PES UNIVERSITY

ENVIRONMENTAL STUDIES AND LIFE SCIENCES

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ENVIRONMENTAL STUDIES AND LIFE SCIENCES

BIOMIMETICS

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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.

In Europe, Japan, and the USA, biomimetics is being recognized as the technology of the future and there is increasing interest and funding.

In particular, global companies such as Ford, General Electric, Herman Miller, HP, IBM, and Nike are collaborating with scientists and designing laboratories to explore novel technologies.

BIOMIMETICS-Strategies and principles

- 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.
- 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.

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BIOMIMETICS- APPLICATION

CONSTRUCTION: Termite Den = Self Cooling Office Building

ENERGY: Whale Edged Fins = Energy Efficient Turbine Blades

MEDICAL: Shark Skin Structure = Anti-bacterial Surface

PACKAGING: Burrs of Burdock = Velcro (hook and loop fastener)

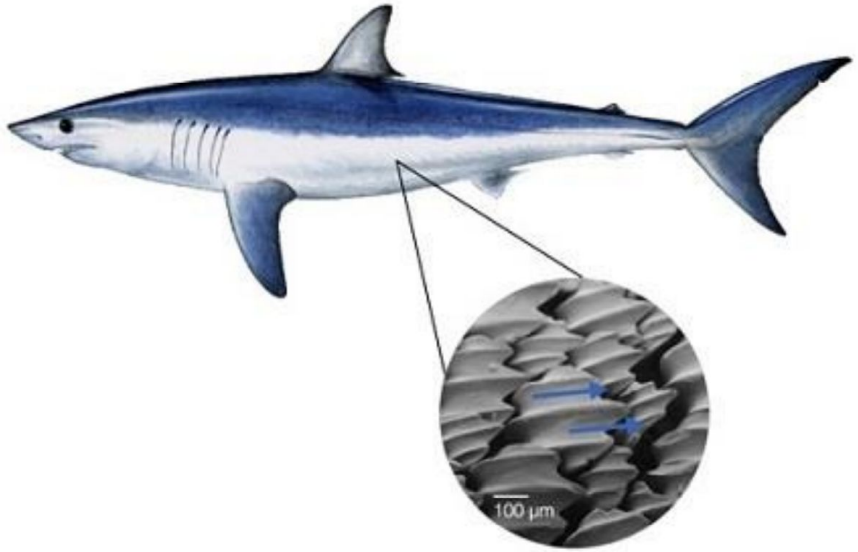
MOBILITY: Kingfisher beak = Low resistance/noise Train Design

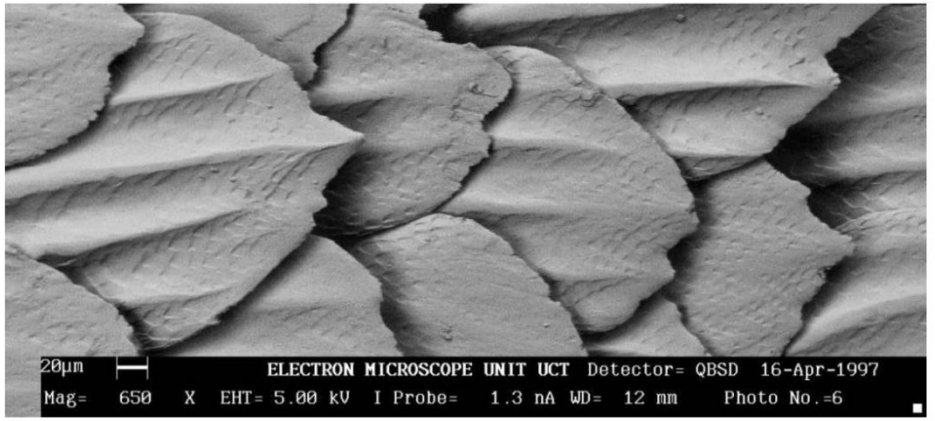
SELF-CLEANING: Lotus Leaves = Hydrophobic Paints/Surfaces

https://www.futurebridge.com/

BIOMIMETICS- APPLICATION

- 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.





https://illumin.usc.edu/

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BIOMIMETICS- APPLICATION

- 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.
- 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.

