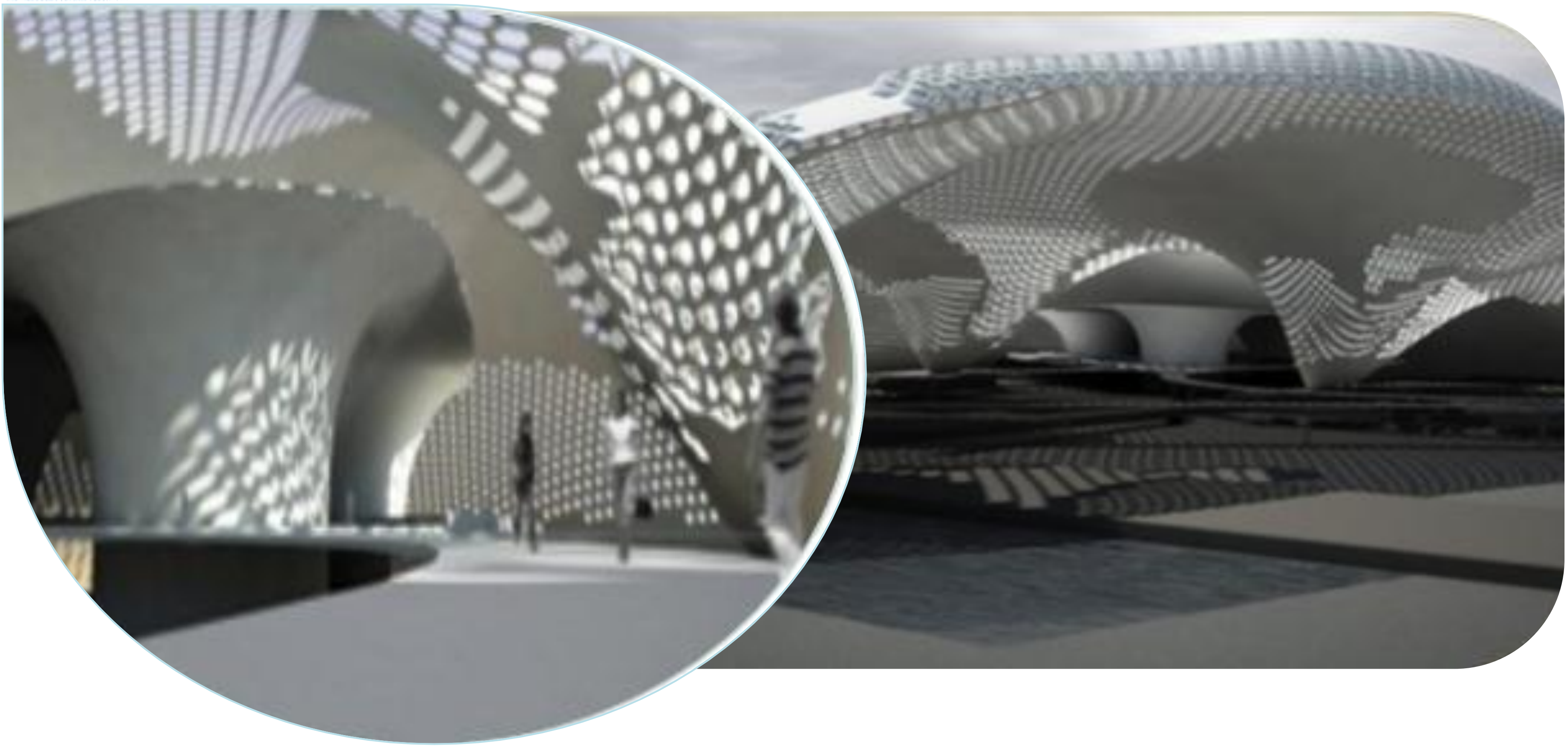
Wall cress responds to touch calmodulin protein triggers biochemical reaction causing it to turn away from the wind

Thigmomorpho-genesis is plant response to mechanical sensation (touch) by altering their growth due to wind, rain, touch of animals

