Learning from nature:

biomimicry in nanotechnology education

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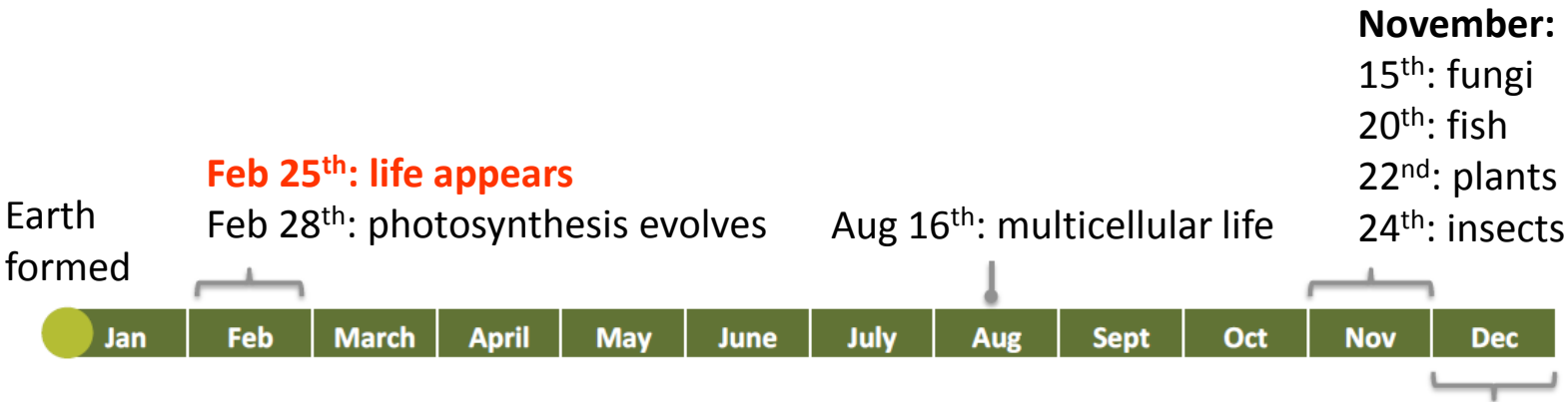
A bit of perspective

