Biomimetics

Part 1

Biomimetics

- Biomimetics is the application of biological methods and systems found in nature to the study and design of engineering systems and modern technology
- Also known as Bionics, biognosis, biomimicry or bionical creativity engineering.

Strategies and principles of Biomimicry

- Nature fits form to function, utilizes a variety of non orthogonal forms and design methods in its constructions to ensure maximization in terms of structural efficiency.
- It minimizes the required input of material.
- Nature recycles everything, Uses waste as a resource
- Nature uses an ordered hierarchy of structures

Strategies and principles of Biomimicry

- Nature banks on diversity, constantly mutating and adapting in a flexible and dynamic flow of change
- Nature Self assembles and generates structural organization on all scales
- Nature is Resilient to changes and self healing
- Nature Optimizes rather than maximize, using the least materials for optimal structure and function

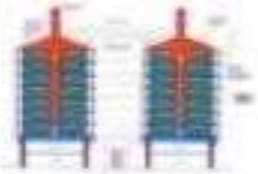
LEVELS OF BIOMIMICRY APPLICATION

- ORGANISM LEVEL
- BEHAVIOR LEVEL
- ECOSYSTEM LEVEL

Biomimicry

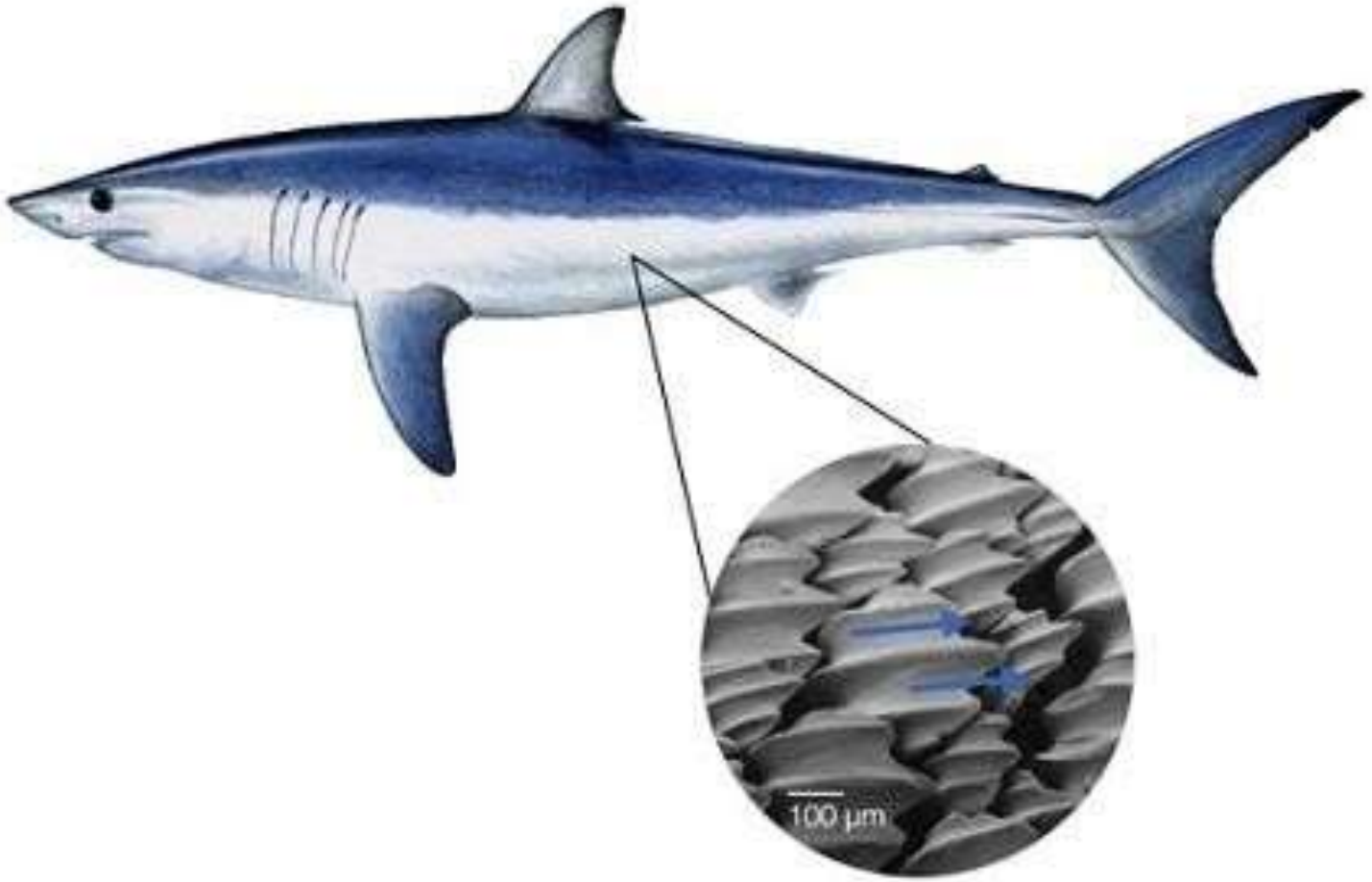
- Mechanical / Fabrication
- Architecture
- Medical/ Bionics
- Energy Conservation
- Industrial/ Production



