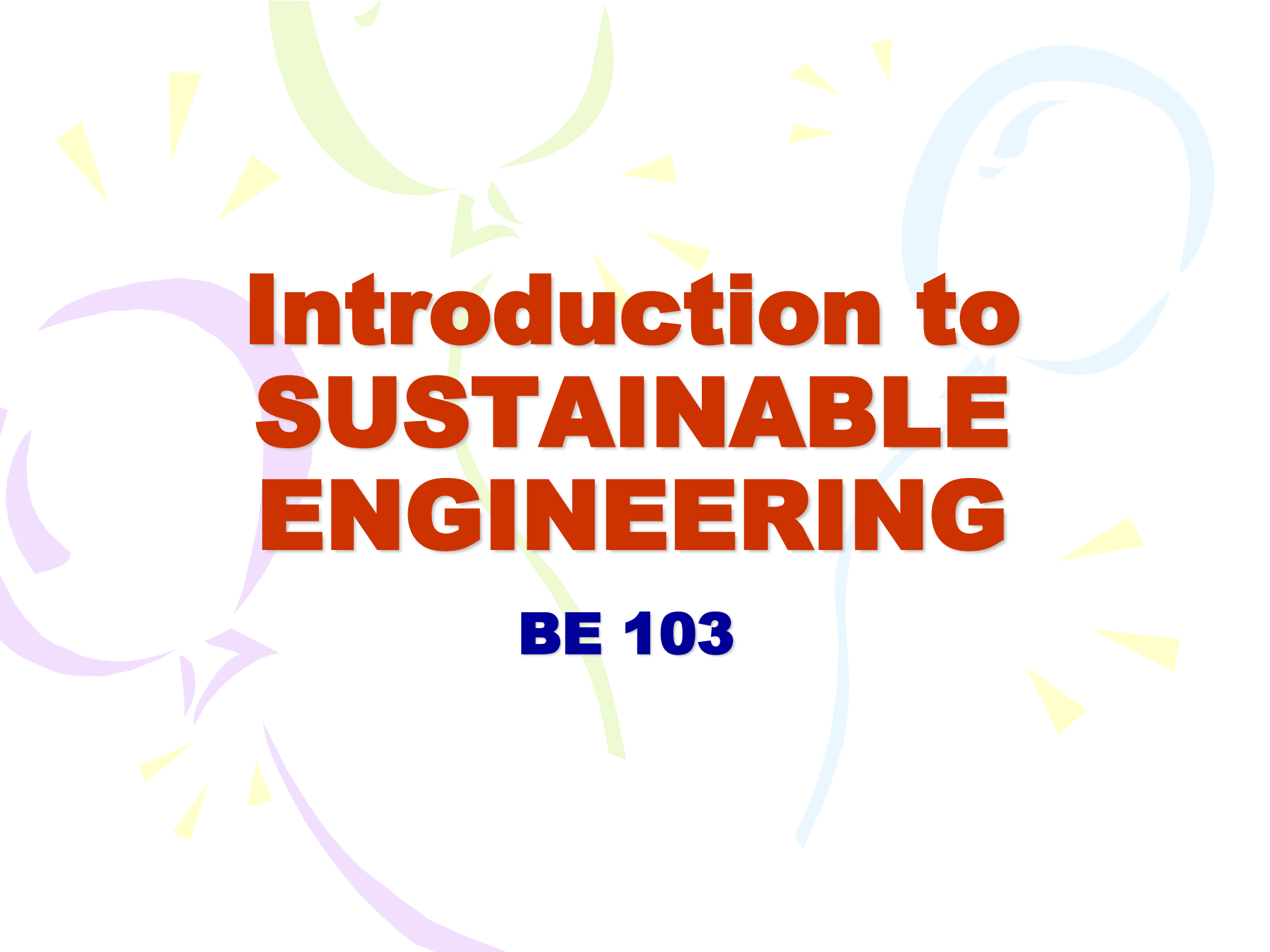




Introduction to SUSTAINABLE ENGINEERING

BE 103

Module III

- **Environmental management standards**
- **ISO 14000 series**
- **Life Cycle Analysis (LCA)**
 - **Scope and Goal**
- **Bio-mimicking**
- **Environment Impact Assessment (EIA)**
 - **Procedures of EIA in India**

Module III (Contd.)

- **Conducting LCA of**
 - **products**
 - ❖ **eg. Aluminium cans, PVC bottles, cars etc.**
 - **or**
 - **activities**
 - ❖ **Comparison of land filling and open burning**
- **Conducting an EIA study of a small project**
 - **eg. Construction of a building**



BIOMIMICKING

Biomimicry

- **The practice of developing sustainable human technologies inspired by nature**
- **Also called Biomimetics or Bionics**
- **Basically biologically inspired engineering**



Inventor of biomimics

- **Otto Schmitt
(1913 – 1998)**

- **an American inventor,
engineer, and biophysicist**
- **Schmitt trigger based on
working of human nervous
system**



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HOW DID IT BEGIN?

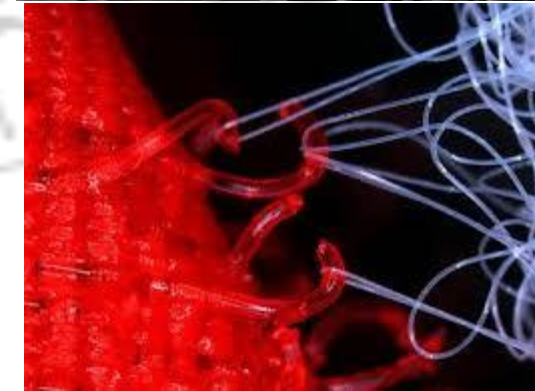
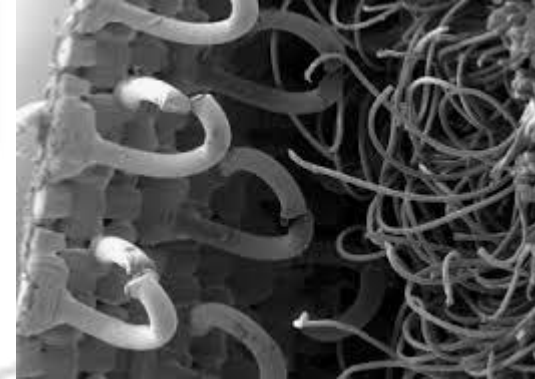
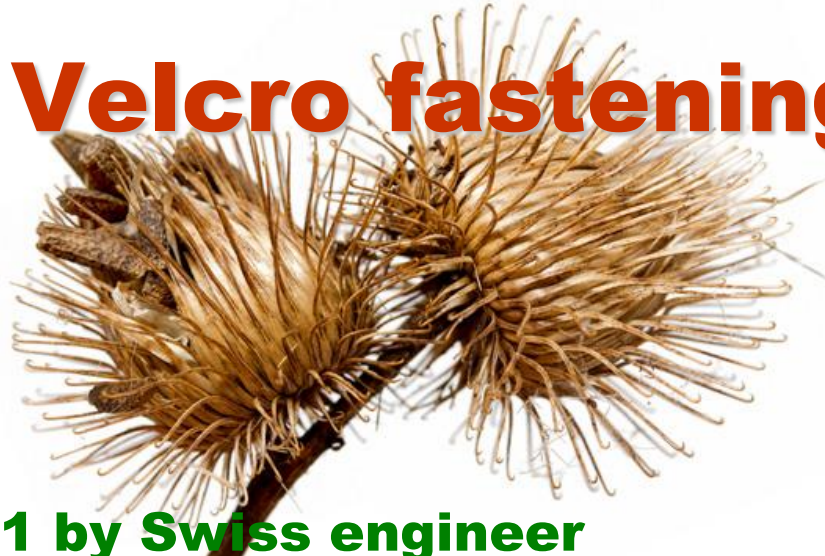
- ❖ **American writer and scientific observer from Montana, USA**
- ❖ **Wrote the book “Biomimicry: Innovation Inspired by Nature” in 1997**
- ❖ **The book gives an insight on how significant biomimicry is in shaping the future**
- ❖ **In 1998 she co-founded the Biomimicry Guild which helps inform, inspire and empower the bridging of nature’s wisdom with human knowledge.**