Principle: Adapt to change

Definition: Embody resilience, redundancy+ decentralization

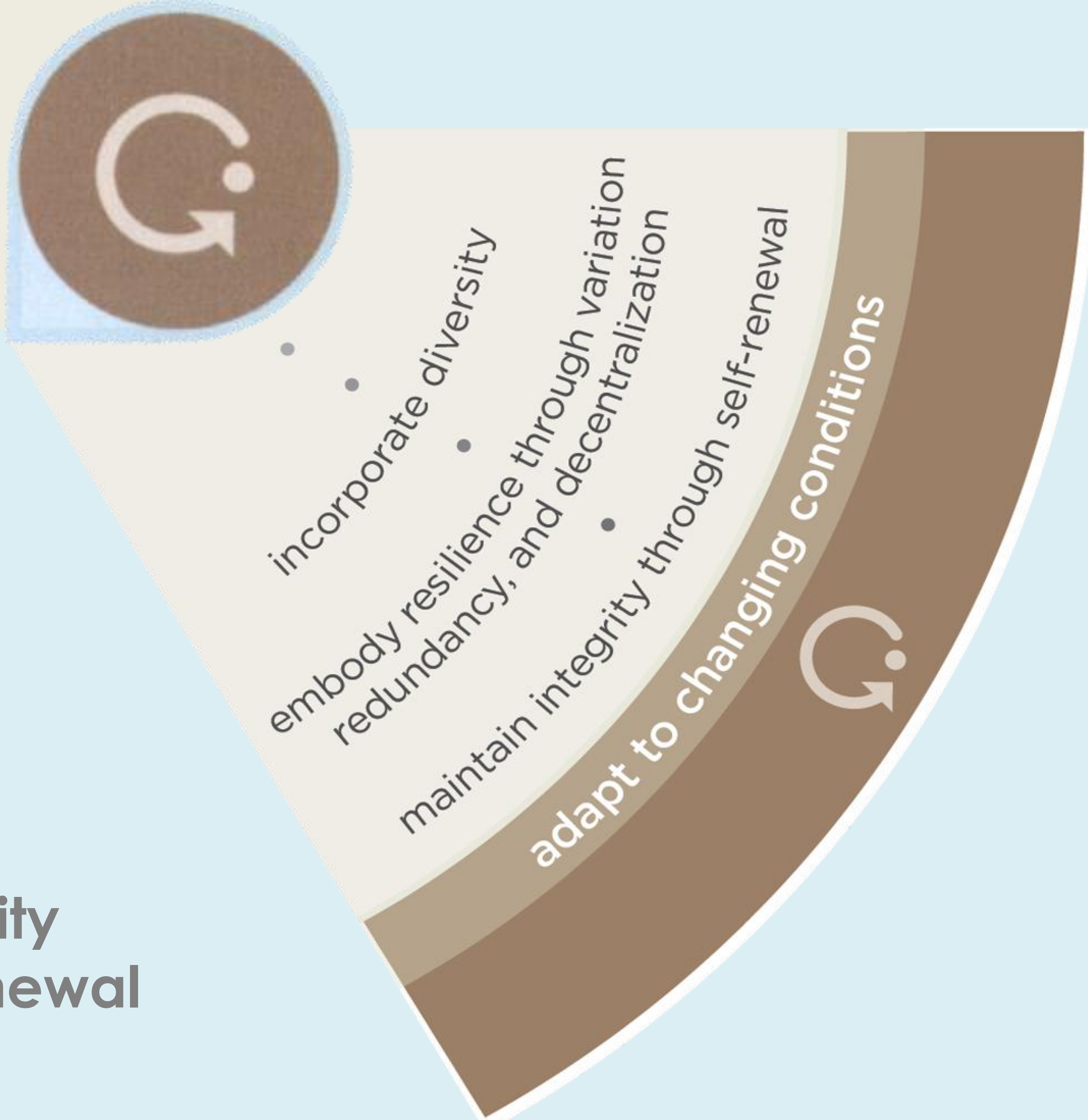
example: thigmomorpho-genesis solar shading response