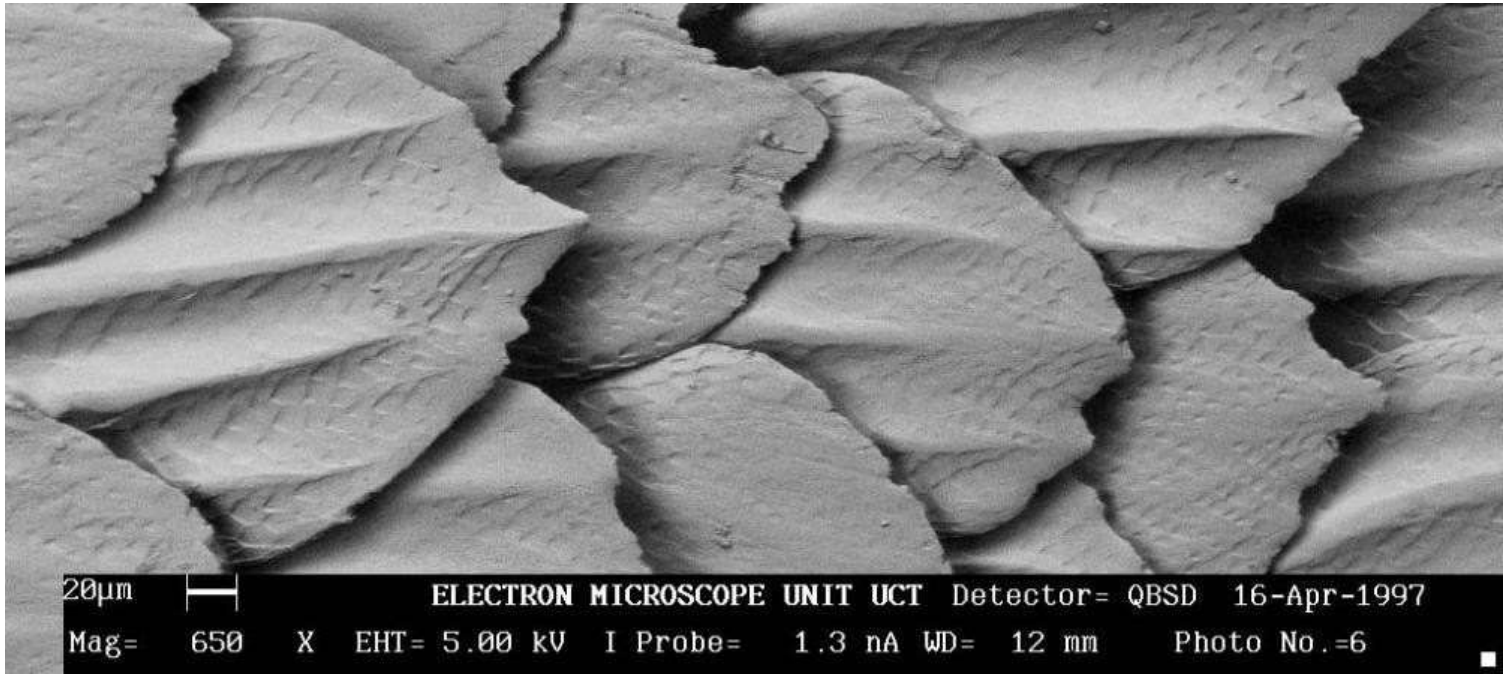



Shark skin



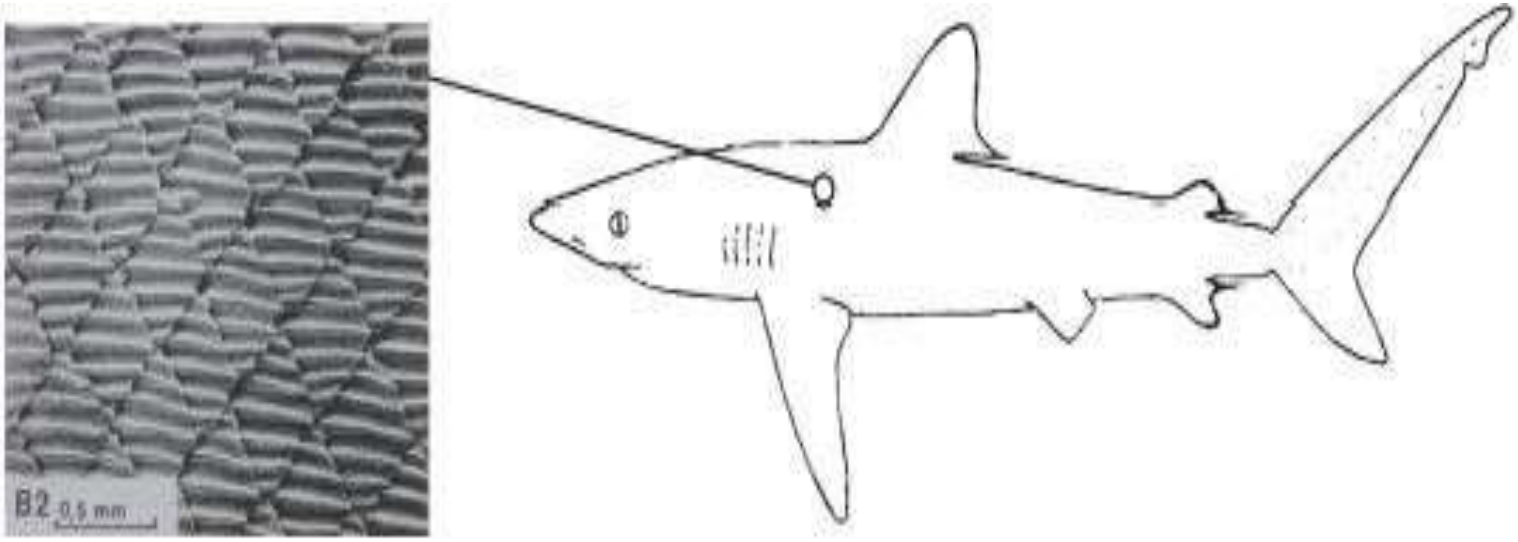
Shark skin

- Shark skin is constructed of overlapping scales.
- Nature through evolution, has ensured that water flows over the scales extremely efficiently, helping the shark to reach high speeds.



Shark skin denticles.

Drag reduction with riblets in nature and engineering



Microstructure of the skin of the Galapagos shark (*Carcharhinus galapagensis*).

Drag reduction with riblets in nature and engineering

- Special alignment and grooved structure of denticles embedded in shark skin decrease drag and thus greatly increase swimming proficiency
- Airbus fuel consumption down 1.5% when “shark skin” coating applied to aircraft

- Shark Skin has been successfully established in air racing.
- It is possible to increase the efficiency of Air planes **up to 4%** by adjusting riblets.
- Brings increase of speed **up to 1.56%**.