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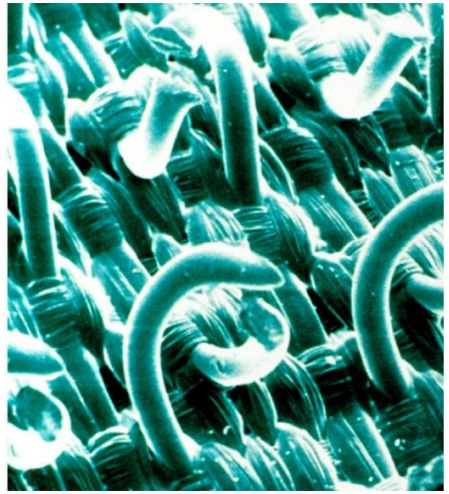
BIOMIMETICS- APPLICATION

- 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

https://www.bloomberg.com/



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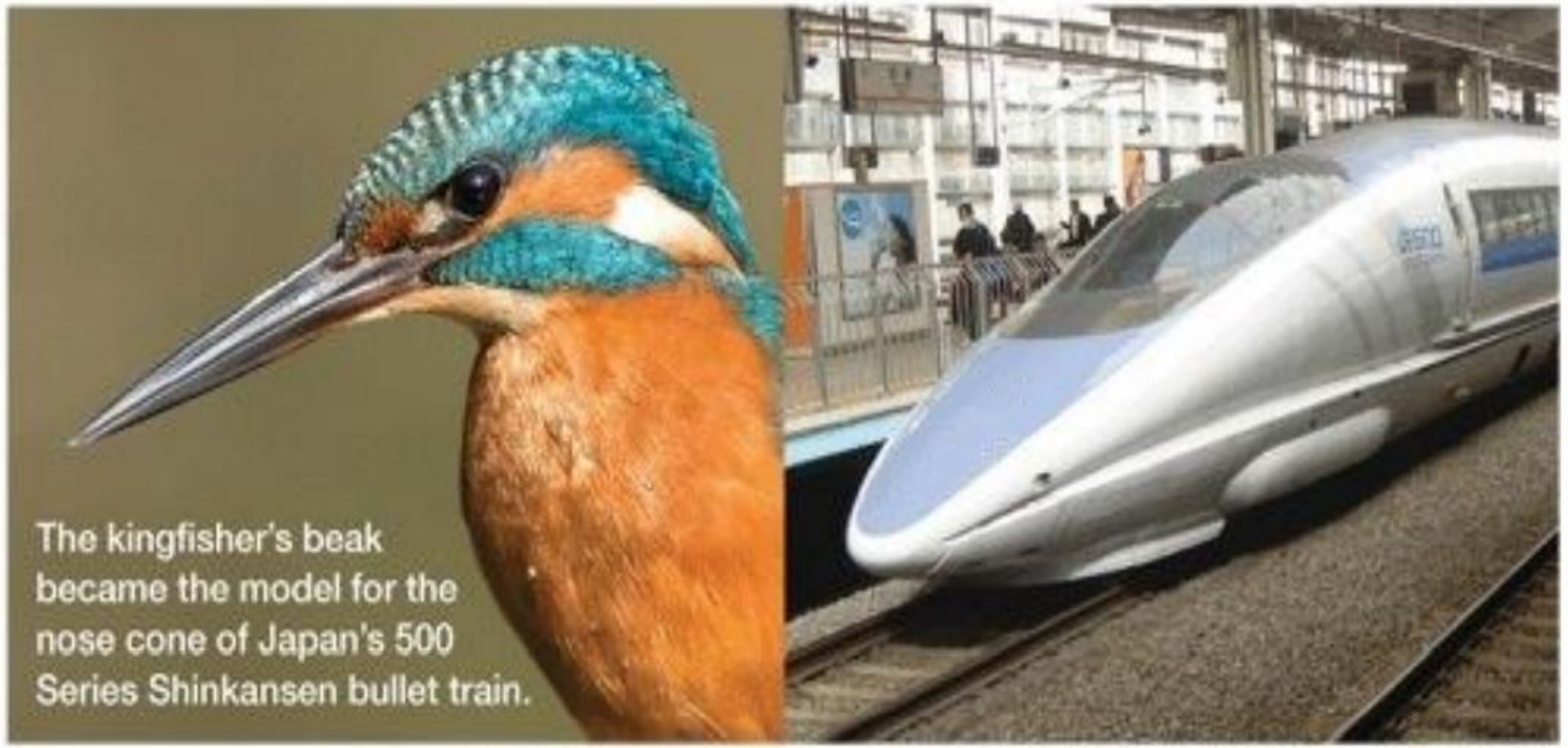
BIOMIMETICS- APPLICATION