PHOTO: BRIAN SMALE

Janine M. Benyus (1958)

Velcro fastening



- ❖ **Invented in 1941 by Swiss engineer George de Mestral**
- ❖ **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**
 - o **strips or patches of a hooked material**
 - o **strips or patches of a loose-looped weave of nylon that holds the hooks**

Passive Cooling



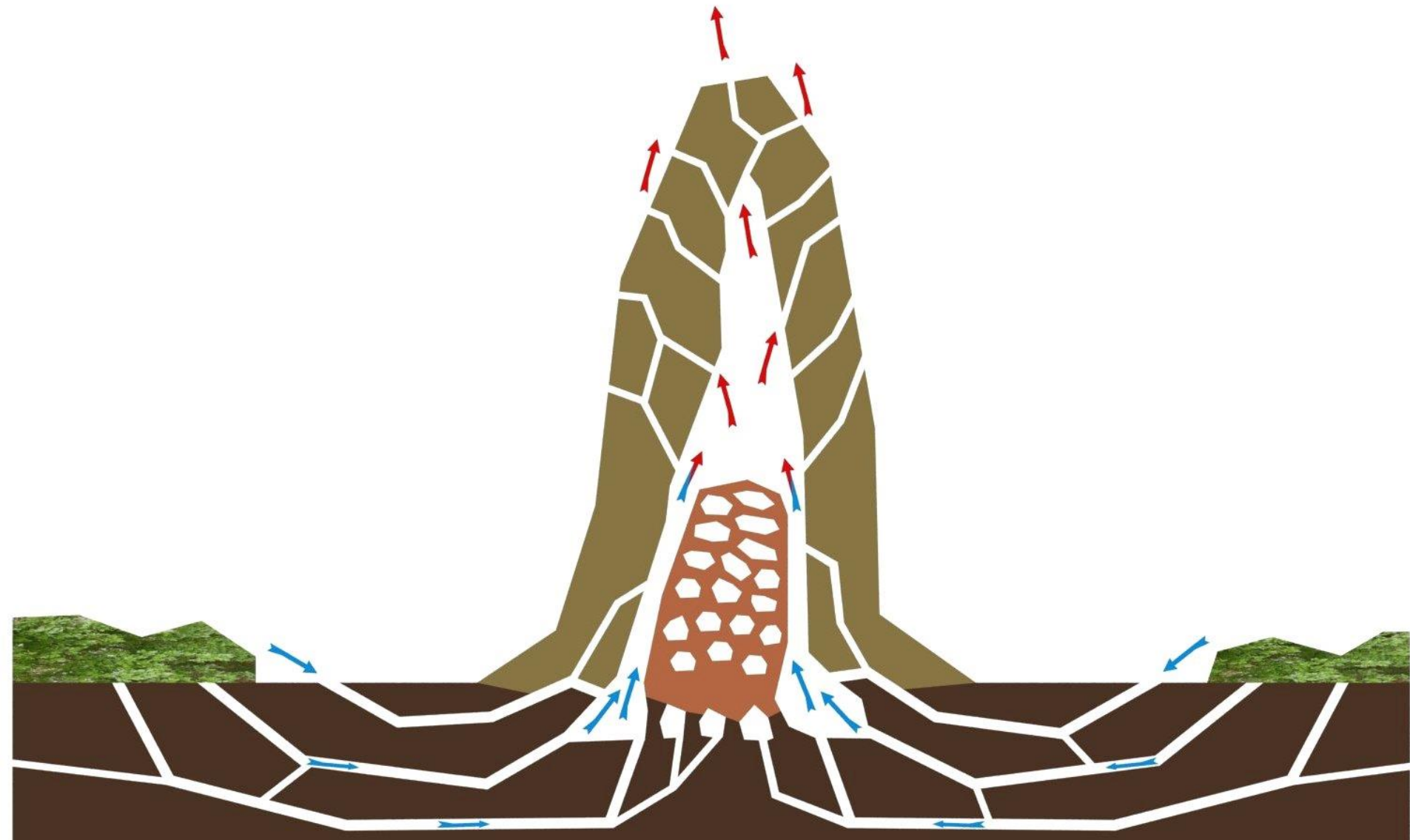
- ❖ **The high-rise Eastgate Centre building in Harare, Zimbabwe was designed to mimic the way that those tower-building termites in Africa construct their mounds to maintain a constant temperature**
- ❖ **The insects do this by constantly opening and closing vents throughout the mound to manage convection currents of air - cooler air is drawn in from open lower sections while hot air escapes through chimneys.**
- ❖ **The innovative building uses similar design and air circulation planning while consuming less than 10% of the energy used in similar sized conventional buildings!**