- The results of the use of riblets are a
  - reduction of the total drag,
  - a higher glide ratio and
  - a better handling of the aircraft.
- Furthermore **more speed with the same energy consumption** can be achieved.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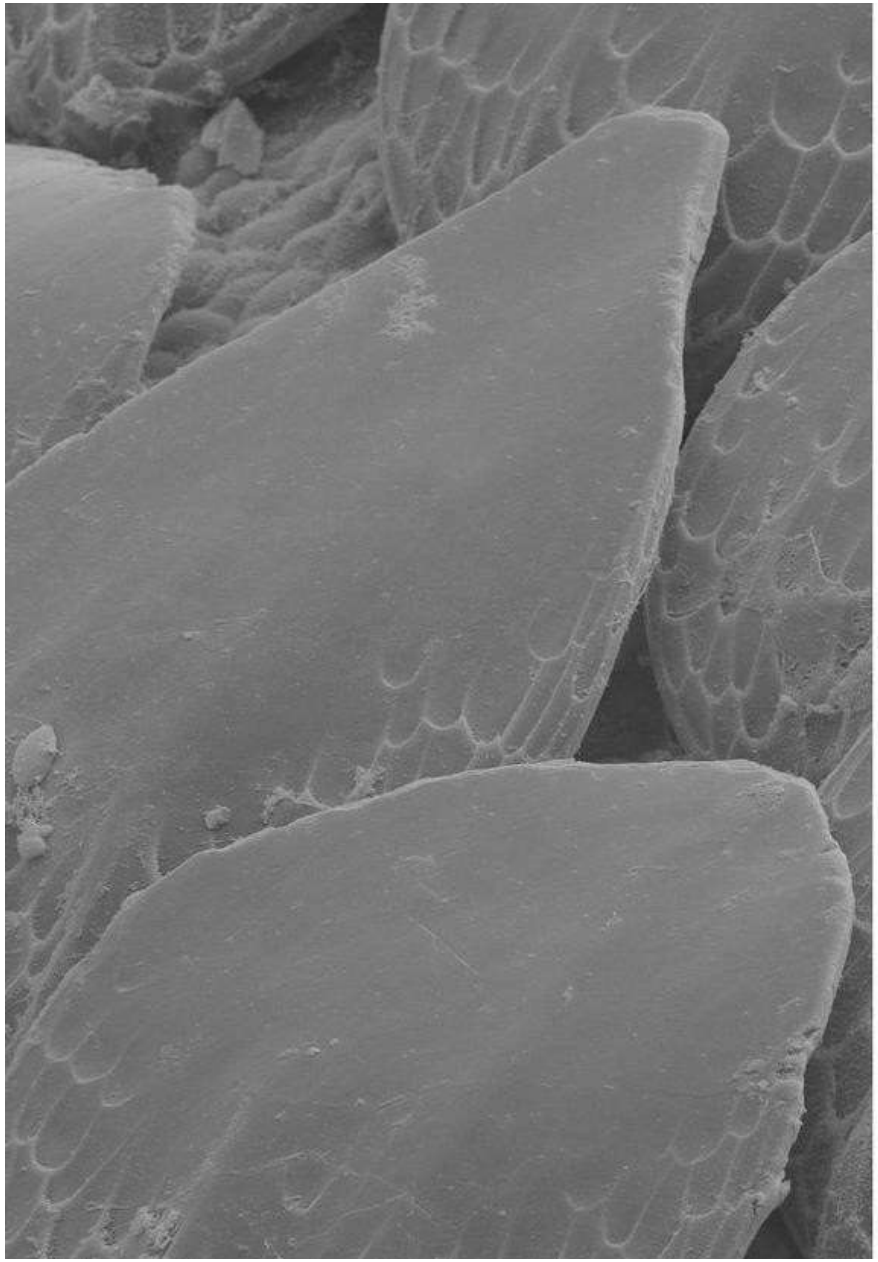
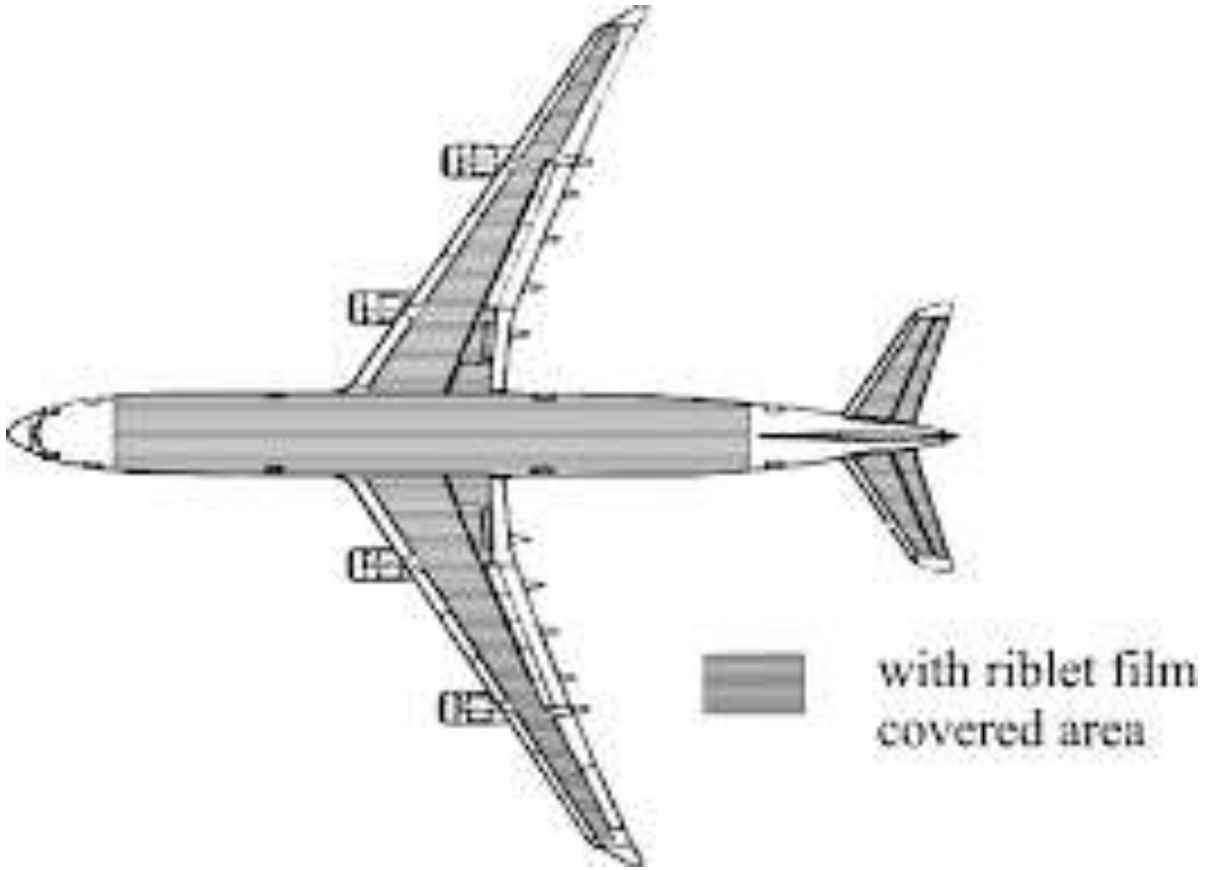
In water

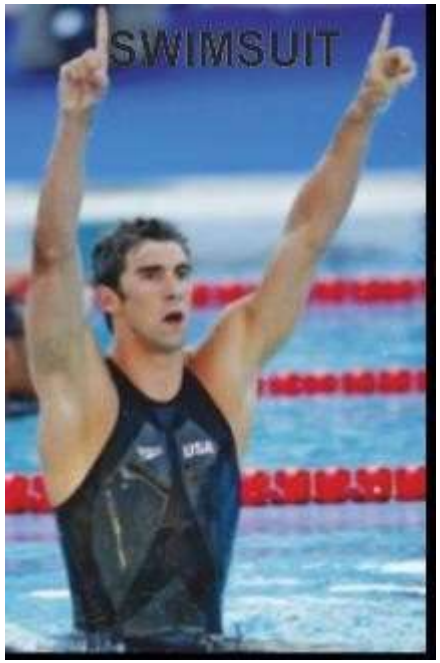
- Riblets also show drag reducing effects on surfaces which are in contact with water.
- Wherever high velocity is found in different fluids or gases, riblets can reduce the drag of the object.
- In different races the drivers of **high speed boats** (e.g. power boats) profit from the aerodynamic optimization gained in the use of riblets.