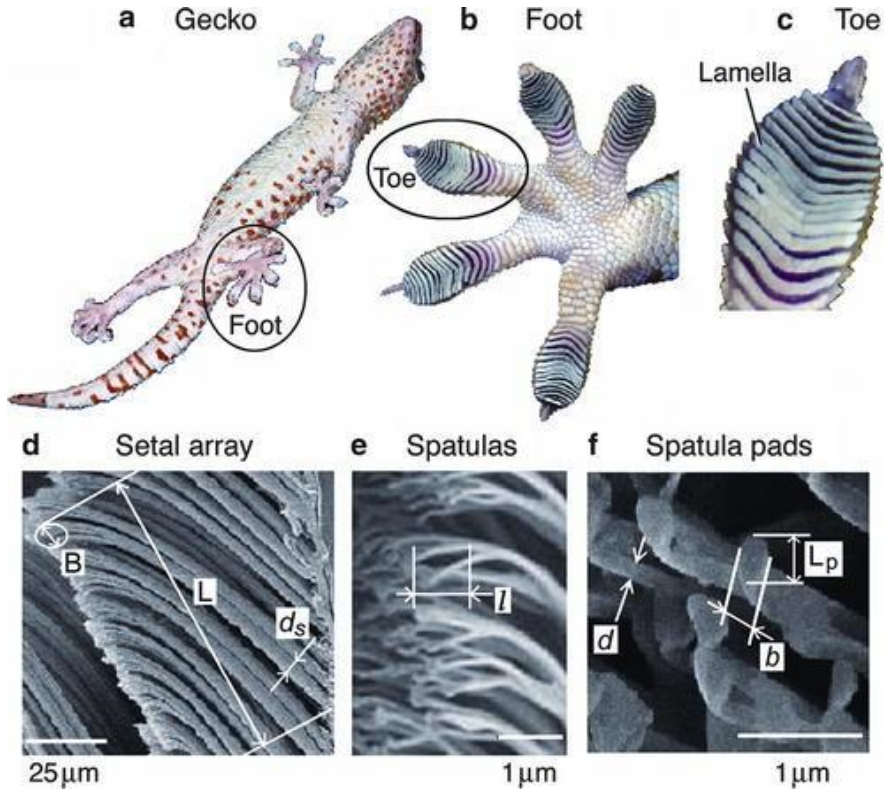


BIOMIMETICS- APPLICATION

- 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.
- 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.

BIOMIMETICS- APPLICATION

- Gecko is a nocturnal lizard which has adhesive pads on the feet to assist in climbing on smooth surfaces.
- Geckos hang single-toed from 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.



https://link.springer.com/

BIOMIMETICS- APPLICATION

- 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.
- 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.

https://link.springer.com/

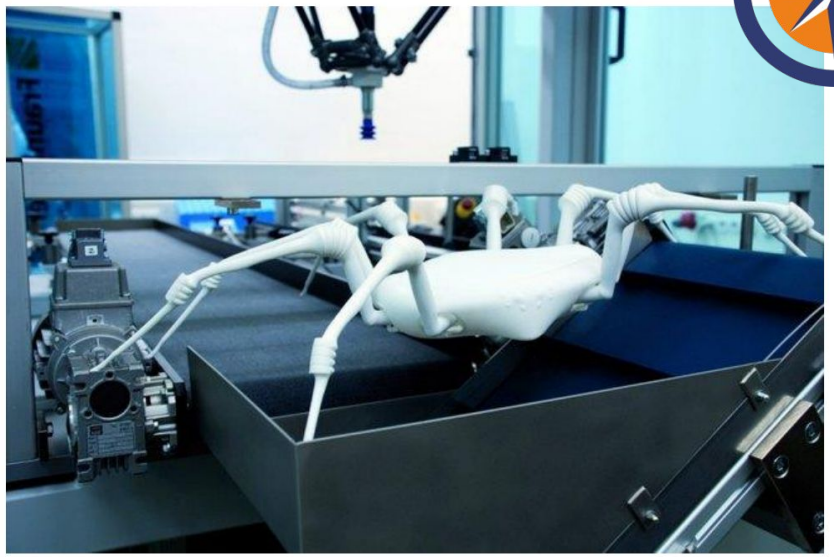
BIOMIMETICS- APPLICATION

- A butterfly's wings are one of nature's most remarkable materials.
- These tiny but complex structures reflect light in such a way that specific wavelengths interfere with each other to create intensely vivid colors one could only find in nature.
- By carefully studying this process, engineers at Qualcomm have been able to mimic this effect, allowing them to develop a system that produces colored electronic screens that are extremely efficient and can be viewed under any light conditions.