Termite mound

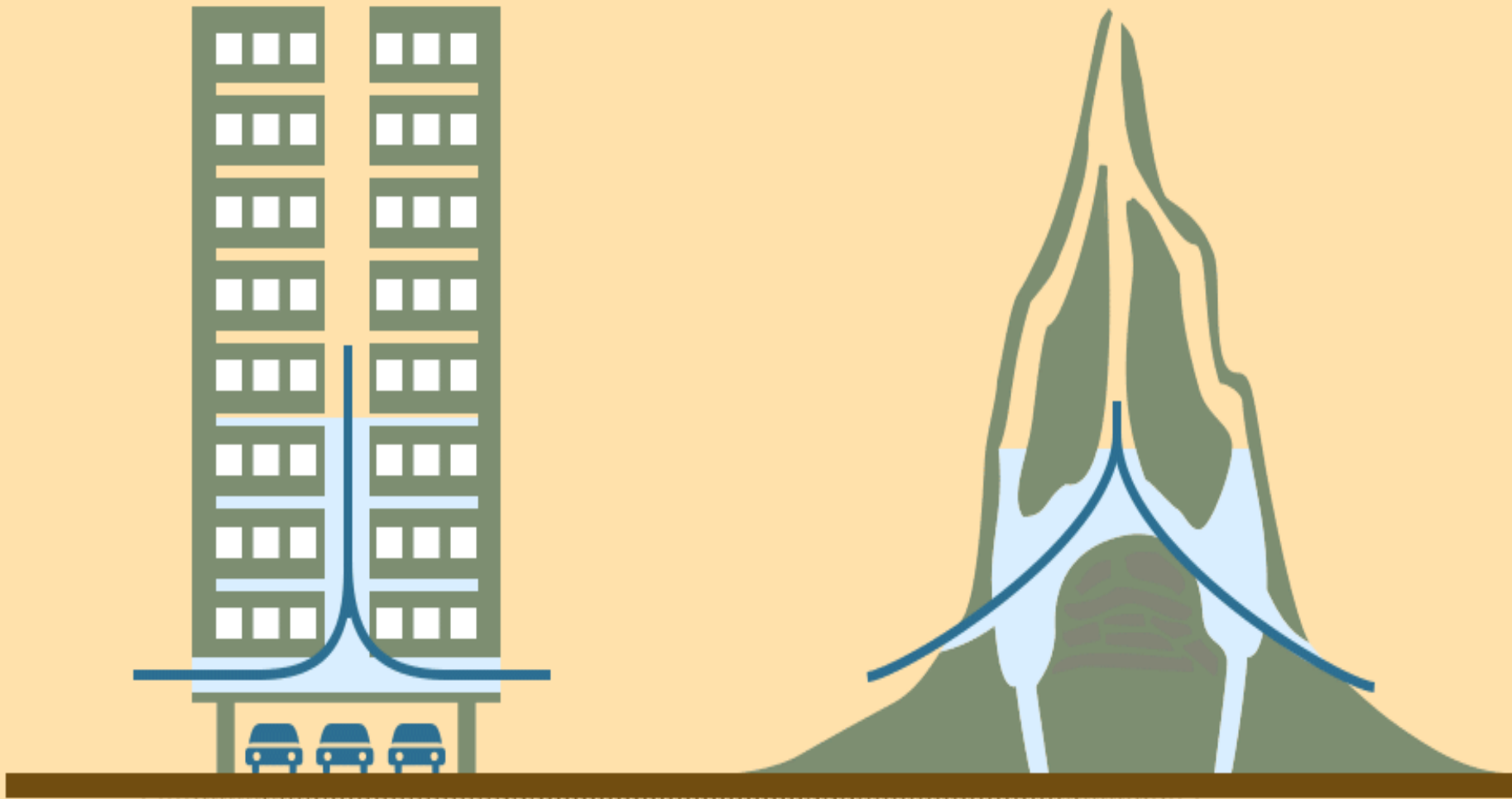


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Ventilation in termite mound



BIOMIMICRY



**Eastgate Centre
building in
Harare,
Zimbabwe**



Eastgate Centre building in Harare, Zimbabwe



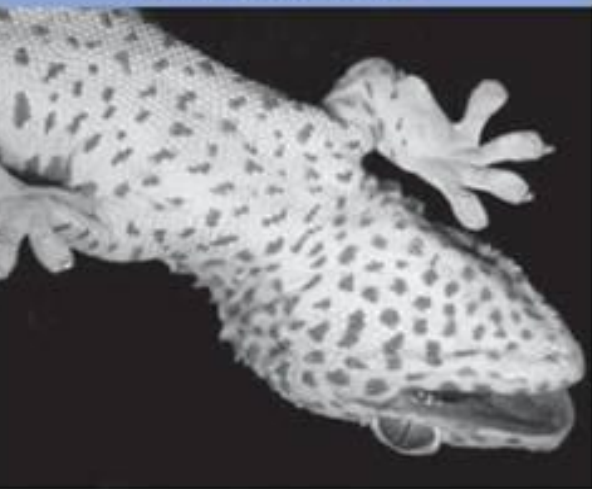
Gecko Tape



- ❖ **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.**
- ❖ **Applications include underwater and space station uses.**