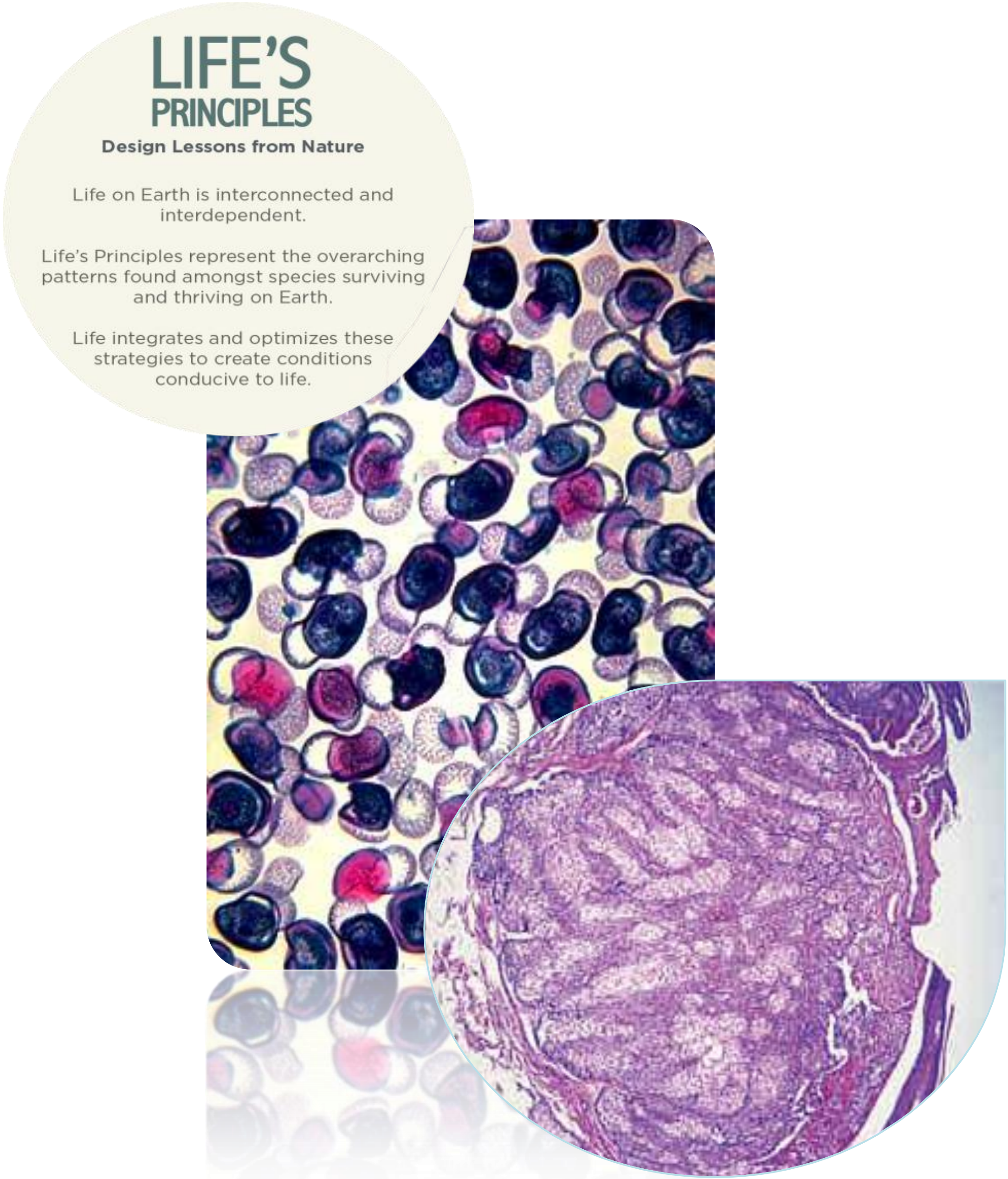
Emulate self-organization processes in nature with a fiber composite that can sense, actuate and efficiently adapt to changing environmental inputs -

Create dynamic solar facades such as strong wind, solar shading + structural forces