https://inhabitat.com/

BIOMIMETICS- APPLICATION

- The ability to squeeze through tight spaces and turn on a dime makes the spider an ideal model for lifesaving robots that could make their way through rubble after a disaster to locate survivors.
- Researchers at Germany's Frauenhofer Institute say this robot can be cheaply reproduced using 3D printers.
- After natural catastrophes and industrial or reactor accidents, or in fire department sorties, it can help responders, for instance by broadcasting live images or tracking down hazards or leaking gas.



https://www.theverge.com/

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BIOMIMETICS FOR SPACE APPLICATIONS

- Space environment, presents a challenging setting due to existing conditions of low to zero gravity, high temperature fluctuations, elevated levels of UV, electromagnetic and particulate radiation, reactive atomic oxygen, as well as natural micrometeoroids and space debris.
- There are recent advances in biomimetic research and developments within the space industry.
- Due to highly fluctuating temperatures within space environment enormous range of extremes, heat flow as well as temperature management and control are crucial steps to maintain the integrity of space systems.
- **Bio-inspired porous carbon** showed promising results regarding their thermal protection of spacecrafts during the re-entry process into planetary atmospheres.

doi.org/10.3389/frspt.2022.1000788

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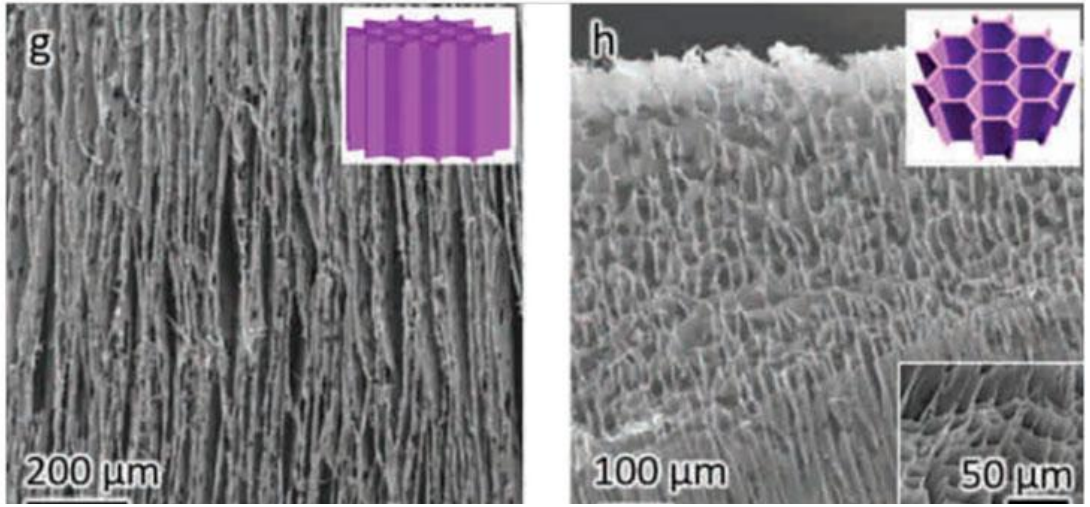
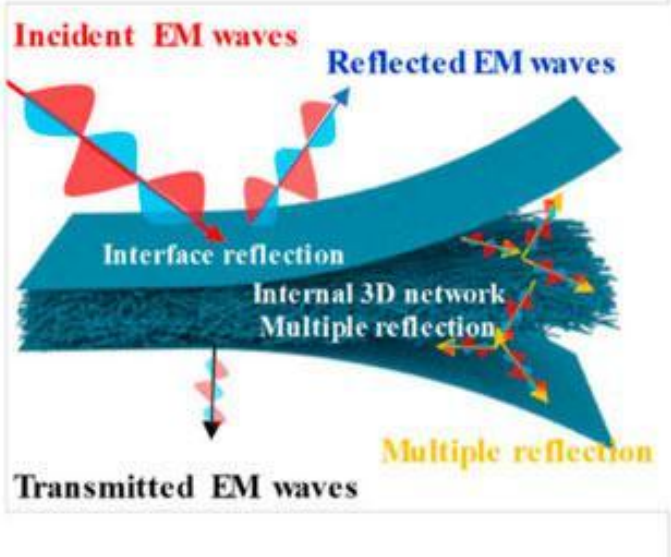
BIOMIMETICS FOR SPACE APPLICATIONS