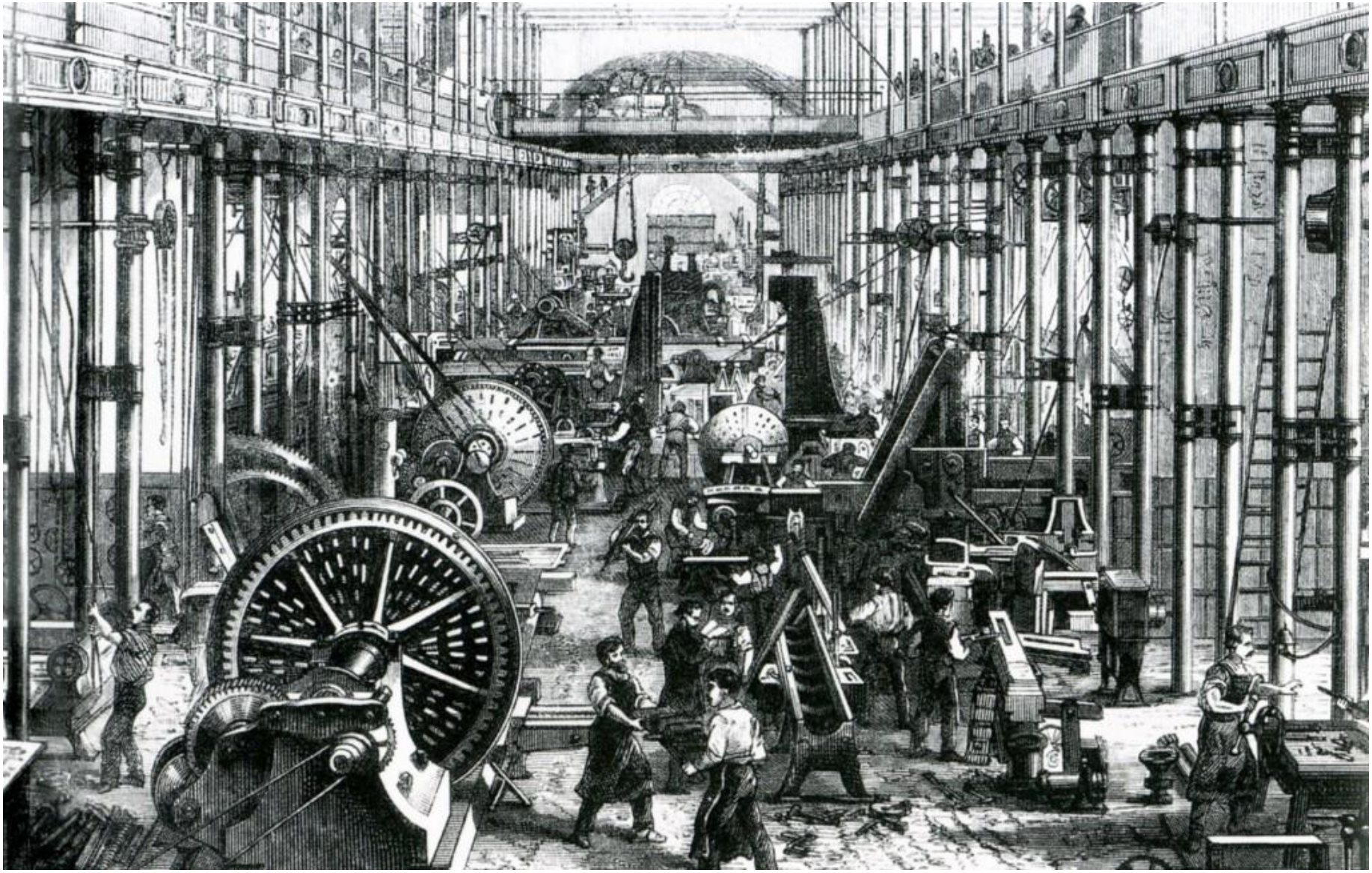


December 31st:
11:00: hominids walk
23:36: homo sapiens
23:59: agriculture
23:59:58: industrial revolution

All of human history would take place in the last half hour of the last day.

The industrial revolution would take place in the last two seconds of the year.

Industrial revolution: heat, beat, and treat



A brute force way to make cement

Mining calcium carbonate with explosives

Heating to over 1600 °C and releasing 6% of GHG

An elegant way to make cement

Assembling calcium carbonate from bicarbonate (from CO_2) and calcium in sea water

Low energy
Low temperature
Low waste

3.8 billion years of product design, testing, and refining

“The conscious emulation of life’s genius is a survival strategy for the human race, a path to a sustainable future. The more our world functions like the natural world, the more likely we are to endure on this home that is ours, but not ours alone.”

Janine Benyus

Co-founder of Biomimicry 3.8

biomimicry

/bʌɪəʊˈmɪmɪkri/

noun

the design and production of materials, structures, processes, and systems that emulate biological entities;

or

the conscious emulation of nature’s genius.

Instead of asking “What can we *extract* from the natural world?”

Let’s shift towards “What can we *learn* from the natural world?”

“How do we make the act of asking nature’s advice a normal part of everyday inventing?”

Janine Benyus

Roadmap for biomimicry education

1. Go outside and observe
2. Learn basic concepts of biomimcry
3. Talk to and collaborate with biologists and ecologists
4. Practice applying biomimicry and making decisions

1. Go outside and observe

"Four days of immersion in nature, and the corresponding disconnection from multi-media and technology, increases performance on a creative problem-solving task by a full 50%."

[*Creativity in the Wild: Improving Creative Reasoning through Immersion in Natural Settings* (2012) by Ruth Ann Atchley, David L. Strayer, and Paul Atchley]