Adapt to change



Maintain integrity through self renewal



Algorithmic simulations

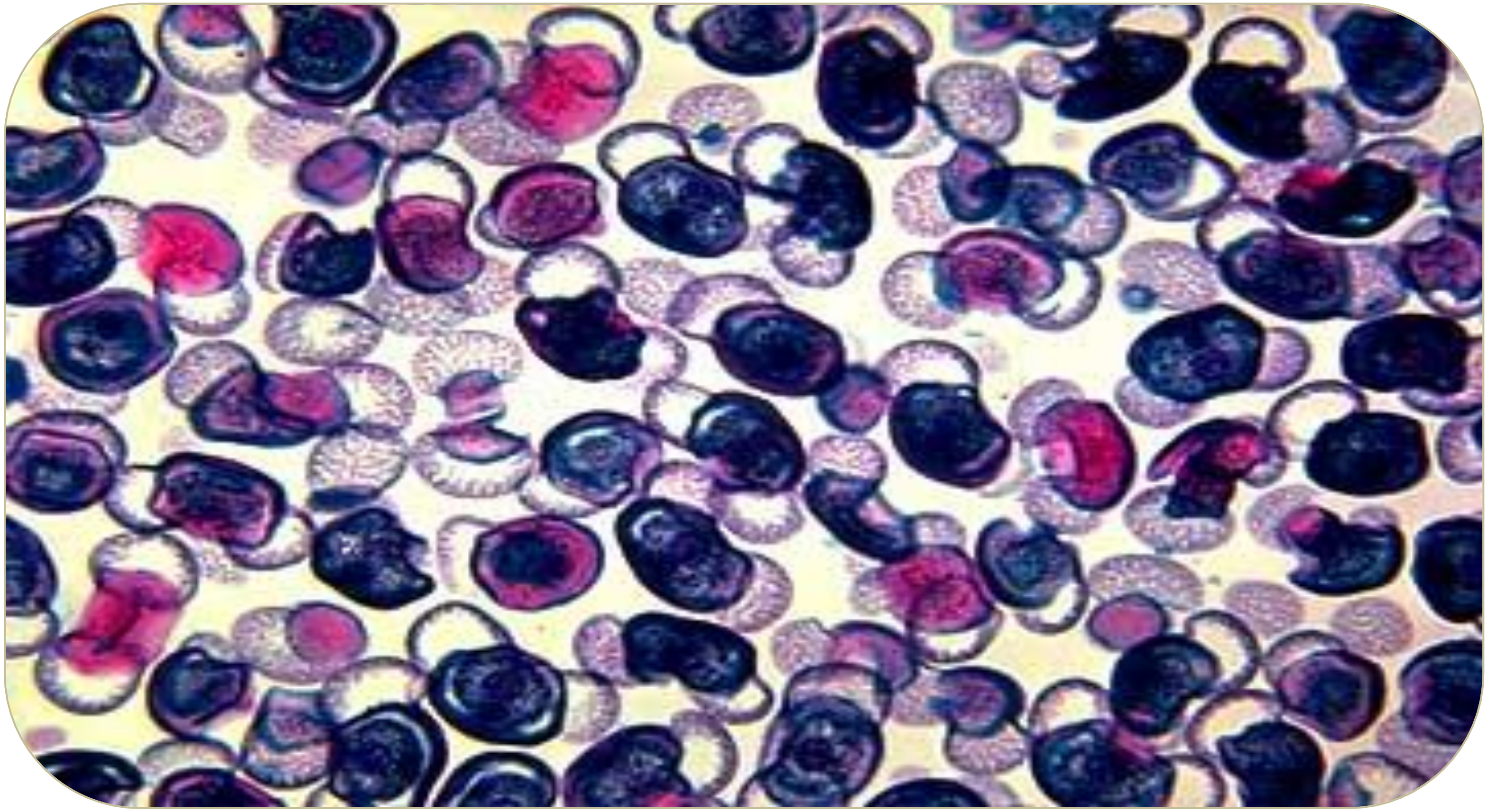
of natural cell growth patterns lead to self renewing

"generative design"

Principle: Adapt to change

Definition: Maintain integrity through self renewal

Biological example: generative cell growth



The generative cell growth of a pine cone has a more regular pattern

How can we generate the appropriate structures to support an architecture of life ?

Principle: Adapt to change

Definition: Maintain integrity through self renewal

Architectural example: Generative Computational Design

will generative computational design lead us back to natural form ?

New technology allows designers + architects to harness computational powers to generate building design options that couldn't otherwise exist

