BIOMIMETIC NANOTECHNOLOGY: PUTTING LIFE INTO MATERIALS

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Abstract: *Now a days we are facing many problems in the society like purification of water, as a builiding material, for the coating of clothes etc. We are developing many kind of polymers with the help of natural products like shell of sea animals. Which contains number of nanosheets. In all these Biomimicry is one of the favorite topics in nanotechnology.*

Key Words: *Nano particles, Sheets, sea animals, clay and pearl.*

Biomimicry is one of the favorite topics in nanotechnology, as scientists take clues from nature to inspire new creations. The study conducted in University of Michigan reveals that Biomimicry and Nanotechnology team up to create transparent plastics as strong as steel. A brick and mortar molecular structure found in sea shells was an inspiration to researchers. It took 300 layers of each the glue like polymer and the clay nanosheets to create a piece of this material as thick as a piece of plastic wrap. The mother of pearl, the iridescent lining of mussel and oyster shells, is built layer-by-layer like this. It's one of the toughest natural mineral-based materials. The glue like polymer used in this experiment, which is polyvinyl alcohol, was as important as the layer-by-layer assembly process (1). The structure of the "nanoglue" and the clay nanosheets allowed the layers to form cooperative hydrogen bonds, which gives rise to what Kotov called "the Velcroeffect." Such bonds, if broken, can reform easily in a new place.The Velcro effect is one reason the material is so strong(2). Another is the arrangement of the nanosheets. They are stacked like bricks, in an alternating pattern.

NANOTECHNOLOGY LEGO CONSTRUCTION INSPIRED BY BIOMINERALS

Nanocrystal engineering learned from biominerals holds promises for the development in biology, chemistry, and materials science(3)(4). Biominerals have inspired novel bottom-up approaches to the development of functional materials for some time now. The

morphology, crystallographic orientation, incorporated organic molecules, and emergent properties of carbonate-based biominerals already have been demonstrated(5). Typical examples of these biominerals are certain layers of seashells, corals, and eggshells. New research now clarifies that biominerals are oriented architectures of calcium carbonate nanocrystals 20–100 nm in size with incorporation of biopolymers(6).

WHY MOVE INTO THE NANOWORLD?

Nanotechnology gives us"

- Novel properties, phenomena & processes
- A bridge between the quantum world and the "real" world.
- Many areas of knowledge meet in the Nanoworld
  - Biology-chemistry-physics-information technology-cognitive science
- A bridge between the living and non-living worlds
- Better understanding of the complexity of life
  - Nature is the master nanotechnologist

WHY BIOMIMICRY?

WHY consider technology transfer between Nature and synthetic, man-made constructs?

- Evolutionary pressure typically forces natural systems to become highly optimized and efficient
- Natural systems materials solution serve as a guide the rational design of target functionalities
- We are not constrained by feedstock availability
- Nature does not produce waste in a stable ecosystem, whereas a modern manufacturing economy produces a vast amount of waste(6)(7).

APPLICATIONS OF BIOMIMETIC NANOMATERIAL

- Anti-reflection coatings
- Diffractive pigments
- Elastomers
- Adhesives
- High strength nanocomposites
- Membranes