with riblet film
covered area

Friction-Reducing Sharkskin

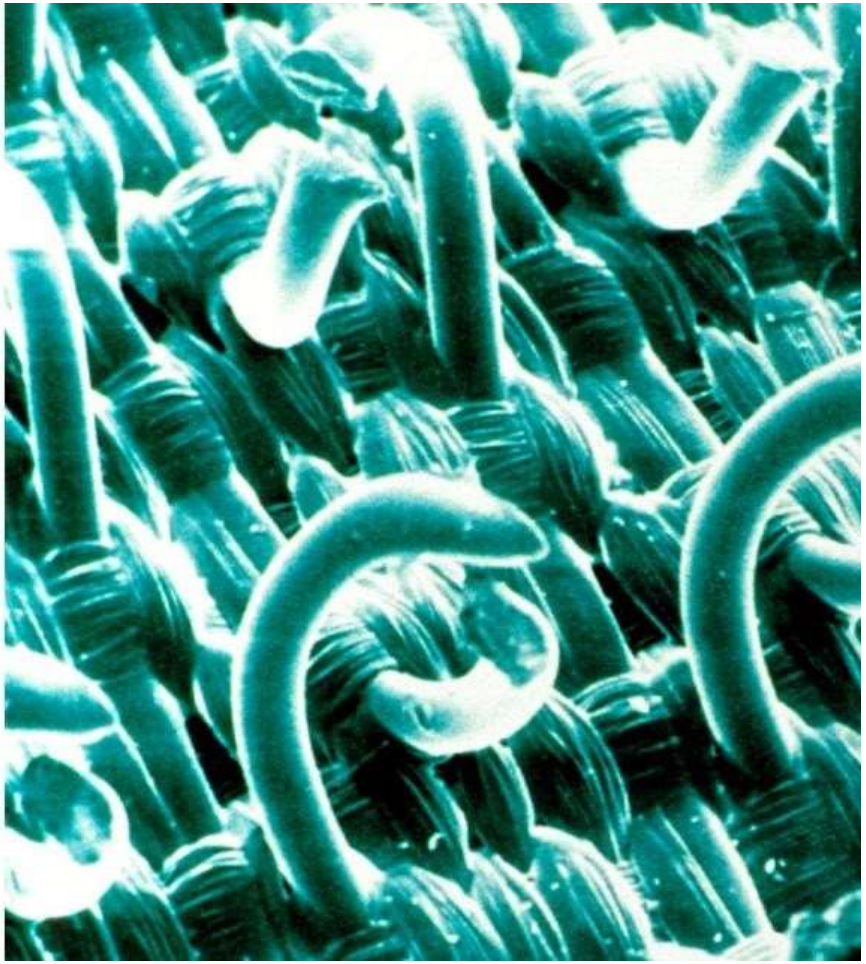
- Researchers are developing coatings for ship's hulls, submarines, aircraft fuselage (main body), and even swimwear for humans.
- **Speedo's Fastskin FSII swimsuits** made their appearance at the Bejing Olympics and may have helped US swimmer Michael Phelps to his record eight gold medals in that competition, and the rest of the team as well.



Velcro

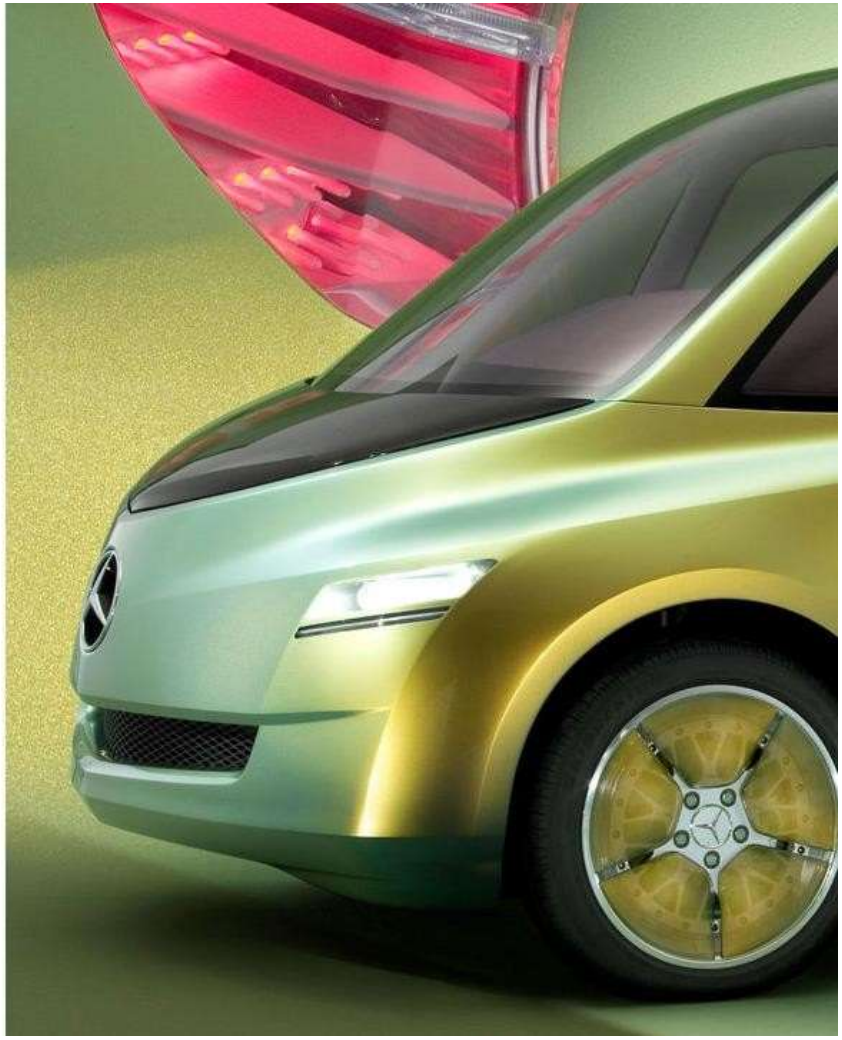
Velcro

- Small hooks enable seed-bearing burr to cling to tiny loops in fabric
- Velcro fastening was invented in 1941 by Swiss engineer George de Mestral, who took the idea from the burrs that stuck to his dog's hair.



- Under the microscope he noted the tiny hooks on the end of the burr's spines that caught anything with a loop - such as clothing, hair or animal fur.
- The 2-part Velcro fastener system uses strips or patches of a hooked material opposite strips or patches of a loose- looped weave of nylon that holds the hooks

Yellow boxfish for Bionic Car



The Mercedes-Benz car concept

- A tropical swimmer; the boxfish (Ostracion cubicus,) which has several characteristics that could be useful in a vehicle.
- Despite its boxy, cube-shaped body, the fish is outstandingly streamlined and therefore represents an aerodynamic ideal with a very **low wind drag coefficient**, a very important factor in car development.