Principle: Adapt to change

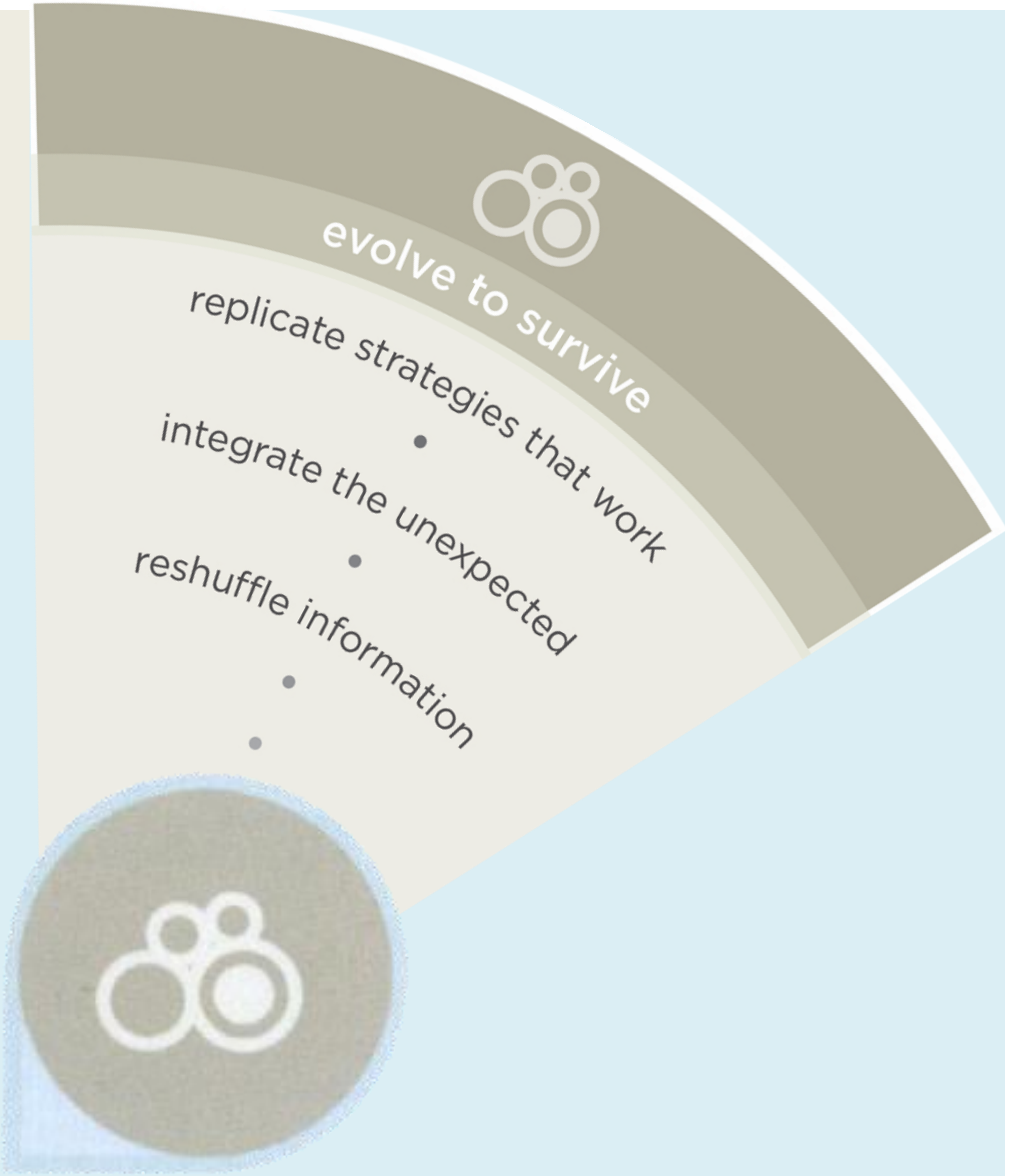
Definition: Maintain integrity through self renewal

Architectural example: Generative Computational Design

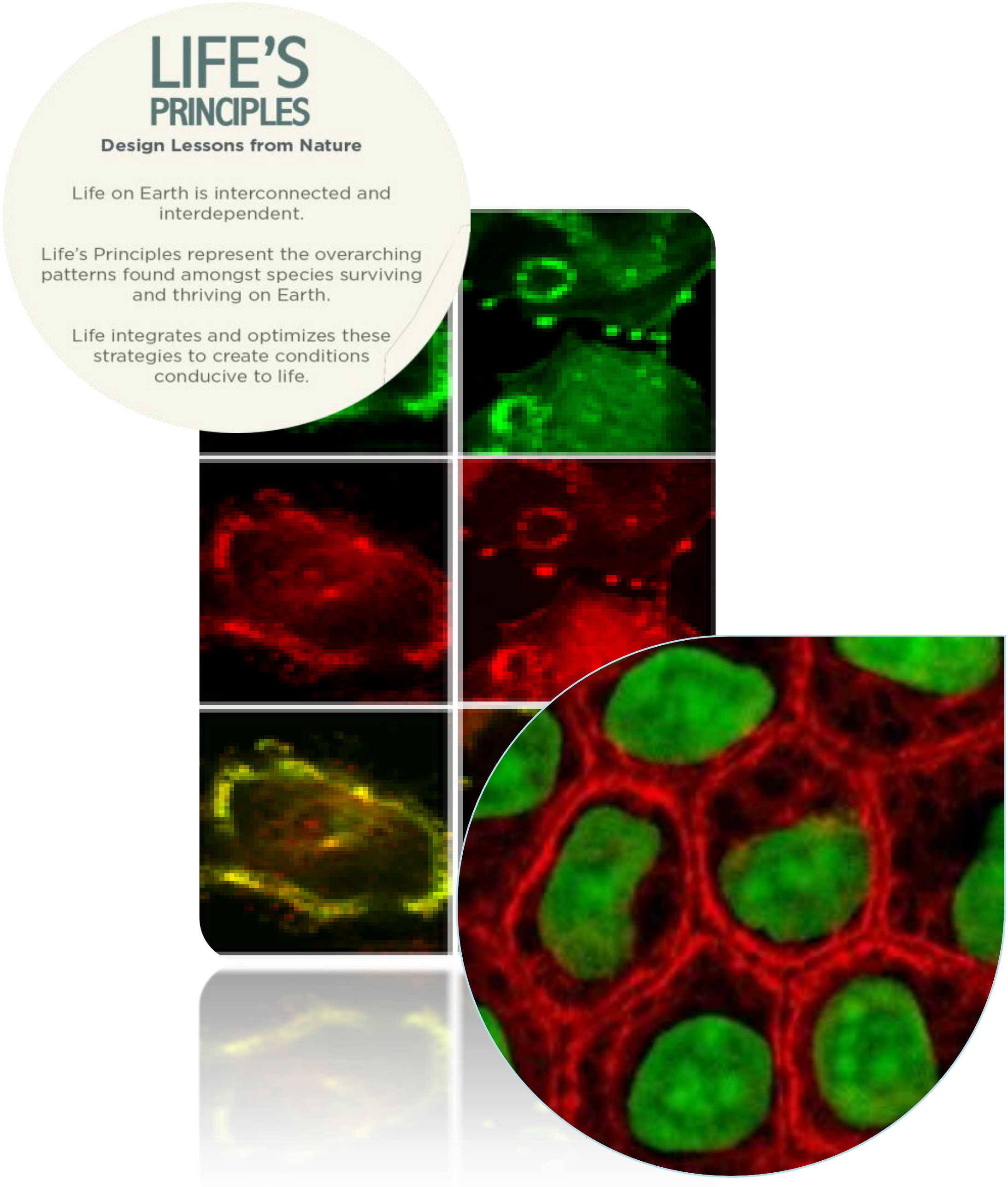
Generative design is not about designing a building ,“ says Lars Hesselgren "It's about designing the system that designs a building."