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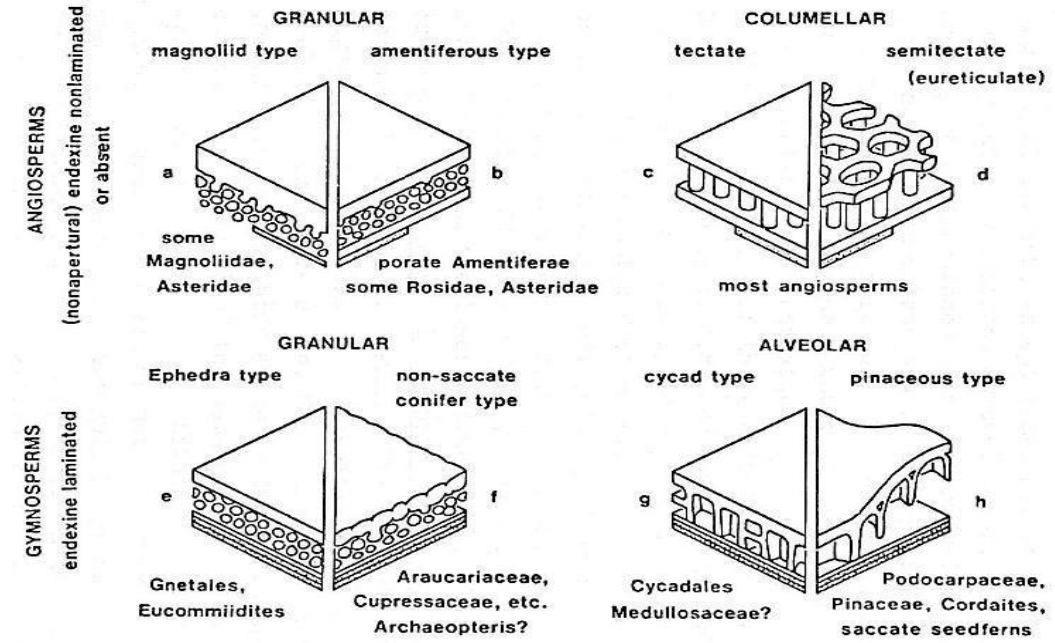
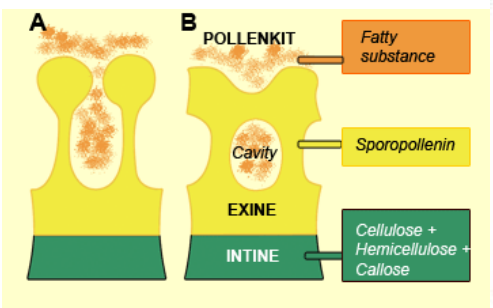
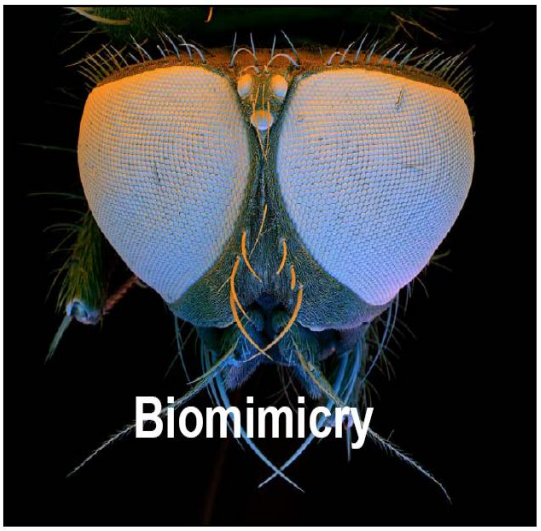
- Fuel cells
- Anti-corrosion coatings

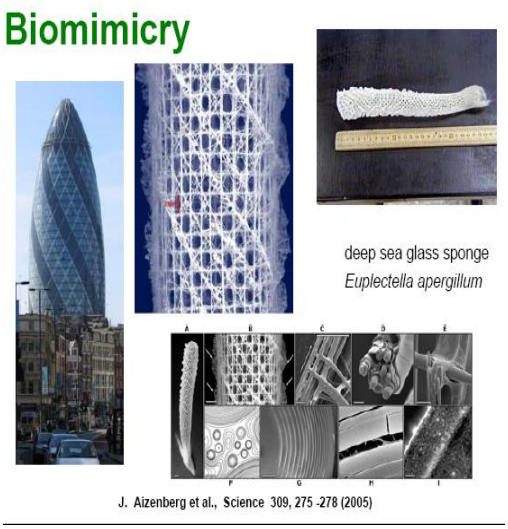
Some of the natural examples which have inspired researchers in technology area:





The pillars mimic the wall of the pollen grain





Good design from Nature

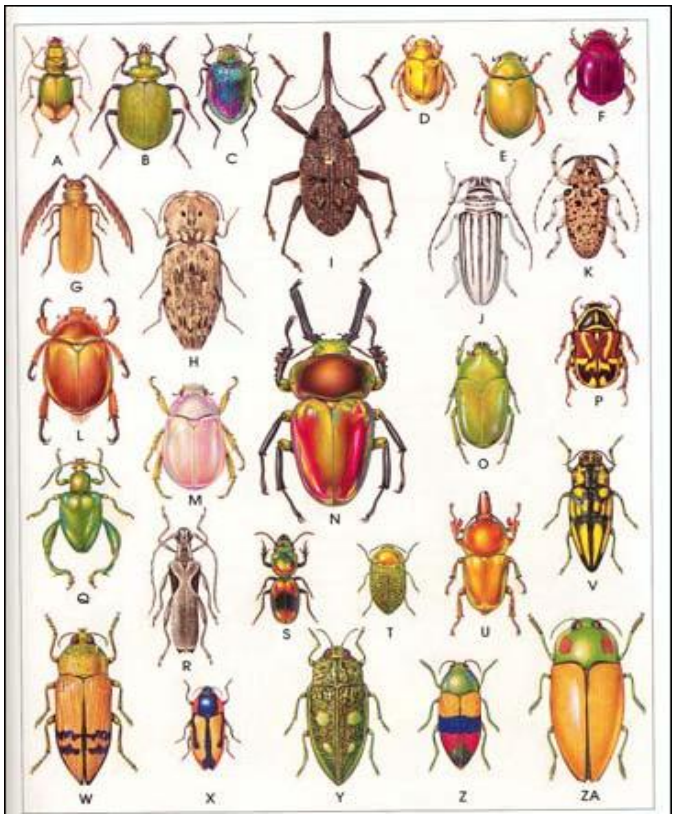
Mercedes-Benz Bionic Concept Car

- Biomimicry operates hierarchically:

Molecular Nano Cellular Organism Ecosystem

Diffractive Pigments (Mimic insect coloration)

- Understand the nature of coloration in target insects
- Mimic the structural basis of colour
- Design and fabricate nanostructures that produce functional coloration



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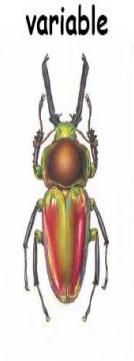
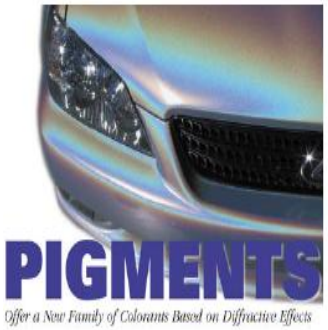
Australia has a unique fauna of metallically coloured beetles

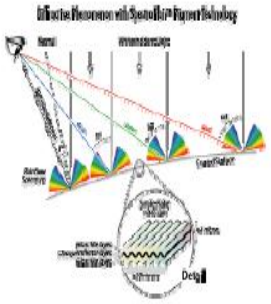

green

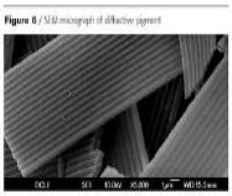

variable


silver

Man-made Diffractive Pigments

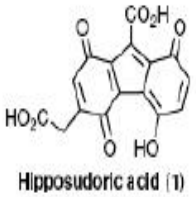




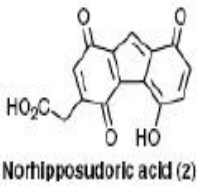


A Cosmetics Marketing Challenge!!!

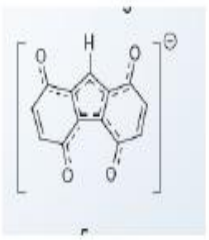
- Hippo sweat
  - UV Absorbing and an excellent antibiotic

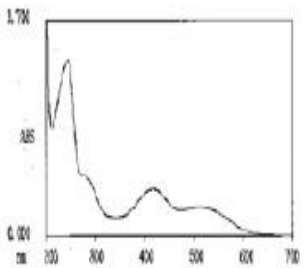


Hipposudoric acid (1)



Norhipposudoric acid (2)





(Nakata, 2004, 2006)

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Water Purification

The largest cost in water treatment is usually energy!

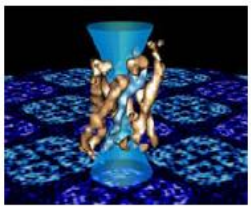
Early seawater desalination systems by reverse osmosis systems required >15 kWh/m3