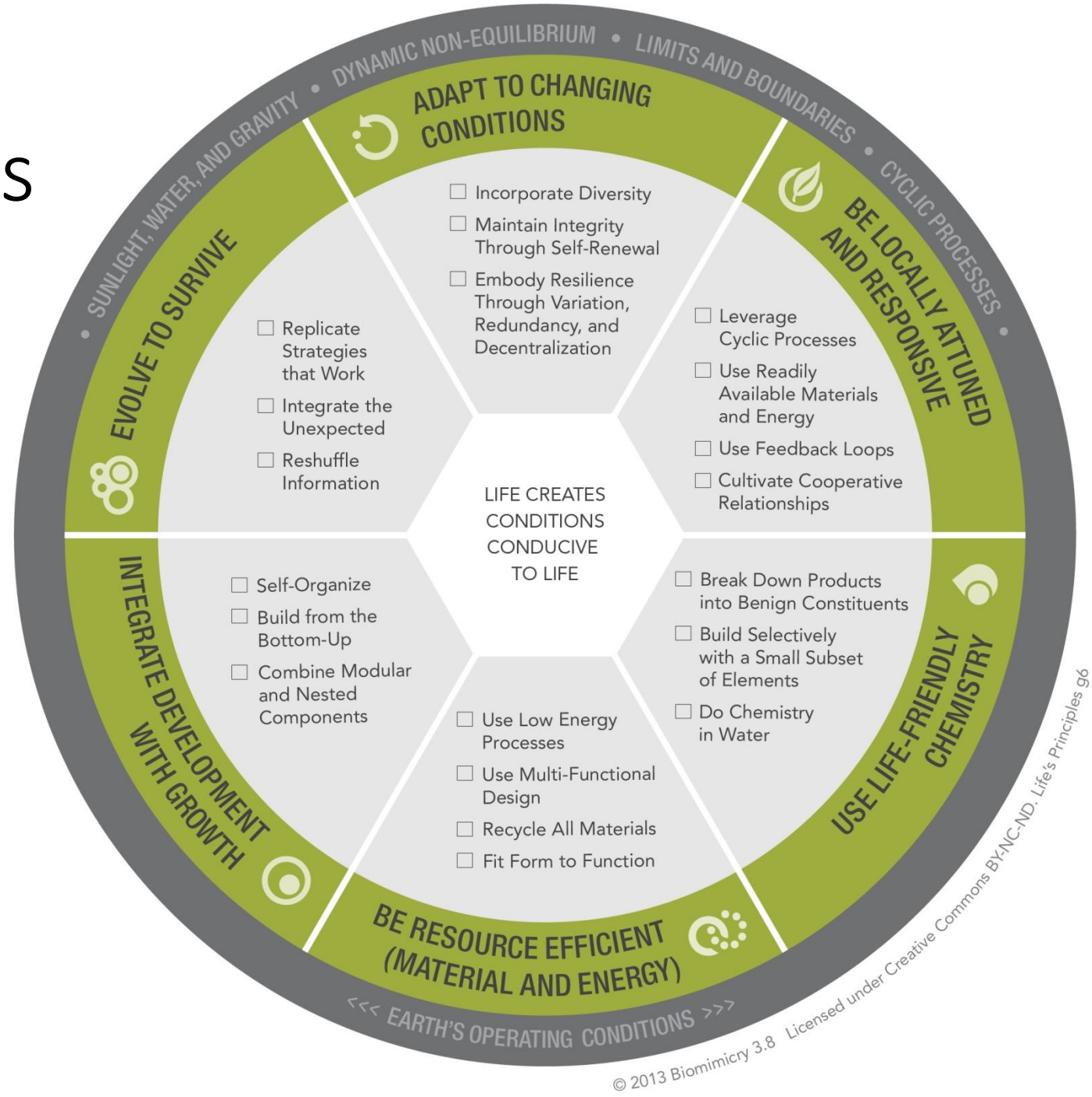
2. Learn basic concepts of biomimicry

Ethos: why we practice biomimicry – to support a sustainable world

(Re)connect: people and nature are deeply intertwined

Emulate: learning from the patterns, strategies, and functions found in nature and applying those lessons to inform human design