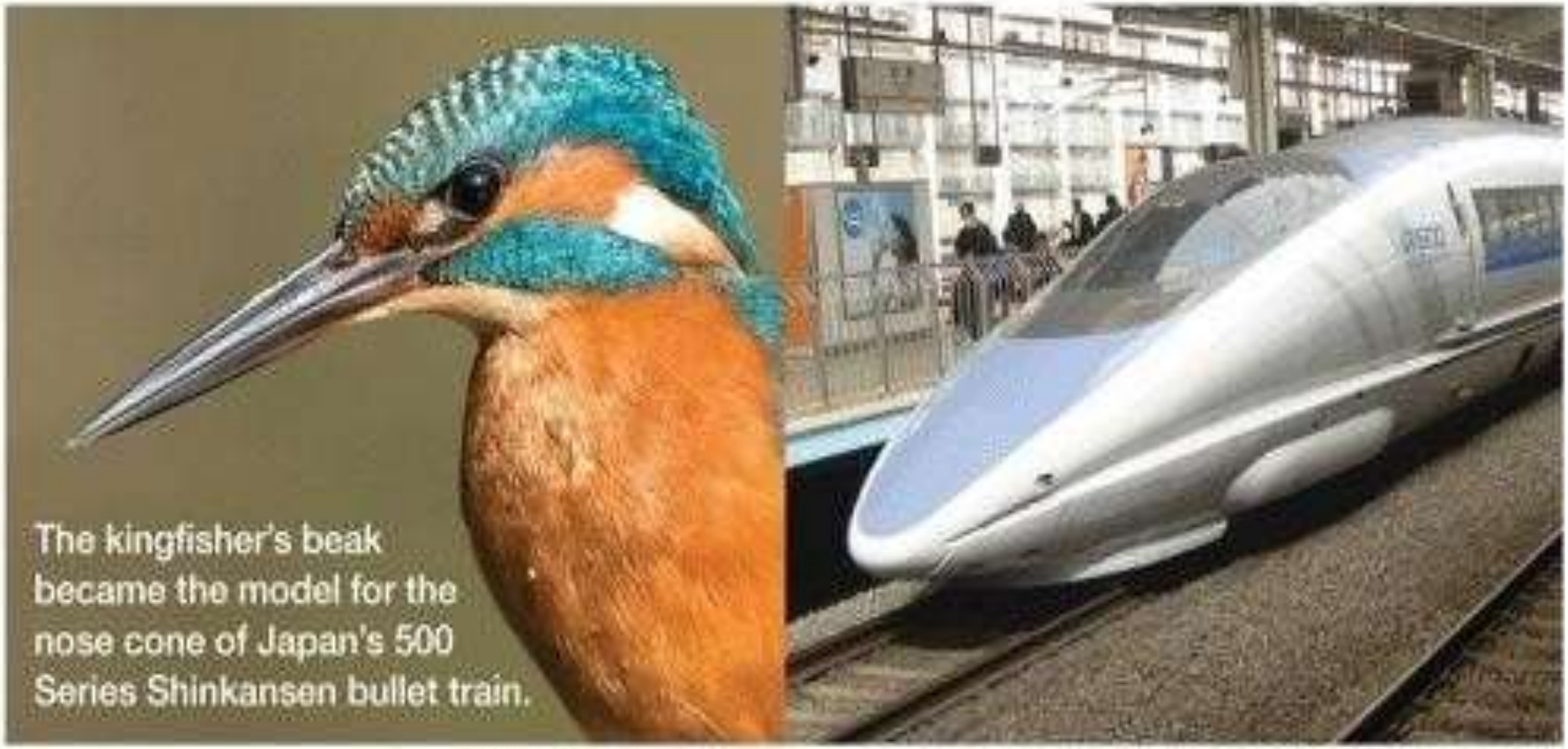
The Mercedes-Benz car concept

- Through designing the car-body in accordance with the principles of the boxfish, 20% lower fuel consumption was achieved
- The species' outer skin is composed of a **vast number of hexagonal bone plates** that overlap to form a rigid armor.
- This bony comb-like structure gives the fish a remarkable rigidity, protecting it against injuries, and it is also the key to its perfect mobility.

The Mercedes-Benz car concept

- This principle was transferred to the car, and up to 40% more rigidity was achieved in the external door panelling compared to conventional designs.
- Calculations showed that if the entire body-shell was made according to this principle, total weight could be reduced by around 1/3rd without diminishing strength and crash safety

Kingfisher beak Japanese bullet train



Shinkansen Bullet Train

- The fastest train in the world at speeds of up to 200 miles per hour, Japan's Shinkansen Bullet Train was a marvel of modern technology.
- But there was one major problem after its initial debut: noise.
- Each time the train emerged from the tunnel, it caused a change in air pressure that caused thunder-like sounds that were a nuisance from a quarter of a mile away.