Modern seawater desalination systems use 3-5 kWh/m3

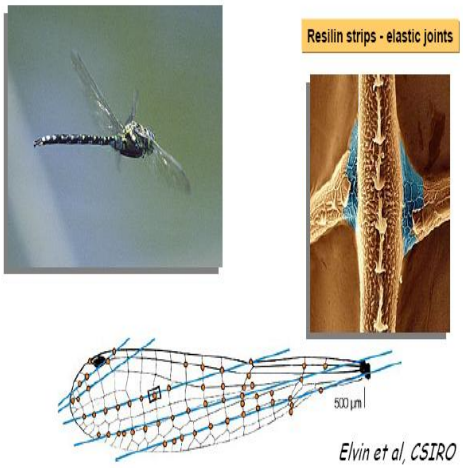
Theoretical limit of 0.8 kWh/m3

Look to Nature

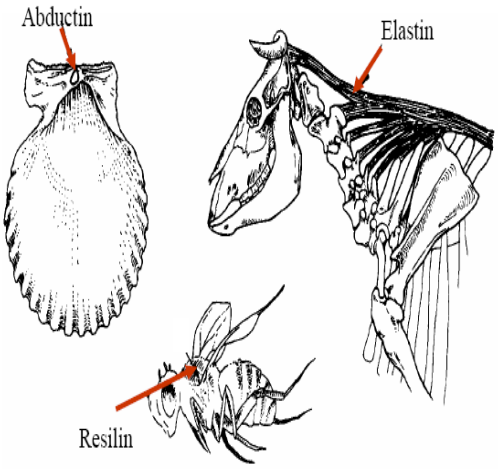
- Aquaporin proteins allow water to pass through cell membranes
- $1m^2$ of AQP 1 units packed at 50% on surface would allow ca 260,000 litres of water per day



Biomimetic Nanostructures - Resilin

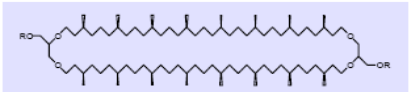


Biological Rubbers

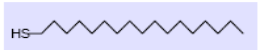


Barrier Coatings

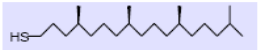
- Archaebacteria – live at 113°C, 1M NaCl, pH1 – tough for anyone
- Special 4nm thick cell wall protects inside of bacteria
- Fluid, self-annealing membranes – "tetraether" lipids



Archaebacterial lipid derived from *Sulfobolus* genus



Hexadecanethiol



Archae Mimic

(Raguse et al, CSIRO)

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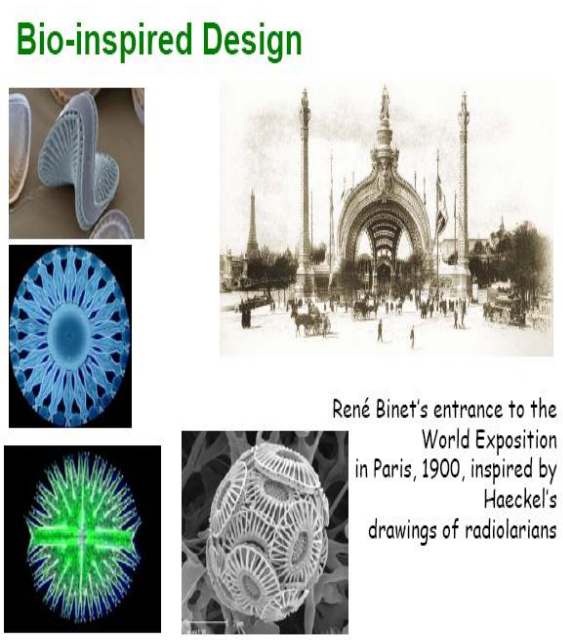
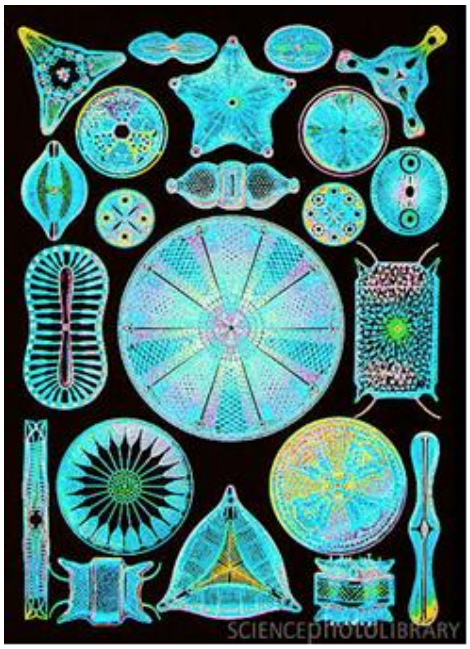
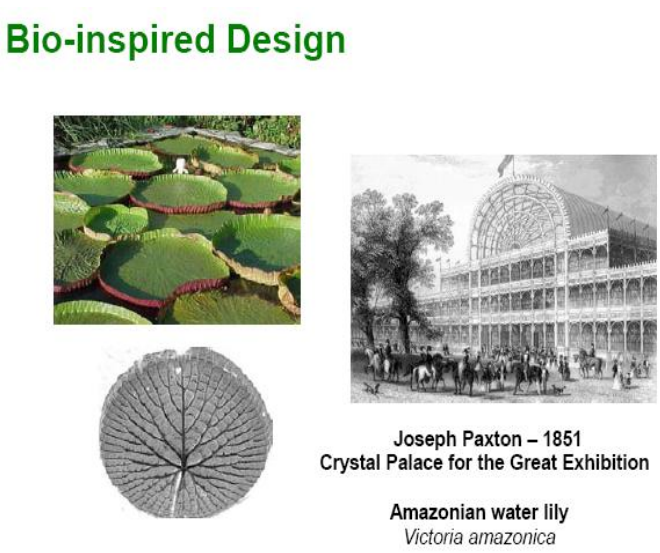