Life's Principles



Scale

Form

shape, surface, texture

Process

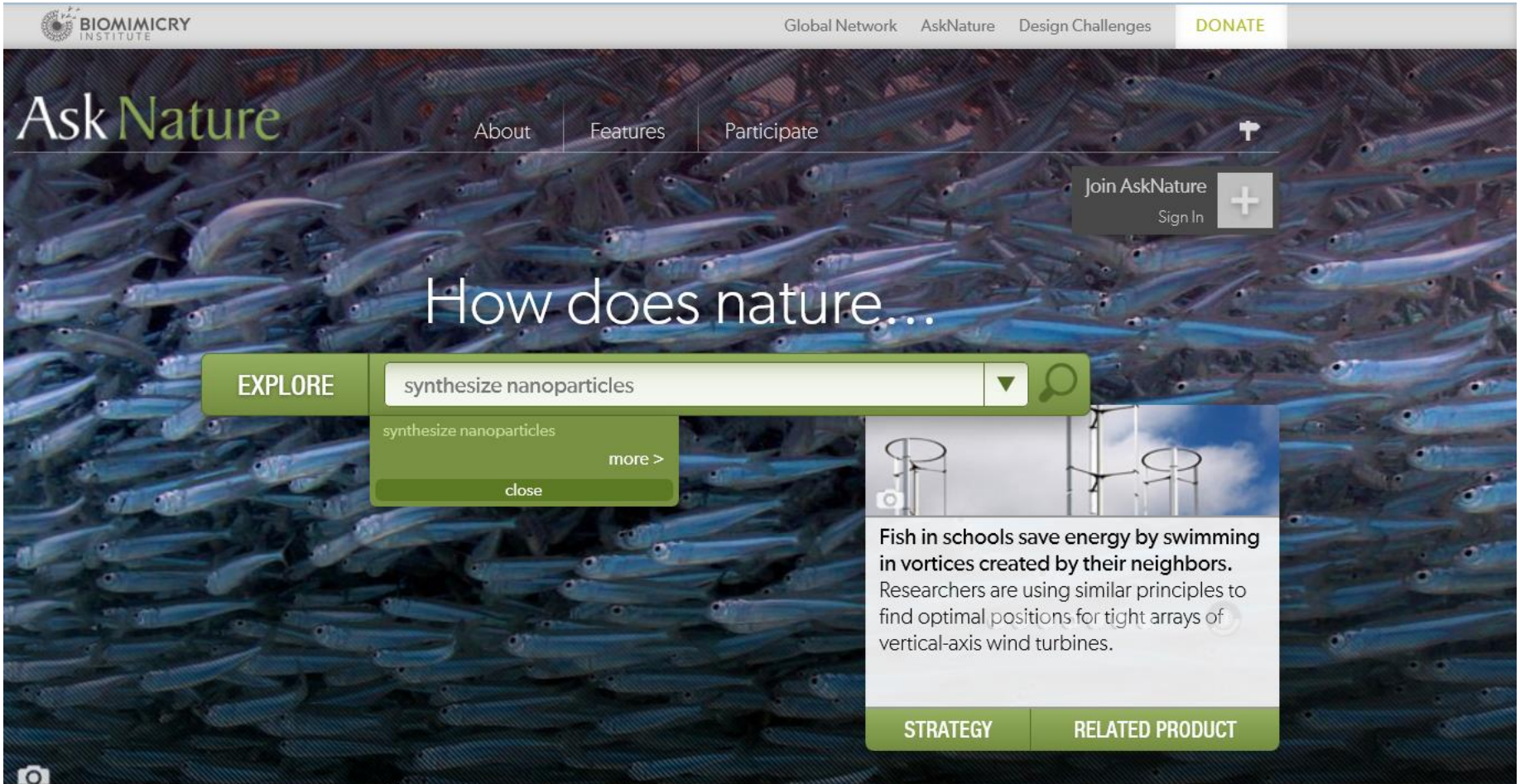
a series of operations

Ecosystem

a network operating together in an ongoing cycle

3. Talk to and collaborate with biologists and ecologists

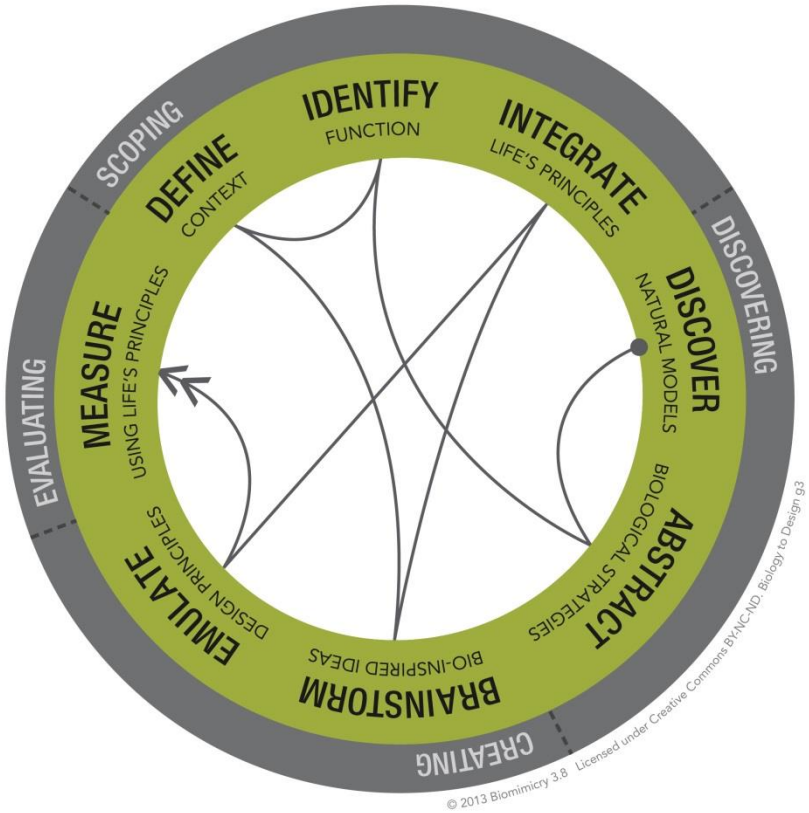
– Information database: www.asknature.org



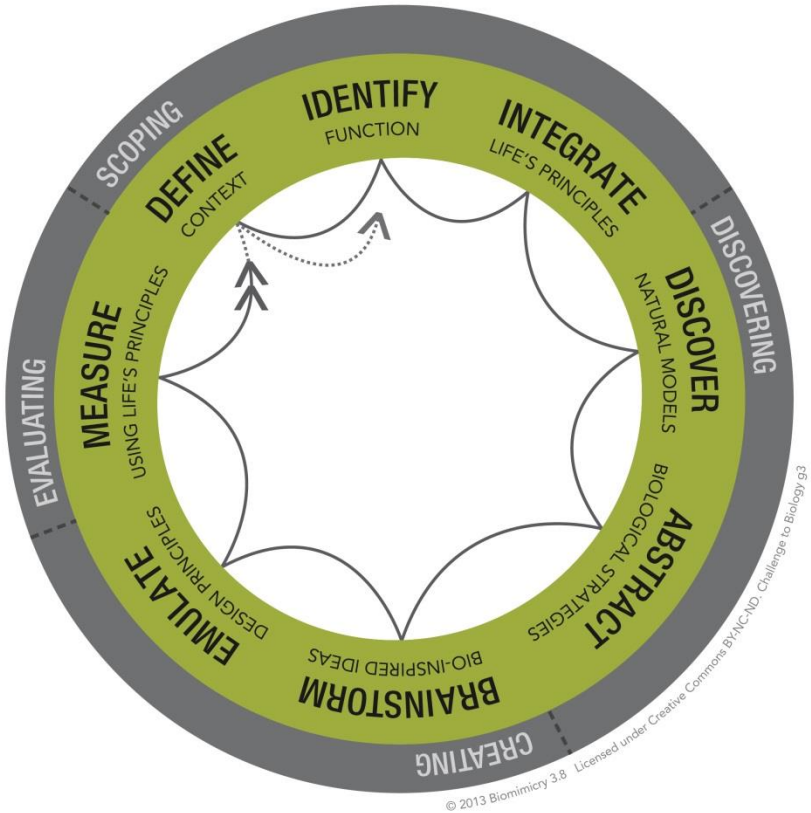
3. Talk to and collaborate with biologists and ecologists

- Information database: www.asknature.org
- Biomimicry consultants: http://biomimicry.net/consulting
- European Biomimicry Alliance: www.biomimicryalliance.eu
- Find biologists and ecologists at your local university, and then go from there…

4. Practice applying biomimicry



BIOLOGY TO DESIGN



CHALLENGE TO BIOLOGY

CHALLENGE TO BIOLOGY

Define context

Specify your challenge and its operating conditions.