- Recently, researchers have developed lightweight and flexible materials for the protection of structures and equipment against electromagnetic radiation.
- Experiments show that electromagnetic interference can be successfully shielded by substituting conventional metal shields with ones inspired by cellular architecture with tiny pores mimicking cell walls as aerogels.





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BIOMIMETICS FOR SPACE APPLICATIONS

- Landing of unmanned spacecrafts on surface of another planet is violent and associated with enormous impact forces.
- Several actions and measures have been taken to protect sensitive equipment and payloads against those forces.
- Option of dealing with high impact forces is demonstrated by the peel of the pomelo fruit.
- Peel of the pomelo fruit demonstrates a thick layer with open cell foam structure of varying pore size which protects the fruit inside from damage when falling from trees.
- This impact damping and energy dissipating capabilities are implemented in artificial versions of the foam to apply in space systems.

doi.org/10.3389/frspt.2022.1000788

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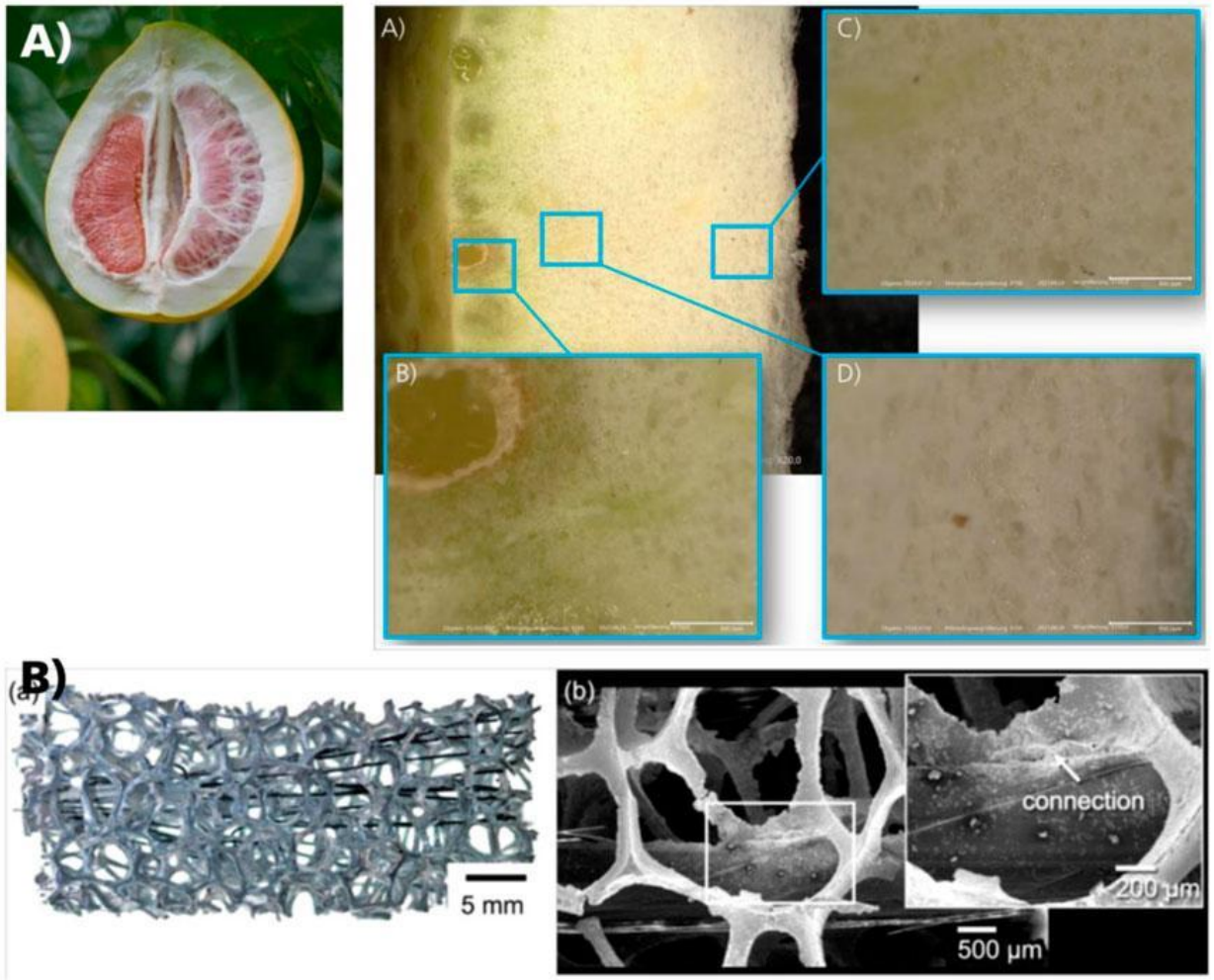
BIOMIMETICS FOR SPACE APPLICATIONS