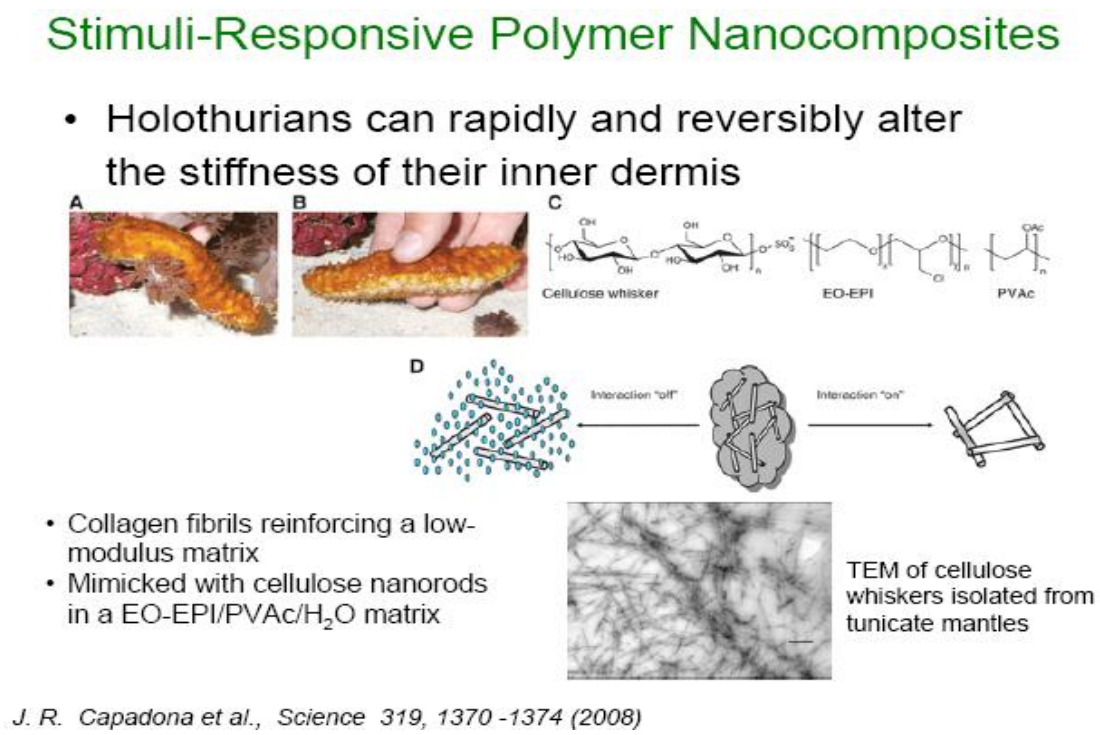


Diatom shapes used in textile industry



The deposition of silica by diatoms may also prove to be of utility to nanotechnology. Diatom cells repeatedly and reliably manufacture valves of various shapes and sizes, potentially allowing diatoms to manufacture micro- or nano-scale structures which may be of use in a range of devices, including: optical systems; semiconductornanolithography; and even using diatom valves as vehicles for drug delivery(9). Using an appropriate artificial selection procedure, diatoms that produce valves of particular shapes and sizes could be evolved in the laboratory, and then used in chemostat(10) cultures to mass produce nano scale component. It has also been proposed that diatoms could be used as a component of solar cells, by substituting photosensitive titanium dioxide for the silicon dioxide normally

used in the creation of cell walls(11)(12).Therefore for the purification of water we are using many techniques for removing the heavy metals and other micro organism from the polluted water(13- 24).



Leonardo Da Vinci rightly said **"Those who are inspired by a model other than Nature, a mistress above all masters, are labouring in vain."**

This can be used in many fields as a adhesive, polymers, as a building material etc. Therefore we are generating such substances which are biodegradable .

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