Make a material to use as concrete.

Identify function

Determine what key function(s) the design must perform. What does it need to do?

Must bear loads, mix with water, and function similar to mined and processed limestone.

Integrate Life's Principles

Commit to incorporating the design requirements.

Use readily available materials.
Do chemistry in water at lower temperatures.

Discover natural models

Find organisms or ecosystems that have evolved strategies to solve for the needed function(s).

Stony coral

Abstract biological strategies

Determine the mechanism behind each organism's strategy and translate that into a design principle.

Brainstorm bio-inspired ideas

Think of multiple ideas for how to apply the design principles to solve the challenge.

Emulate design principles

Hone in on the best idea from your brainstorm and develop a design concept. Consider aspects of scale, and whether you can go beyond emulating form to also emulate process and ecosystem.

Measure using Life's Principles

Assess your design using Life's Principles as a checklist, as well as LCA and other tools.

Diffusion-dependent (passive) uptake of Ca^{2+} and HCO_3^-; transport of the building blocks to grow the skeleton

CALERA

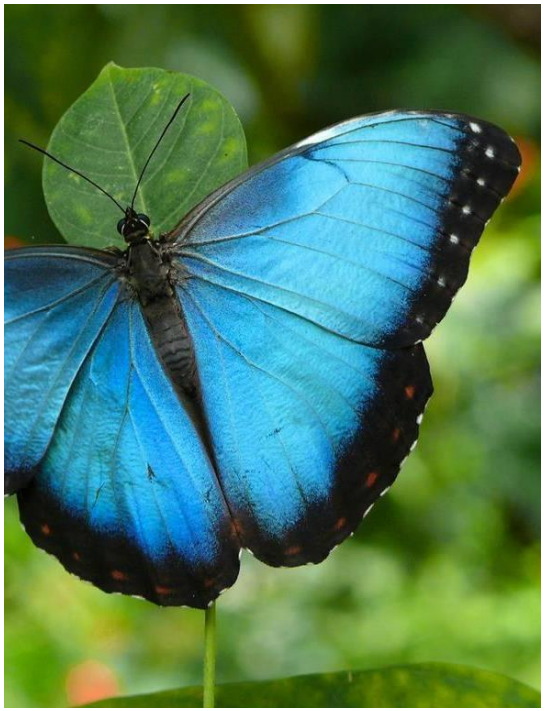
Green Cement for a Blue Planet

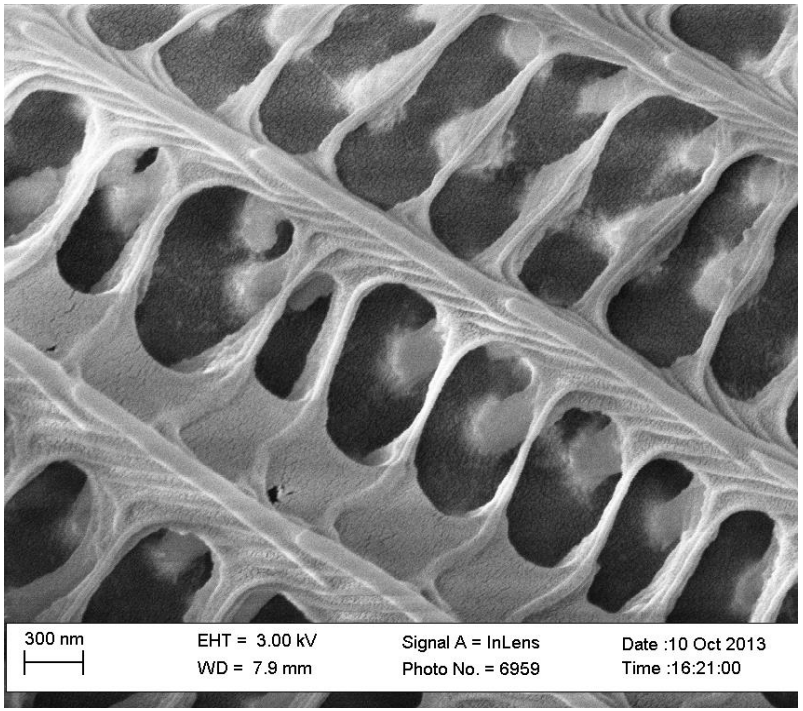
CO_2 + Alkalinity + Calcium = Calcium Carbonates

More biomimicry in action

Wind tunnel tests by the US Naval Academy showed that blades with bumps on the leading edge reduced drag by 32% and increased lift by 8%.