Pomelo peel as dampener,
(A) Photographs of the honey pomelo's peel.
(B) Photograph of an Aluminium foam sample showing the connection between the fibre bundle and the foam matrix

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BIOMIMETICS FOR SPACE APPLICATIONS

- As space debris has become a major topic of concern, recent efforts have concentrated on space debris removal and mitigation measures.
- Robotic systems inspired by octopi arms have already been proposed for space debris removal.
- Their great mobility, maneuverability and adaptability makes them very suitable to wrap around complex target shapes.
- Seahorses use their tail for grasping activities involving different diameter objects.
- Arrangement like continuously decreasing square cross-section in their tail made from four individual plates connected through special joints, provide great bending and torsion abilities for grasping, especially of a diverse range of shapes and sizes.
- In addition, due to specialized construction, their tails shows great fracture resistances under crushing and impact forces.

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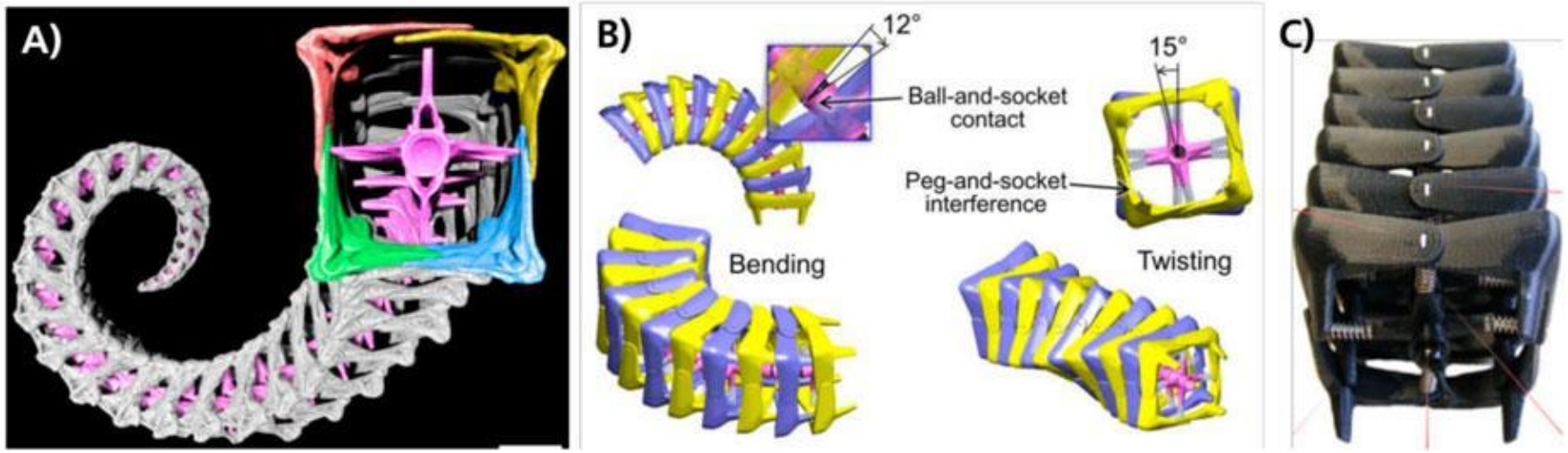
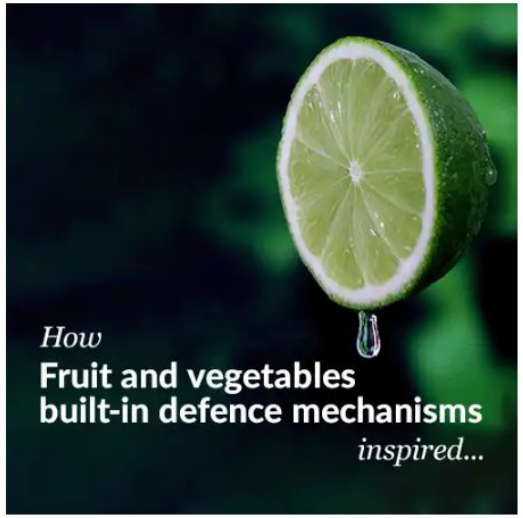
BIOMIMETICS FOR SPACE APPLICATIONS