Hesselgren is director of research at Kohn Pedersen Fox Associates International design studio + founder of “Smart Geometry”

Evolve to survive



Integrate the unexpected

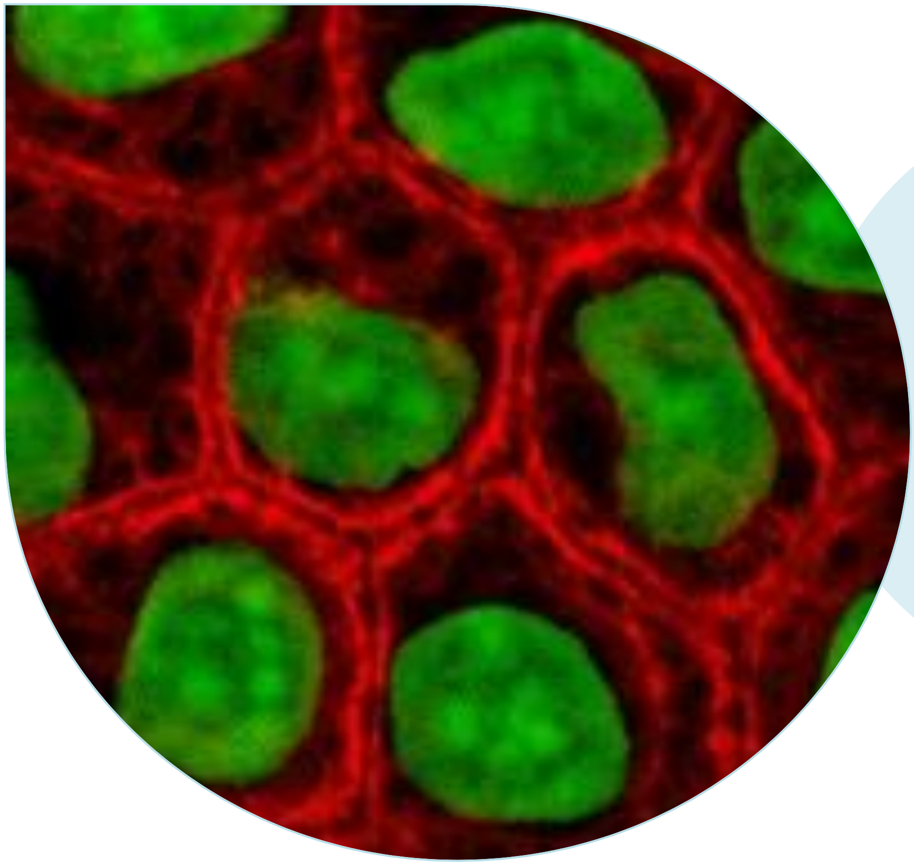


How can the unexpected aspect of response to nature be integrated in architecture?

Principle: Evolve to survive

Definition: Integrate the unexpected

Example: cancer cell behavior and adaptations



Cellular adaptation to toxicity

Many cells adapt to toxicity- how can designers model algorithms to model changes in real time in order to develop materials with the flexibility and adaptively of human cells ?