Color through nanostructure





http://www.virlab.virginia.edu/nanoscience_class/labs/materials/Spider%20pics/morpho%20butterfly%20wing%207.gif

Collecting water in the desert

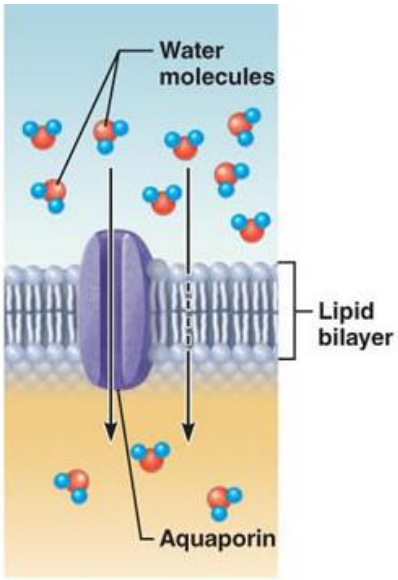
The Namib Desert Beetle

AQUAMIST

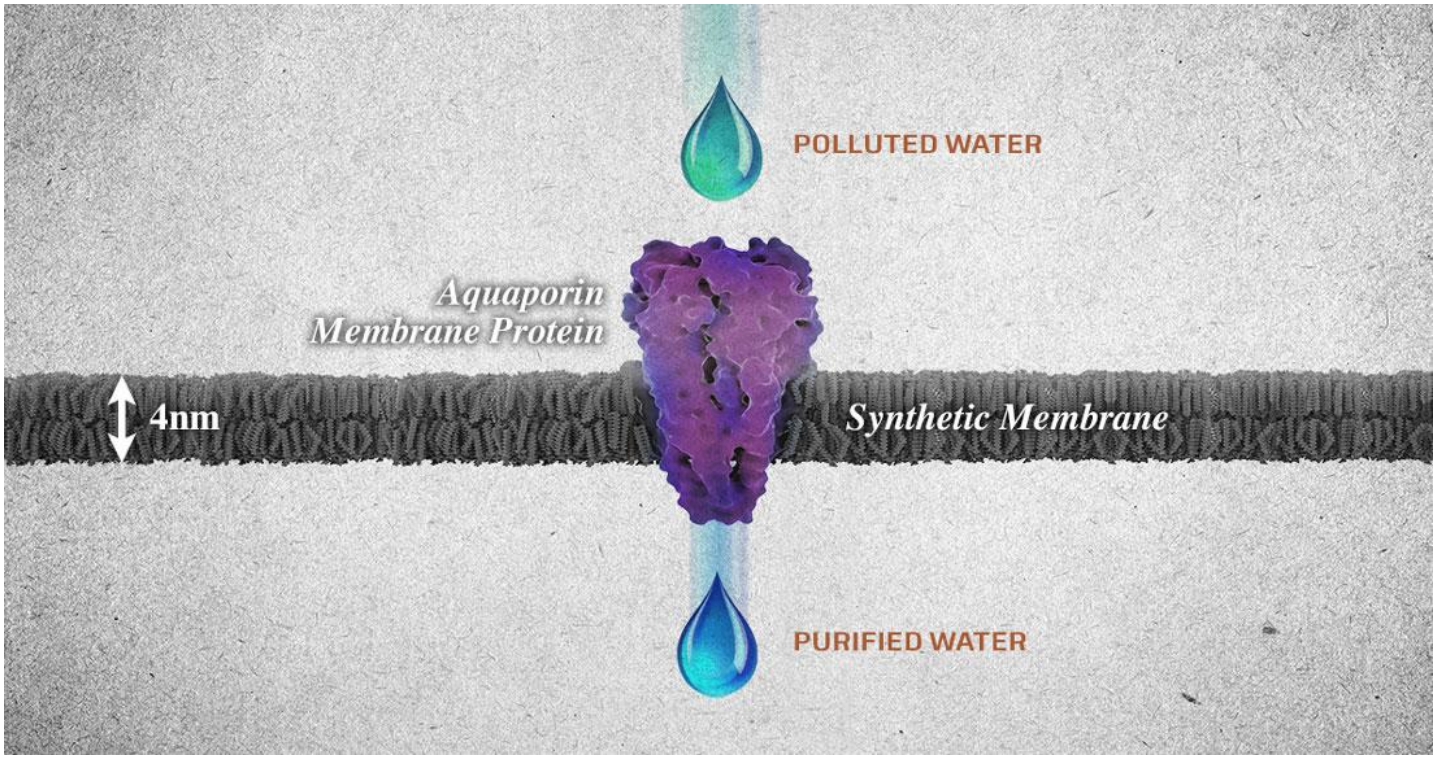
ENTER THE AQUAMIST. THE NEW AGE IN AQUACULTURE.