Seahorse tail inspired robotic arm

doi.org/10.3389/frspt.2022.1000788

BIOMIMETICS OTHER APPLICATIONS



Plant based volatiles inspired packaging sachets – GreenPod Labs

With ~40% of fresh produce lost before it reaches consumers, Greenpod Labs have created bio-inspired packaging sachets that mimic the built-in defense mechanisms within specific fruits or vegetables, in order to slow down the ripening rate and minimize microbial growth. These are called plant-based volatiles, and the right formulation reduces the need for cold storage and cold supply chains.

https://www.learnbiomimicry.com/

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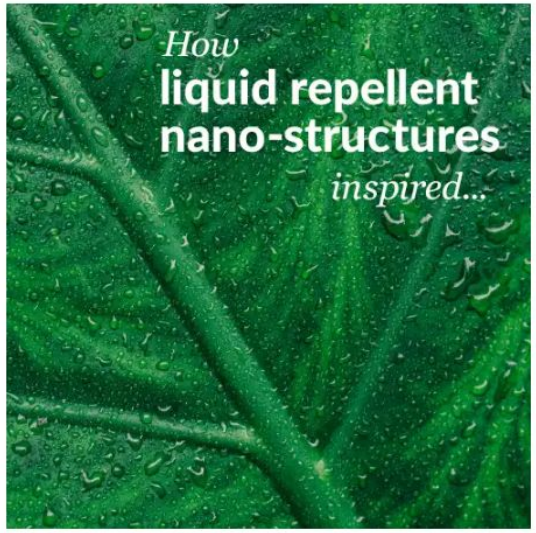
BIOMIMETICS OTHER APPLICATIONS



Nano structured inspired waterproof and breathable Textiles – Amphibio

Using textiles made from one source material, they've accomplished creating a new recyclable and PFC-free alternative for the outdoor and sportswear industry (think the future Coretex 2.0). Removing the need for any chemical treatments, Amphibio has mitigated two of the biggest barriers to sustainable textile production today - one material and no need for any chemical treatments.

https://www.learnbiomimicry.com/

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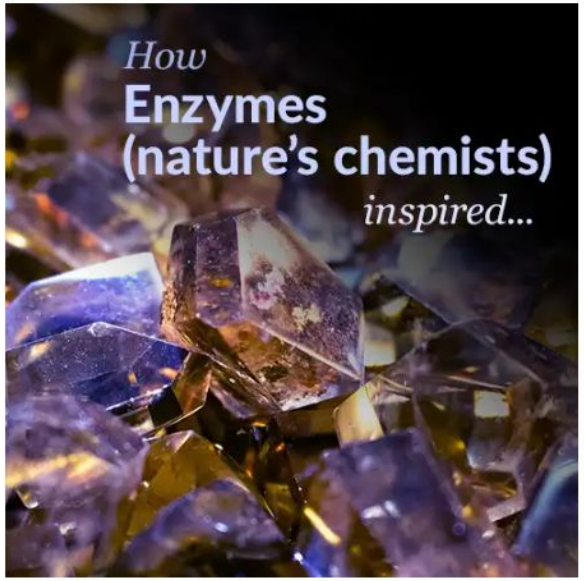
BIOMIMETICS OTHER CURRENT APPLICATIONS



Embedding enzymes for better plastic degradation - Intropic Materials

Intropic Materials is solving plastic waste from the inside out by embedding enzymes directly inside specific plastics to speed up natural degradation. These plastics break down at the end of use into biodegradable or chemically recyclable small molecules without producing microplastics, in accessible life-friendly conditions like warm water baths or compost.

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THANK YOU

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