Gecko feet

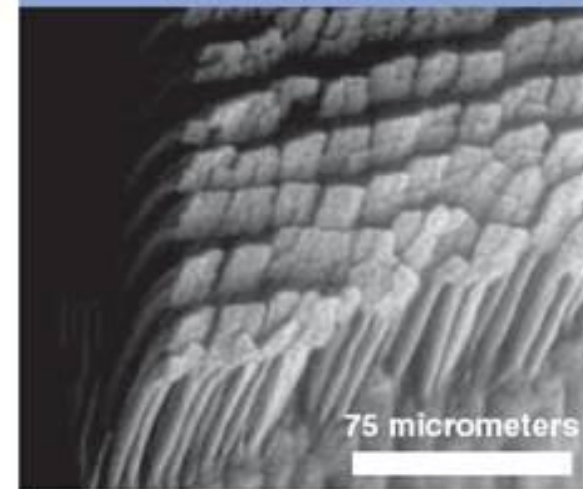
macrostructure



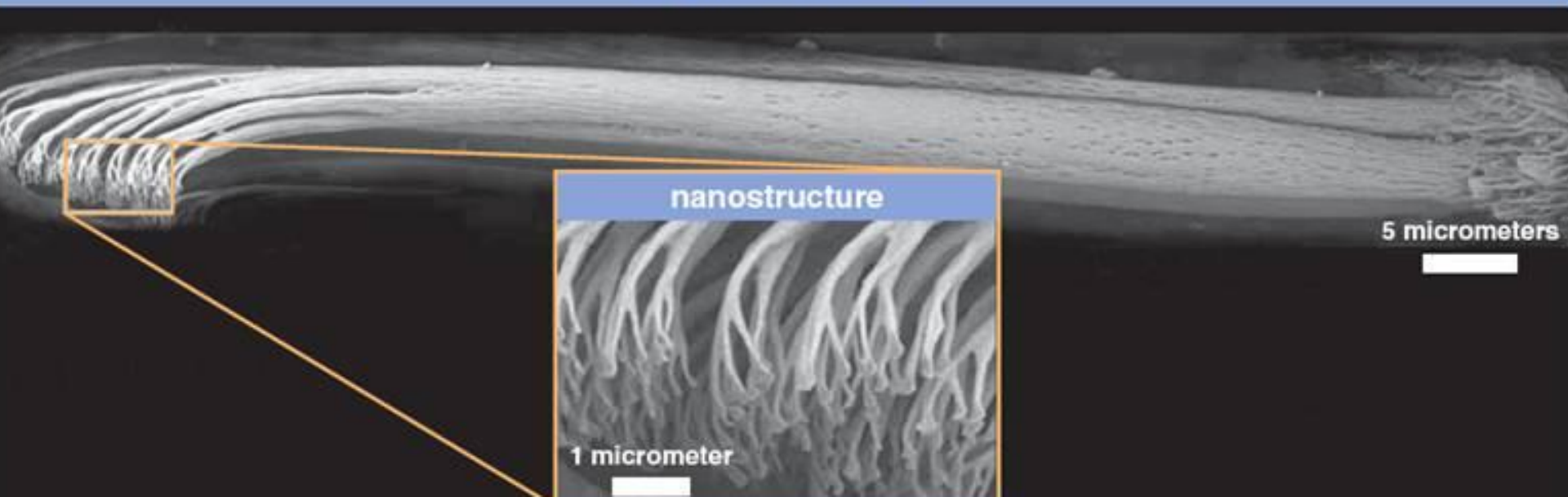
mesostructure



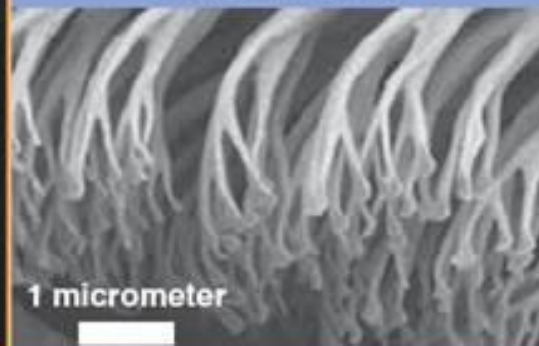
microstructure



fine microstructure



nanostructure

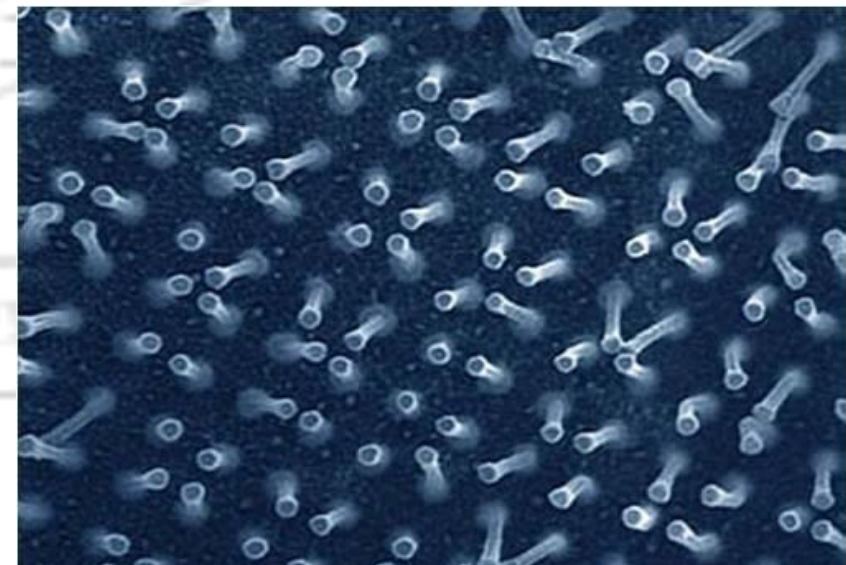
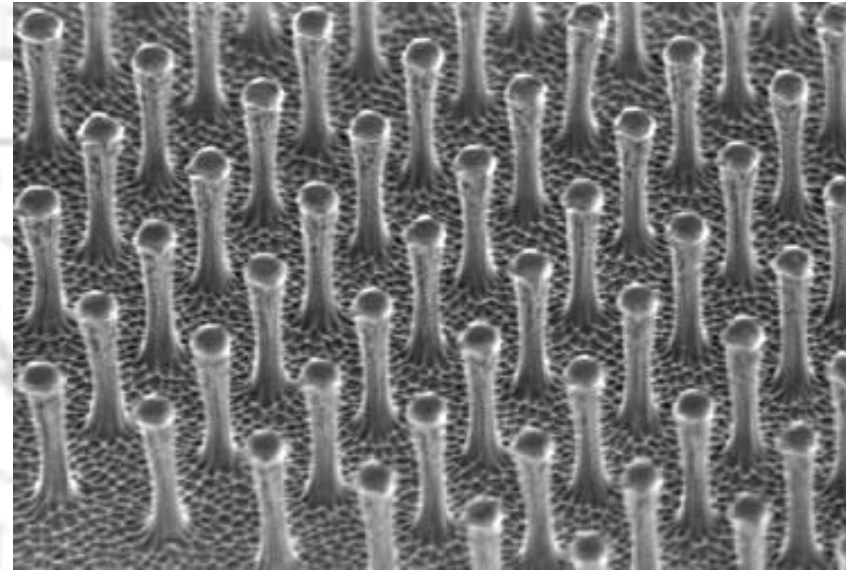


Gecko feet

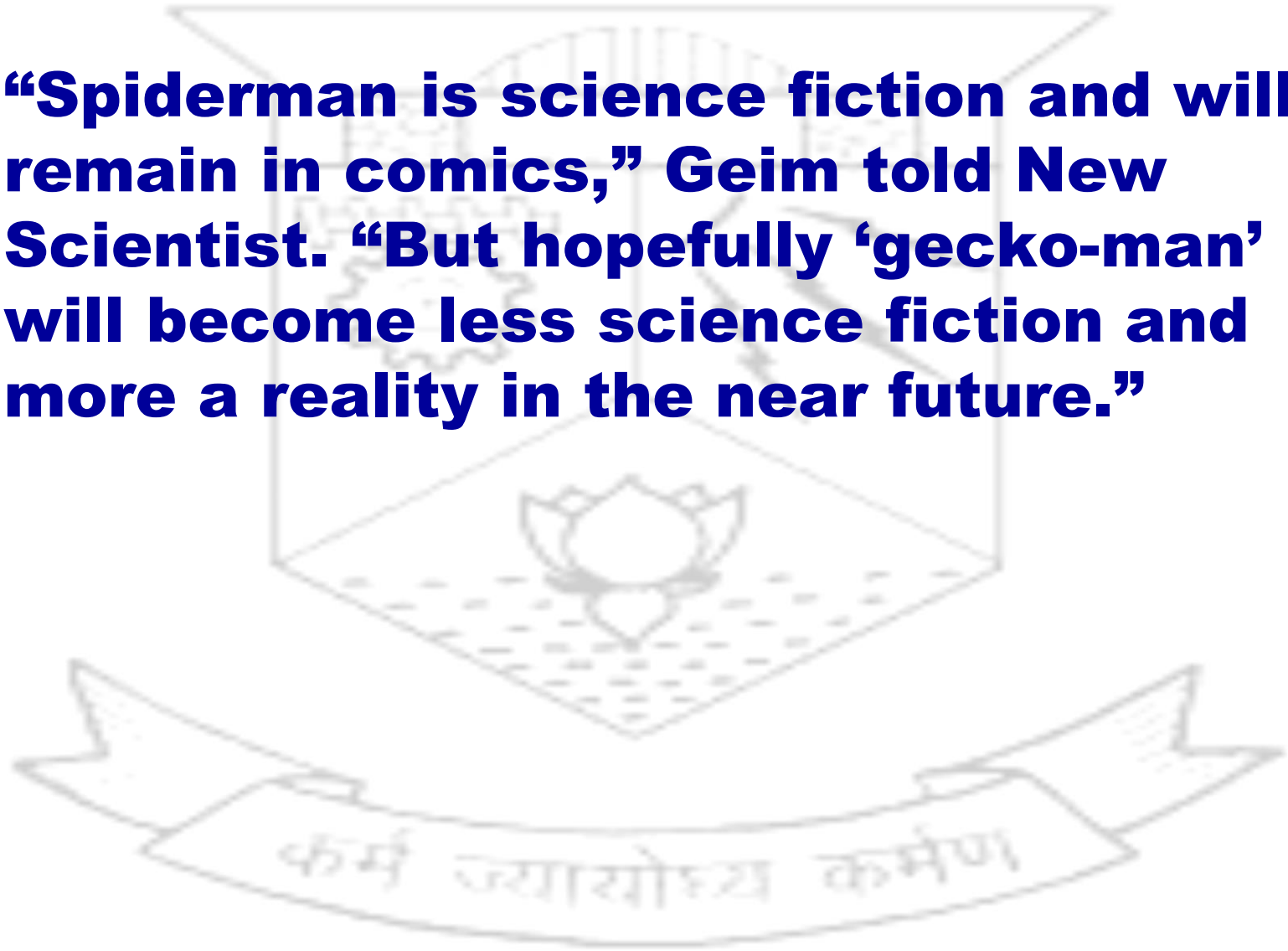
- **Geckos can climb even the most slippery surface with ease and hang from glass using a single toe.**
- **The secret behind this extraordinary climbing skill lies with millions of tiny keratin hairs – called setae – on the surface of each foot.**
- **An intermolecular phenomenon known as van der Waals force is exerted by each of these hairs. Although the force is individually miniscule, the millions of hairs collectively produce a powerful adhesive effect**