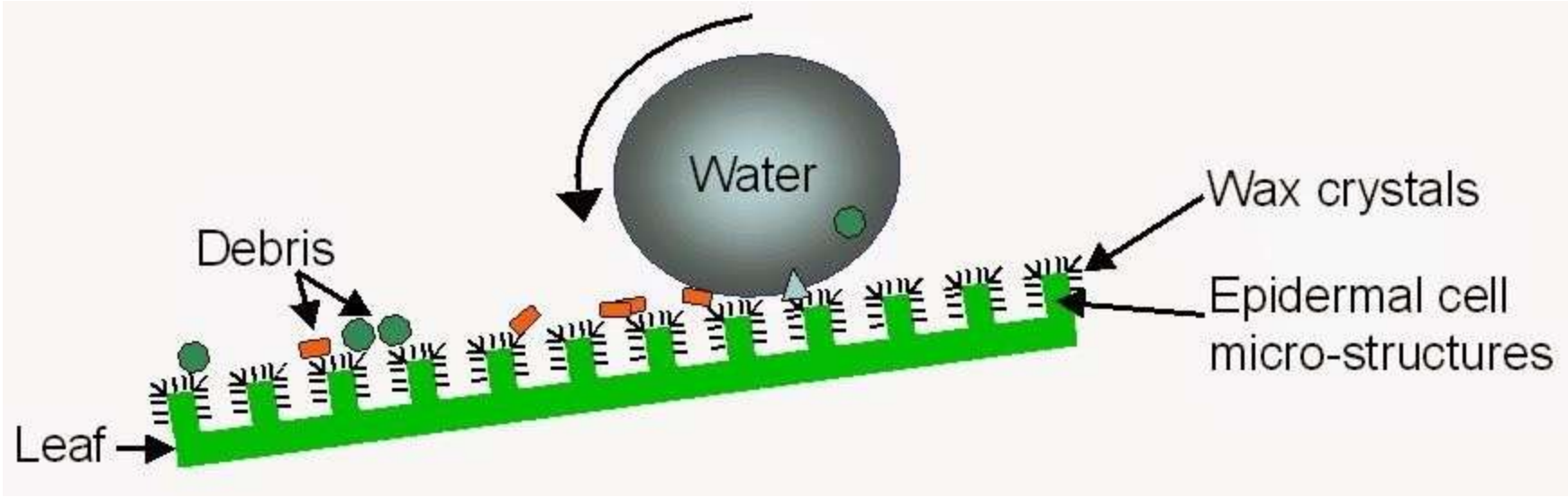
Shinkansen Bullet Train

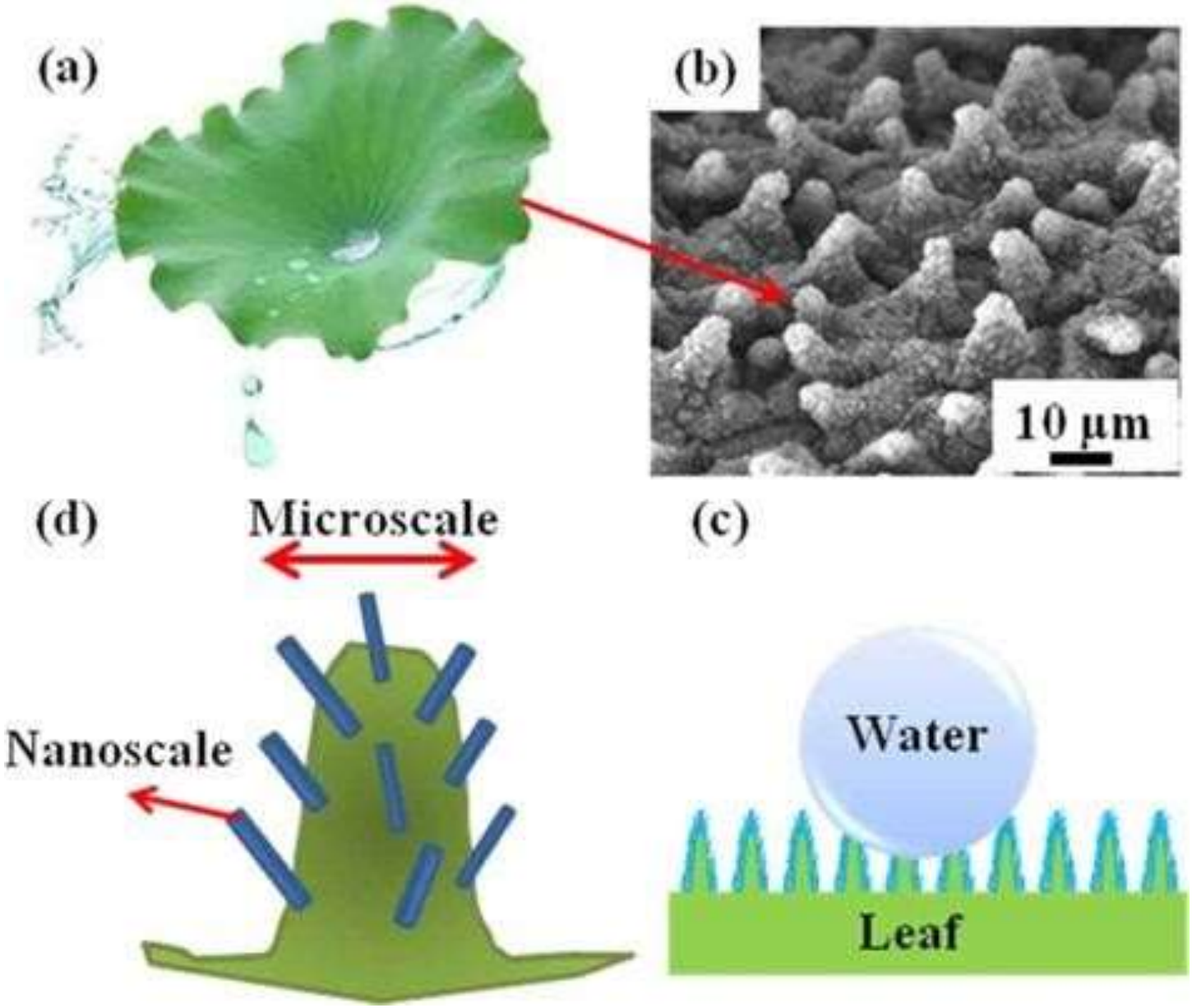
- The train's chief engineer, a bird-watcher, had an idea: taking inspiration from the shape of a bird's beak to make it more aerodynamic.
- The resulting design was based on the narrow profile of a kingfisher's beak, resulting in a quieter train that also consumes 15% less electricity and goes 10% faster than before.

Lotus leaf-Self-clean water repellent surfaces

- The surface of lotus leaves are bumpy, and this causes water to bead as well as to pick up surface contaminates in the process.
- The water rolls off, taking the contaminates with it.

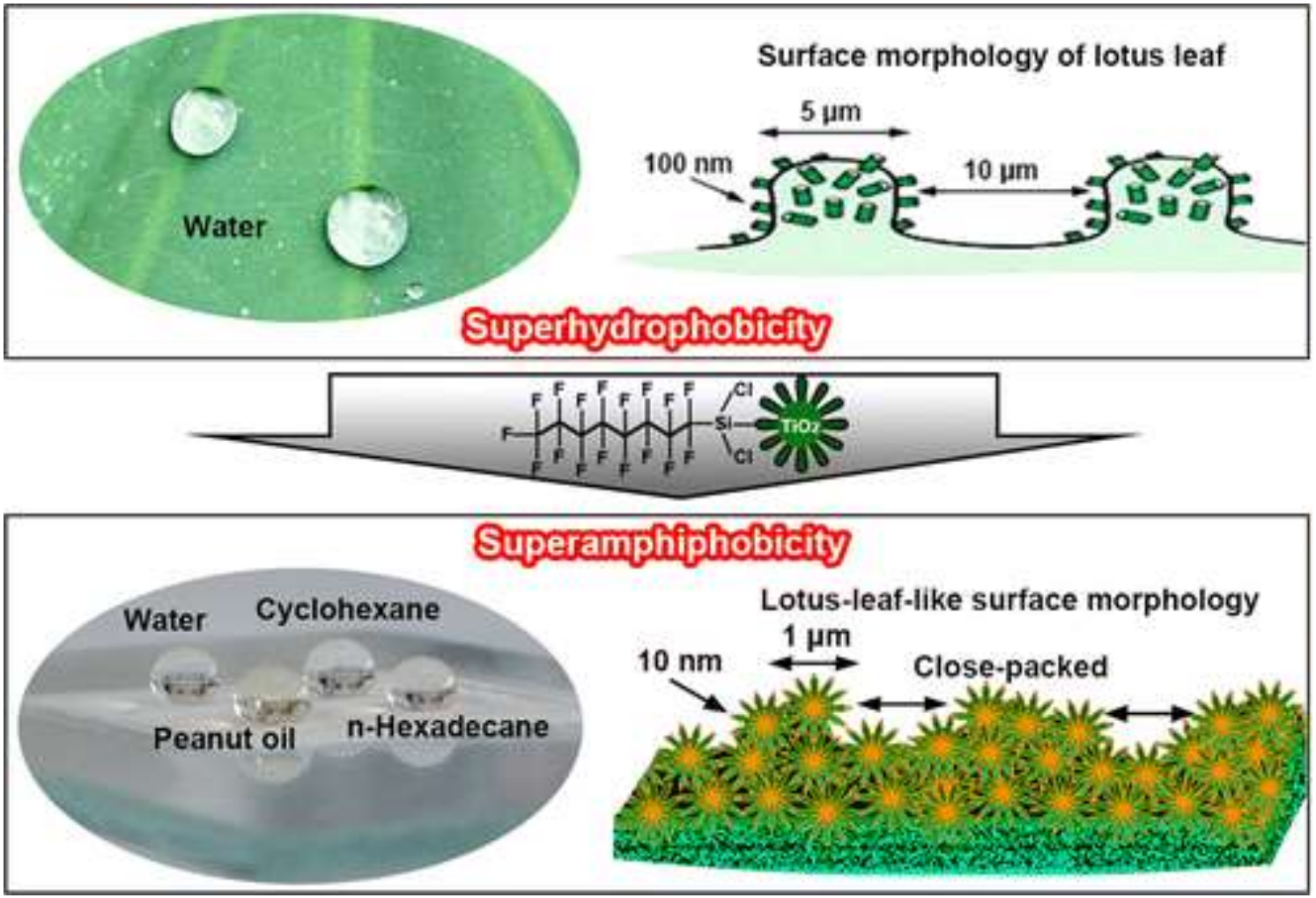
Researchers have developed ways to chemically treat the surface of plastics and metal to evoke the same effect.