Principle: Evolve to survive

Definition: Integrate the unexpected

U Penn School of Medicine, Engineering, Applied Sciences

Future adaptive building skins and sensors

Architectural problem: the inability of buildings to adapt to changing external conditions and lack of resiliency and energy waste

Buildings need to evolve to survive – to become Smart Buildings

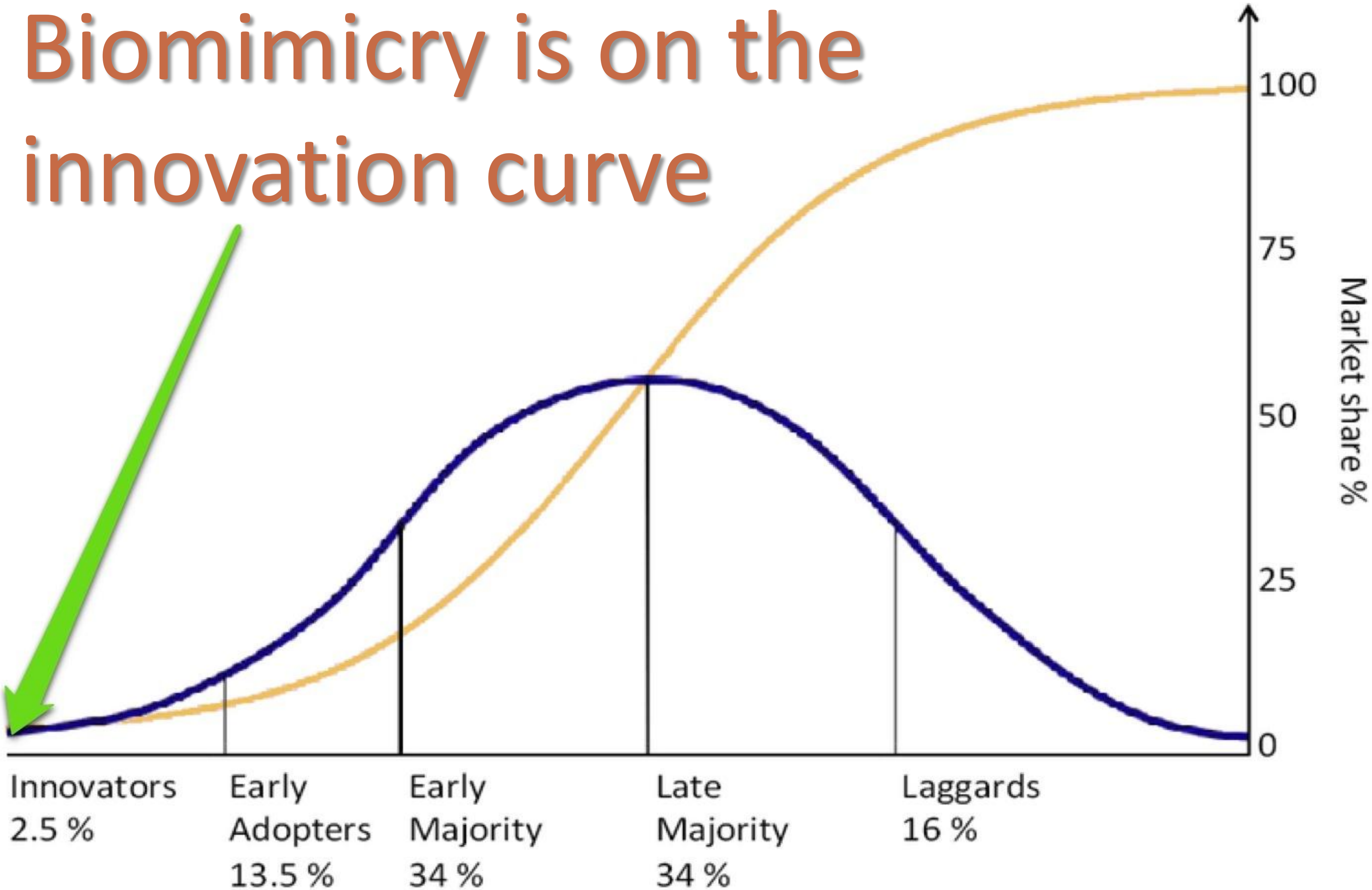
Principle: Evolve to survive

Definition: Integrate the unexpected

Architectural example: e-Skin- Penn Design

Expect the unexpected with e Skin – a proposed adaptive building skin that incorporates sensors and feedback loops to generate characteristics of a more efficient building envelope and comfortable interior