Gecko tape

- o The researchers found that the synthetic hairs had to be soft and flexible enough to attach to uneven surfaces but not so weak that they would break easily or bunch together. The substrate that the hairs were mounted on also had to be sufficiently flexible for the material to work.
- o Each synthetic hair is made from a material called kapton and measures 2.0 microns in height and 0.2 microns in diameter – the same as gecko hairs.
- o A piece of tape one centimetre square holds around 100 million of these artificial setae and could support a weight of one kilogram



- **“Spiderman is science fiction and will remain in comics,” Geim told New Scientist. “But hopefully ‘gecko-man’ will become less science fiction and more a reality in the near future.”**





Surrounded by other team members, Achim Oesert from the University of Kiel hangs from the ceiling using bioinspired polymer tape (Image: University of Kiel) alongside an image of a gecko

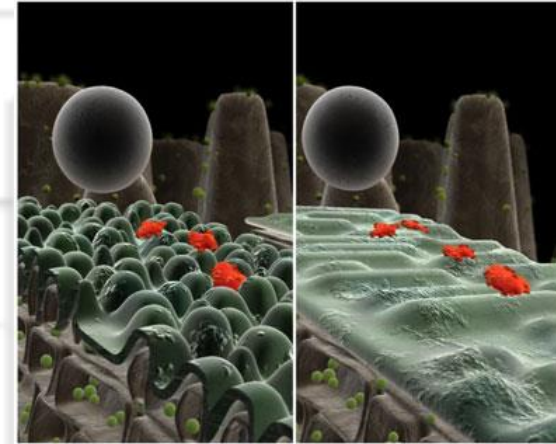
Lotus Effect Hydrophobia

❖ The Lotus Effect:

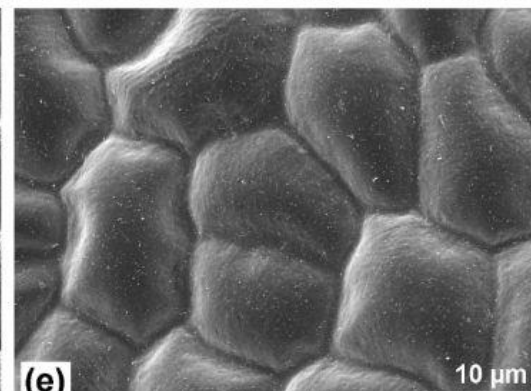
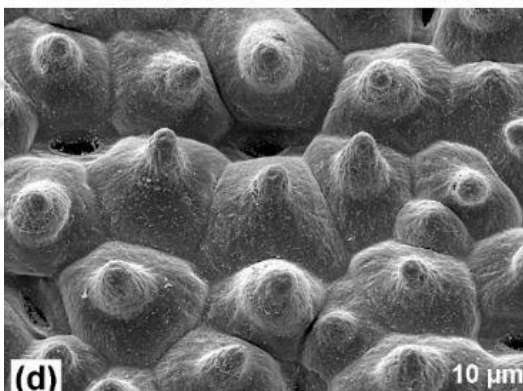
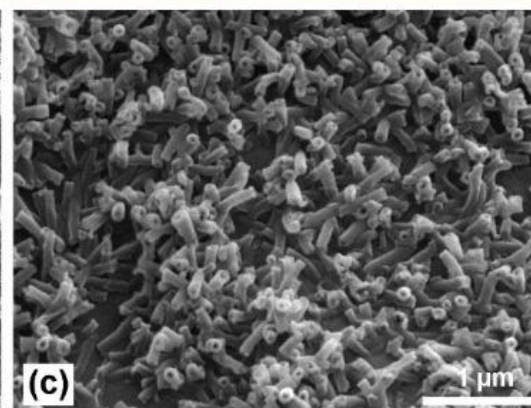
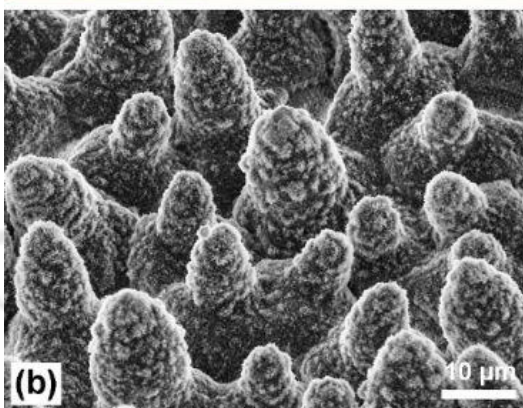
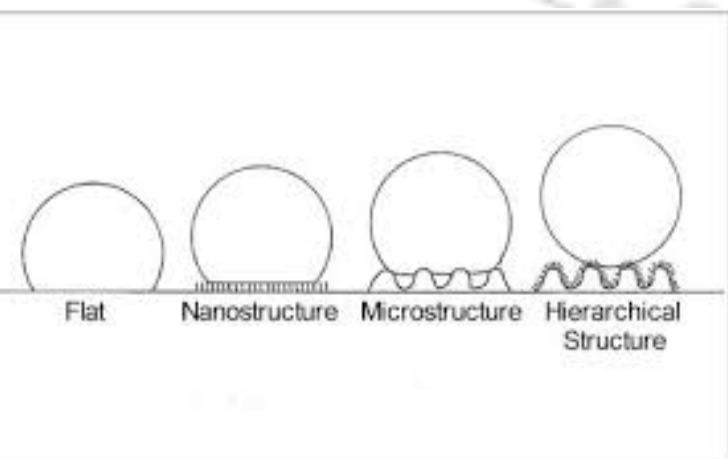
- o The surface of lotus leaves are bumpy
- o This causes water to bead as well as to pick up surface contaminants in the process
- o The water rolls off, taking the contaminants with it