Water
Wax crystals
Debris
Epidermal cell
micro-structures
Leaf


(a)
(b)
10 µm
(d)
Microscale
Nanoscale
(c)
Water
Leaf

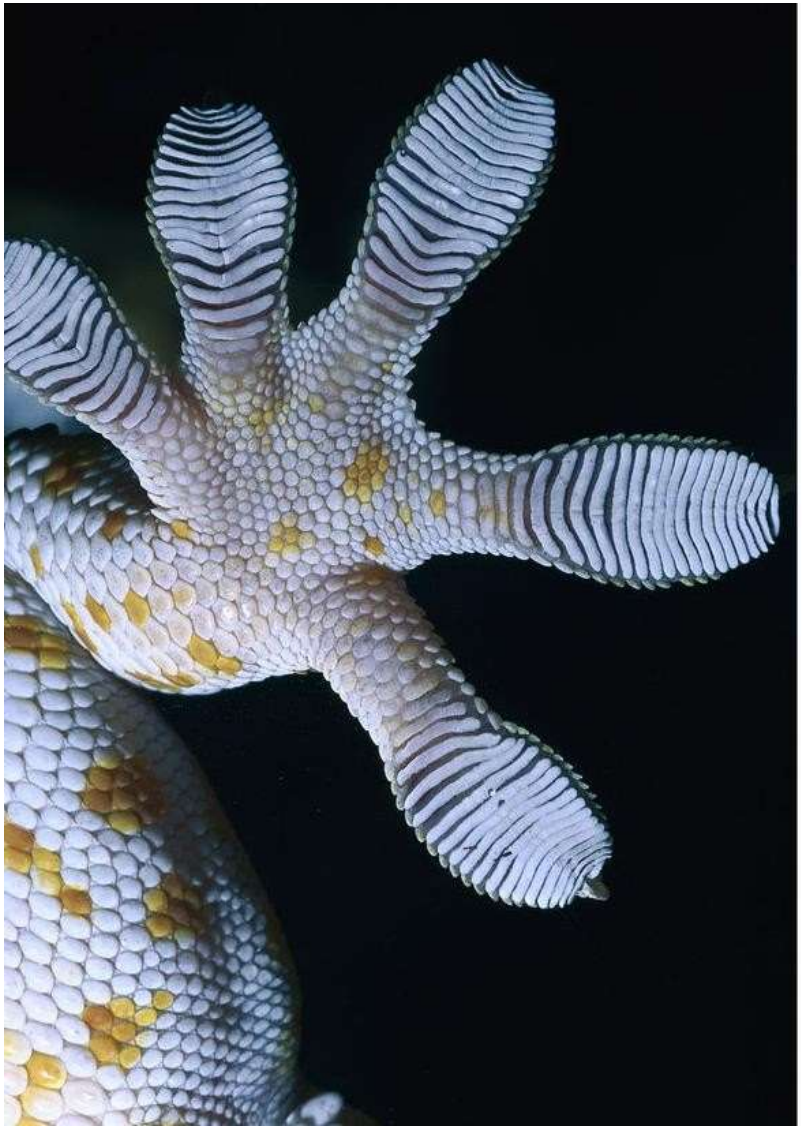
Lotus leaf-Self-clean water repellent surfaces

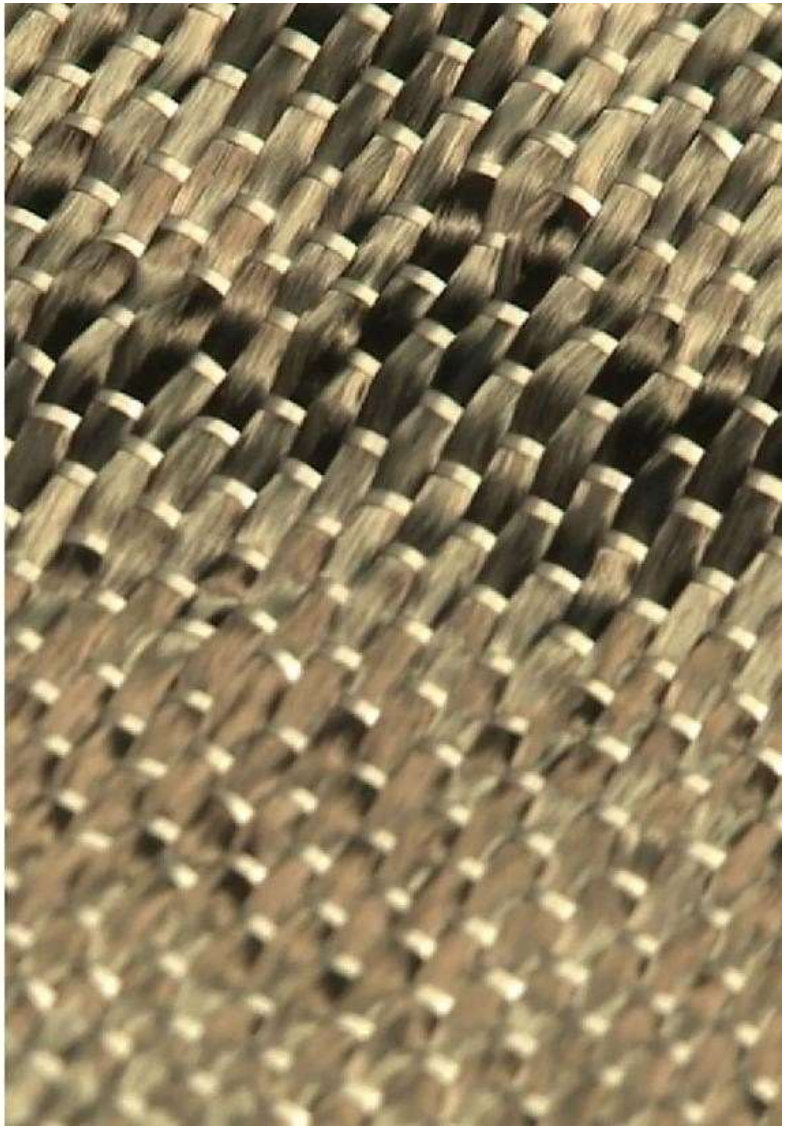
- Lotus effect
- Most efficient self-cleaning plant
- This is mimicked in paints and other surface coatings
- pipe cleaning in oil refineries