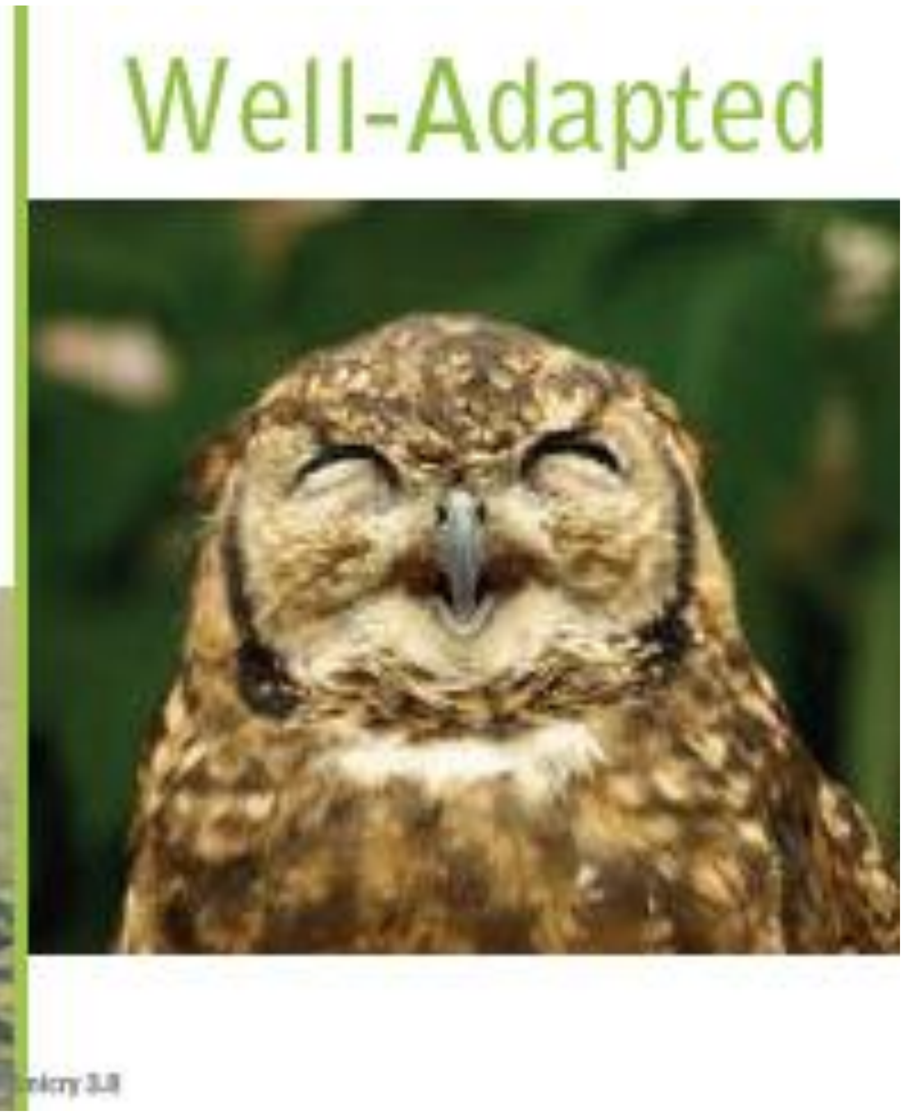
Biomimicry is on the innovation curve



Why should we care?

How can we not care?

Nature has 3.8 billion years of design genius



What will you design with nature's genius?

BIOMIMICRY 3.8

Further Resources

www.asknature.org

BIOMIMICRY 3.8

Further Resources

www.biomimicry.net

Bringing together scientists, engineers, architects, and other innovators to create sustainable technologies and business practices

- Online Introductory Courses
- 1- 3 Day Backyard Workshops
- 10 day excursions - Mexico, Costa Rica, South Africa
- 8 Month Biomimicry Specialist Programs
- 2 year Biomimicry Professional Programs
- BaDT Program -Biologist at the Design Table

Further Resources

BIOMIMICRY NYC

OUR MISSION

Biomimicry NYC is the leading regional network of individuals from all industries, sectors and backgrounds dedicated to fostering a community of biomimicry practice in the New York City metro region.

OUR VISION

BNYC envisions a city mentored and inspired by nature's genius, where private and public decision making asks, "does this create conditions conducive to life?"

CONNECT

http://biomimicrynyc.com

Further Resources

Tuesday, March 5, 2012 (9am - 5pm)
NESEA Building Energy 13 (www.nesea.org)
Seaport World Trade Center, Boston, MA

BUILDINGENERGY 13

Biomimicry in Action Workshop:
Applying Nature's Principles for Resilient Design

Further Resources

contact: songayla@sunyulster.edu call : 845 687 5012

Further Resources

BIOMIMICRY 3.8

www.biomimicry.net

USGBC- Urban Green Council is a registered provider with The American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members are available upon request.

This program is pending with the AIA/CES for continuing professional education. As such, it does not include content that be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Thank you - Questions?