THIS REFILING DEVICE USES NBD NANO PATTERNED SUPERHYDROPHILIC TECHNOLOGY TO AUTOMATICALLY REFILL LIVESTOCK TANKS WITH FRESH, CLEAN WATER. OR, WHEN CONNECTED TO AN OVERFLOW DRAINING SYSTEM, IT ALLOWS AUTOMATIC AND CONTINOUS WATER CHANGES TO TAKE PLACE. NO MESS. NO HASSLE.

Purifying water like cells do



Osmosis, diffusion of a solvent such as water through a specific channel protein (aquaporin) or through the lipid bilayer



http://classes.midlandstech.edu/carterp/Courses/bio210/chap03/lecture1.htm; http://www.nanowerk.com/spotlight/spotid=34964.php

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Biomolecular specificity controlled nanomaterial synthesis†

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Chin-Yi Chiu,[a] Lingyan Ruan[a] and Yu Huang*[ab]

Biomolecules capable of fabricating complex nanomaterials with required functions in nature have been exploited to artificially control nanomaterial synthesis in all aspects. This tutorial review provides an overview of recent efforts in biomimetic synthesis and the relevant mechanistic studies on biomolecular specificities toward material surfaces. It starts with a discussion of the state-of-the-art progress in colloidal nanocrystal synthesis, wherein the importance of the interfacial control over nanoscale building blocks discloses the potential of exploiting biomolecular recognition properties in nanostructure synthesis.

Researchers are developing ways to synthesize nanomaterials using biomolecules under relatively mild conditions.

YouTube: Janine Benyus + biomimicry

Biomimicry taps into things students care about

Sustainability

Nature

Solving real and meaningful problems

Creativity

SEEING DIFFERENTLY

LEARNING ABOUT:

- Scientific name: *Pinus ponderosa*
- Found in low - mid elevations throughout the U.S.
- USDA Hardiness Zones 3-7
- Important U.S. timber species
- Needles 5-10" long, in clusters of 3

Ponderosa Pine

LEARNING *FROM:*

- Leaves create solar energy without toxins
- Xylem transports water hundreds of feet without fuel.
- Canopy re-humidifies air
- Uses CO_2 as a building material
- Expertly light-weighted materials

Thank you!

akiser@icra.cat

Flying Totems; Birds for Da Vinci, Linocut, 30 x 80"

SOURCES

- Slide 7: (L) http://lagallery-frankfurt.de/hatakeyama1.html; (R) http://static.panoramio.com/photos/large/20308534.jpg:
- Slide 8: (L) https://s-media-cache-ak0.pinimg.com/originals/f9/2d/37/f92d3719358b26f1814f00d39fc35eda.jpg; (R) Jessica Rosenkrantz - http://digitalphototimes.com/blog/the-alien-landscapes-lurking-inside-coral-stunning-close-up-photography-2/
- Slide 9: (L - 1) http://images.gizmag.com/hero/hpylori.jpg; (2) http://static.guim.co.uk/sys-images/Environment/Pix/columnists/2013/7/12/1373631755998/beech-leaf-006.jpg (3) http://cdn2-www.webecoist.momtastic.com/assets/uploads/2011/11/gecko-robot-1.jpg
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