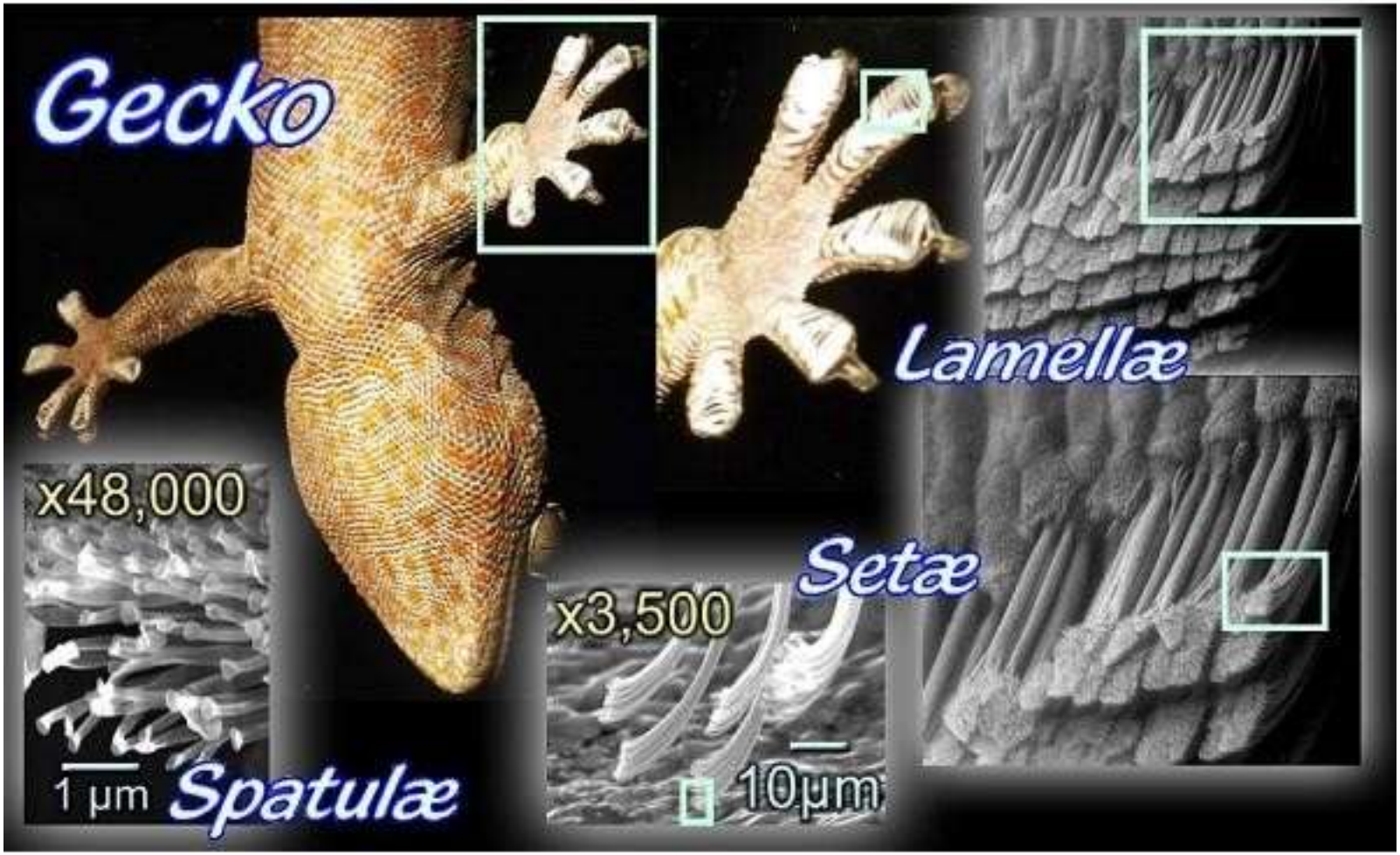

Surface morphology of lotus leaf
5 μm
100 nm
10 μm
Water
Superhydrophobicity
F
Cl
Si
TiO2
Superamphiphobicity
Water
Cyclohexane
Peanut oil
n-Hexadecane
Lotus-leaf-like surface morphology
1 μm
10 nm
Close-packed

Gecko tape for mechanical fabrication

- Gecko is a nocturnal and often highly vocal lizard which has adhesive pads on the feet to assist in climbing on smooth surfaces.
- Geckos hang single-toed from sheer walls and walk along ceilings using fine hairs on feet







Gecko's feet comprise of lamellae. Lamellae are equipped with setae; each seta ends in a spatula-like structure. Nanoscale spatulae interact with wall atoms; generate Van der Waal's forces. The adhesive system demonstrates high friction.

- Gecko Tape is a material covered with nanoscopic hairs that mimic those found on the feet of gecko lizards.
- These millions of tiny, flexible hairs exert van der Waals forces that provide a powerful adhesive effect.
- One square centimeter of gecko tape could support a weight of one kilogram

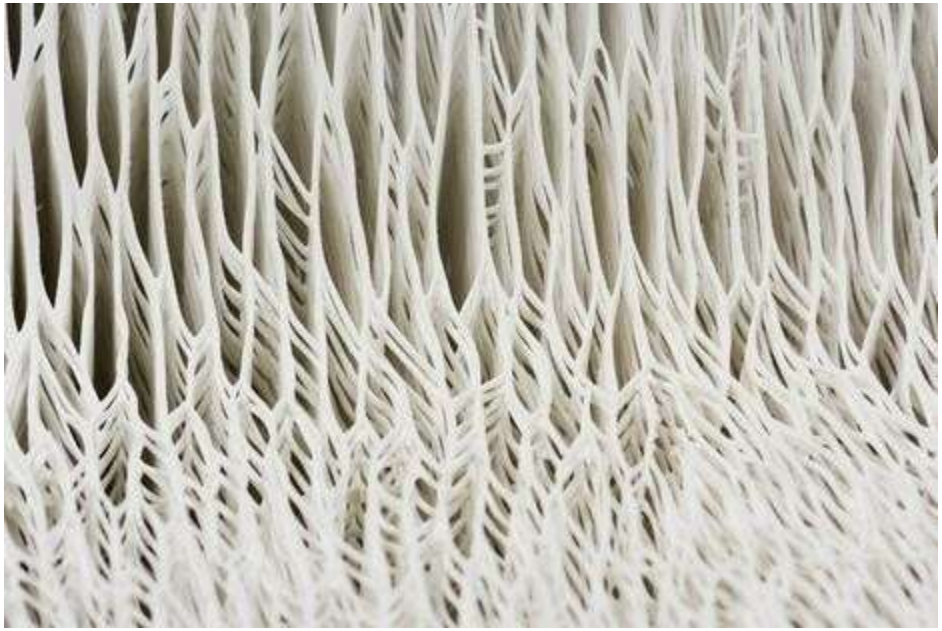
- Applications include underwater and space station uses.
- University of California - Berkeley created an array of synthetic micro-fibres using very high friction to support loads on smooth surfaces.
- Gecko-footed robots could climb to the roof and emplace permanent anchors for suspension of utilities, transportation, or even entire lunar bases.
- Tethers tipped with gecko-tech pads can extend the reach of robots and humans.
- Humans wearing a flexible skin-tight spacesuit with gecko-tech pads could climb over large rocks

Vibram shoes

Vibram shoes inspired by gecko's foot.

The manufacturer claims they have a natural feel and their grip aids walking, running and climbing.

Industrial design from trees and skeletal system



Conceptual Chair Inspired By 3D Printed Plant Cells

The Eiffel Tower weighs less than the air around it. It achieves this by exploiting the same structural ideas that make your bones so strong yet so light

Stuttgart Airport

Stuttgart Airport with multiple tree like columns in the interior to support the slanted roof structure

Material That Mimics Structure Of Bone

Scientists at KIT (Karlsruhe Institute of Technology) in Germany have created a lightweight but very strong material inspired by the intricate microscopic architecture of bones. The research could pave the way for future **super-light materials** that could be used in microfluidics devices or to make lighter (and thus cheaper) spacecraft.