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

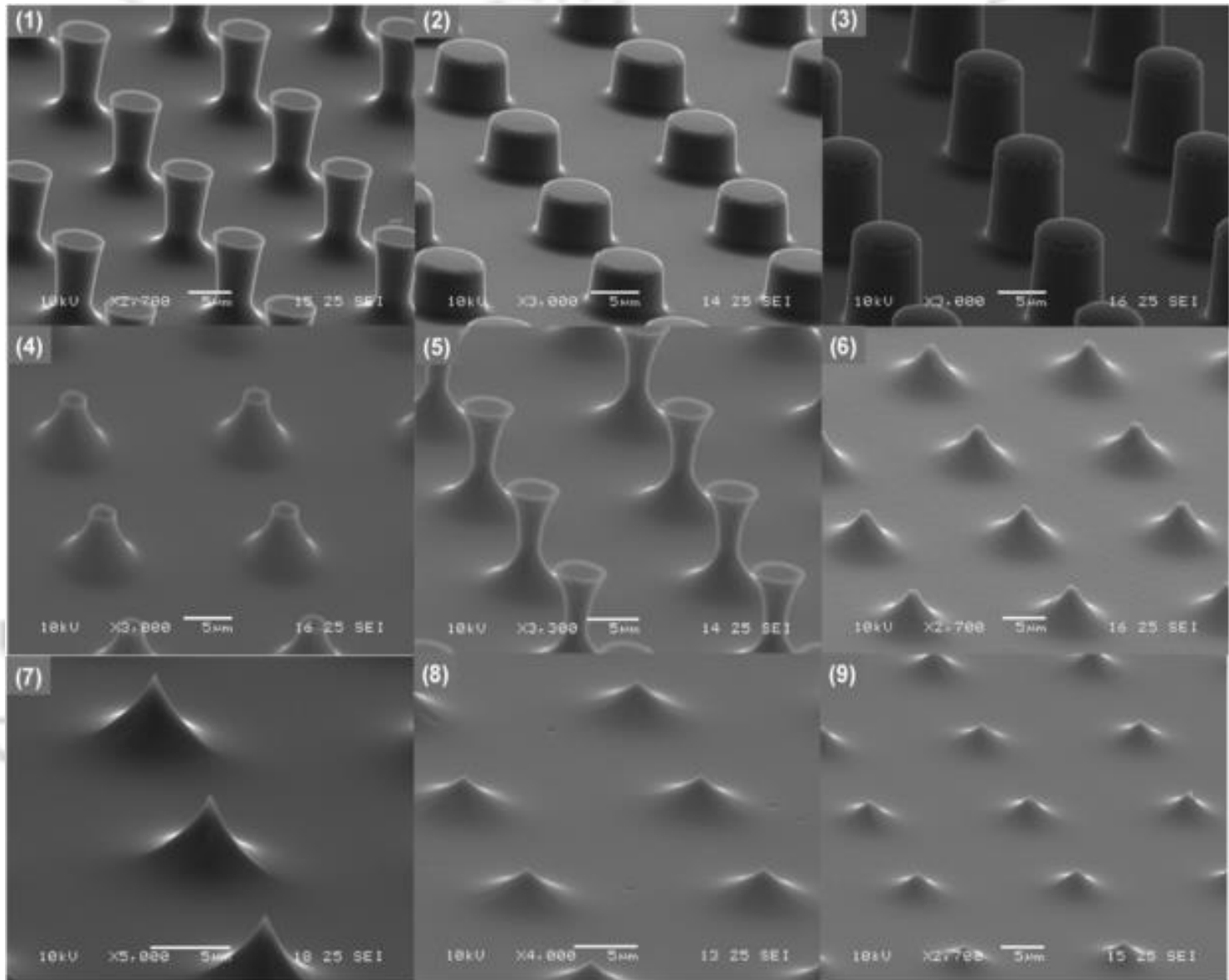
❖ Applications are nearly endless, and not just making windshield wipers and car wax jobs obsolete



Nanoscopic view of the surface of a lotus leaf



Nano scopic of the plastic surface



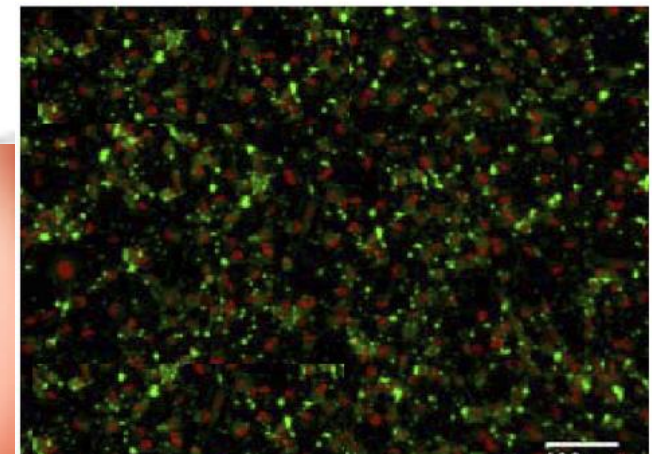
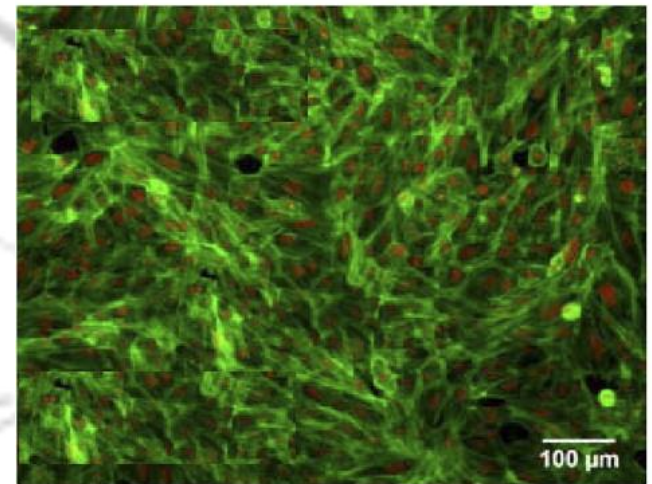
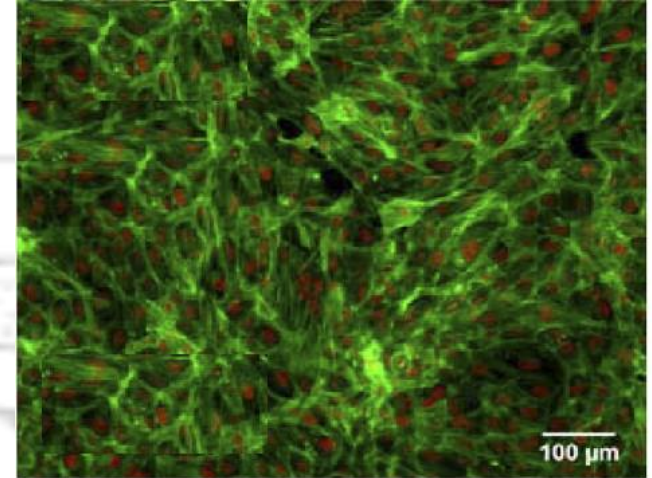
Self-Healing Plastics



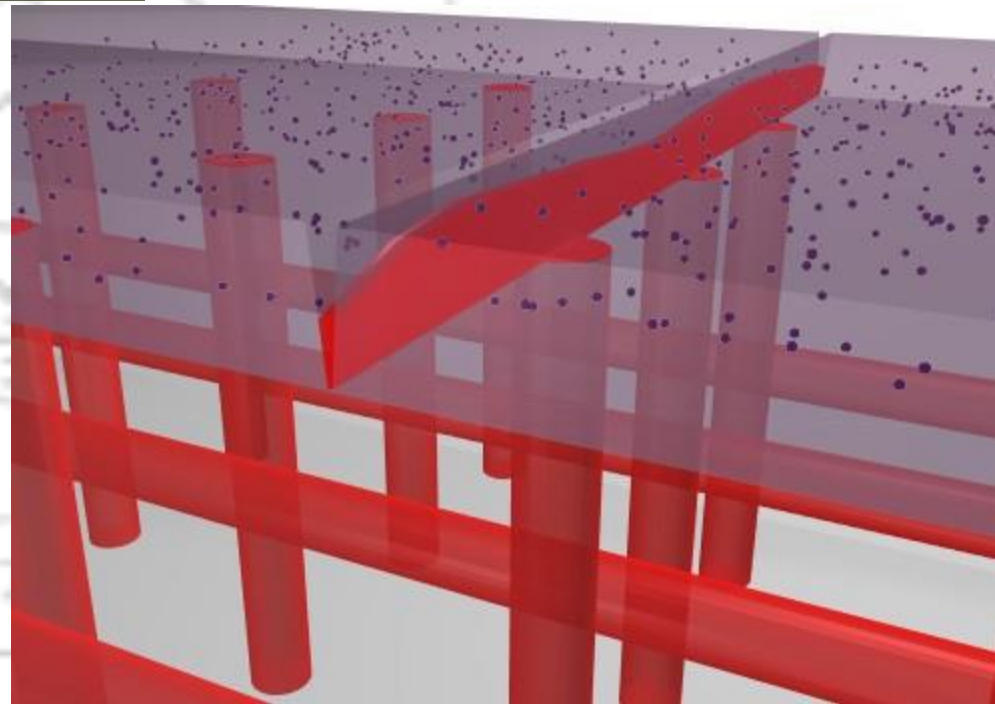
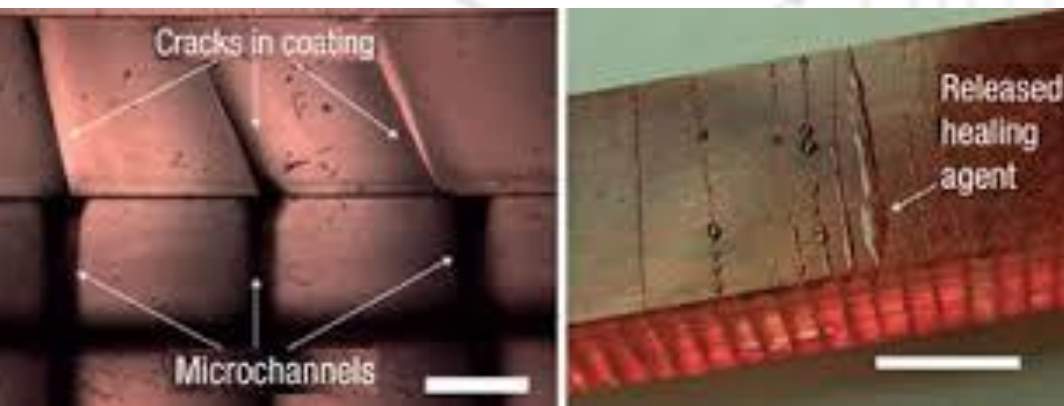
- o **Consider the body's power to heal itself of scrapes and cuts**
- o **The value of the same sort of process in light polymer composites that can be used to produce things like aircraft fuselage becomes obvious. The new composite materials being developed are called self-healing plastics.**
- o **They are made from hollow fibres filled with epoxy resin that is released if the fibres suffer serious stresses and cracks. This creates a 'scab' nearly as strong as the original material. Such self-healing materials could be used to make planes, cars and even spacecraft that will be lighter, more fuel efficient, and safer.**

➤ Healing of wound

- ❖ Immediately upon wounding soft tissue, the fluids (blood, lymph and other fluids) in our body leak from the broken tissue. Almost immediately though, the body springs into action.
- ❖ As soon as the injury occurs, your body starts trying to patch the leaks and contain the damage. Your body quickly builds thin membranes around the injury to stop the bleeding.



Self healing plastic



Self healing plastic



Before



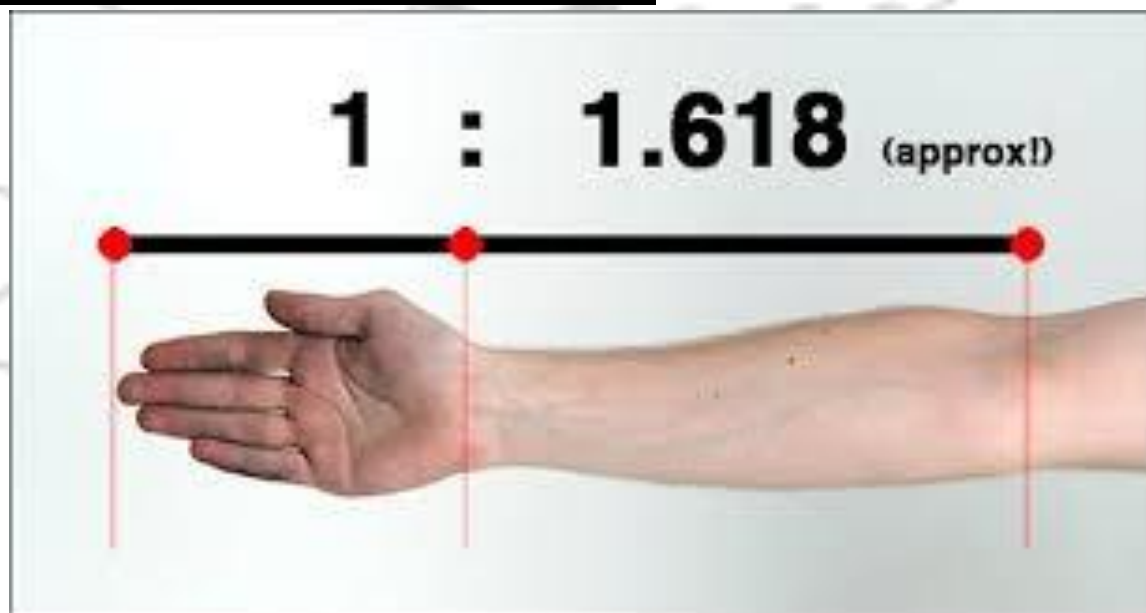
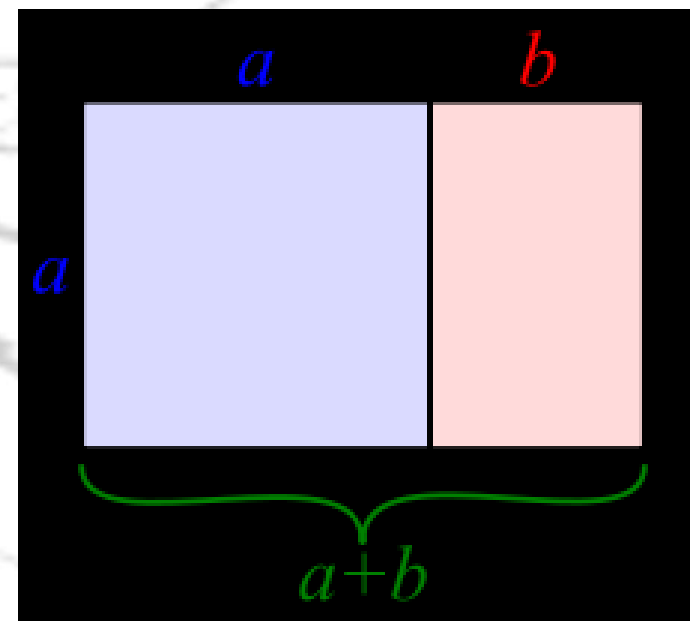
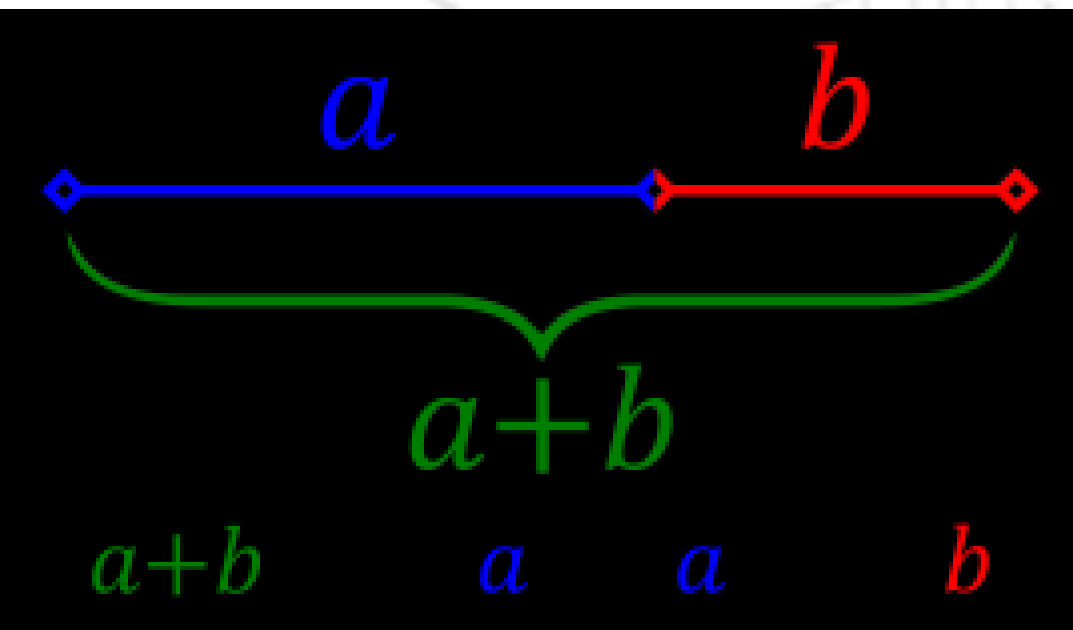
After

The Golden Streamlining Principle

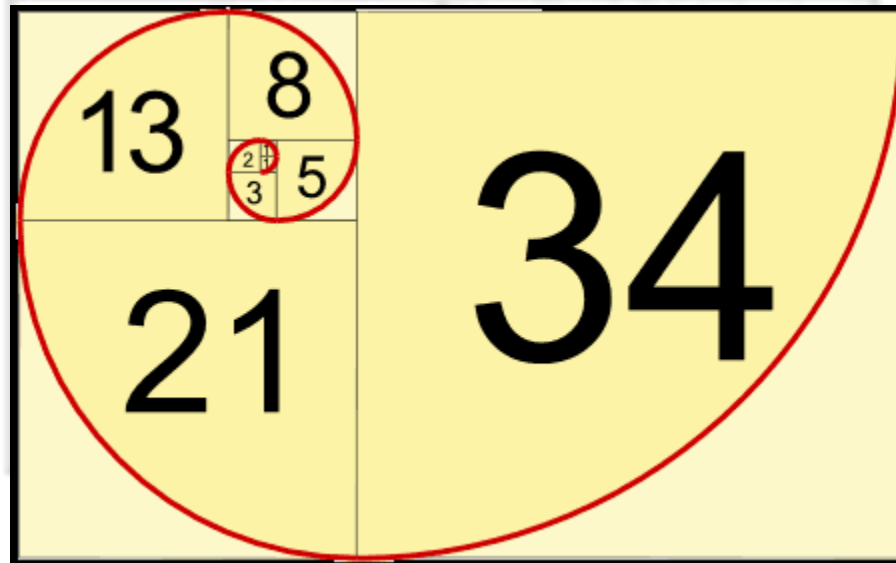


- o A company called PAX Scientific out of San Rafael, California has been developing air and fluid movement technologies based on such beautiful and recurring natural designs as the Fibonacci sequence, logarithmic spirals and the Golden Ratio.
- o These shapes align with the observation that the path of least resistance in this universe isn't a straight line.
- o Put all this together and you get the "Streamlining Principle," being applied to fans, mixers, impellers and such that move air and liquids around in systems. Such fans on motors, compressors and pumps of all sizes and in all applications could save at least 15% of all the electricity consumed in the US.

Golden ratio



Fibonacci / logarithmic spiral



Fibonacci series

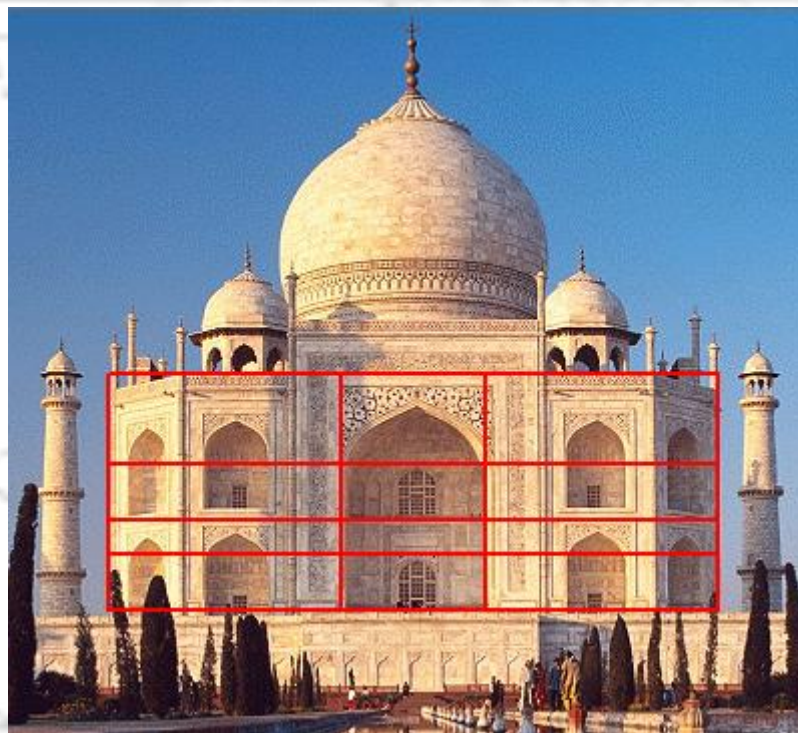


Fibonacci / logarithmic spiral

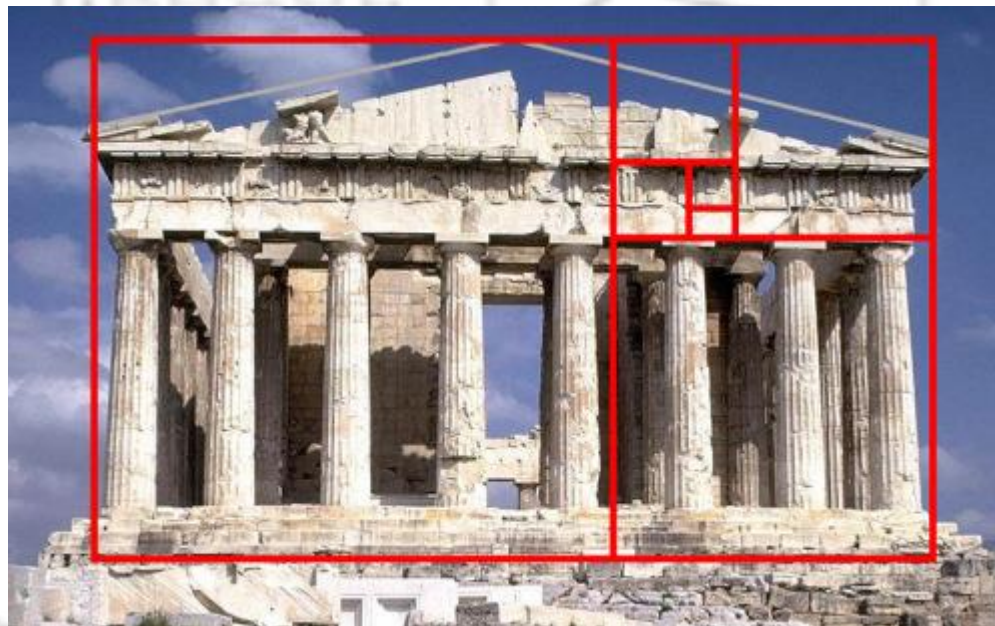


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Golden ratio



Golden ratio

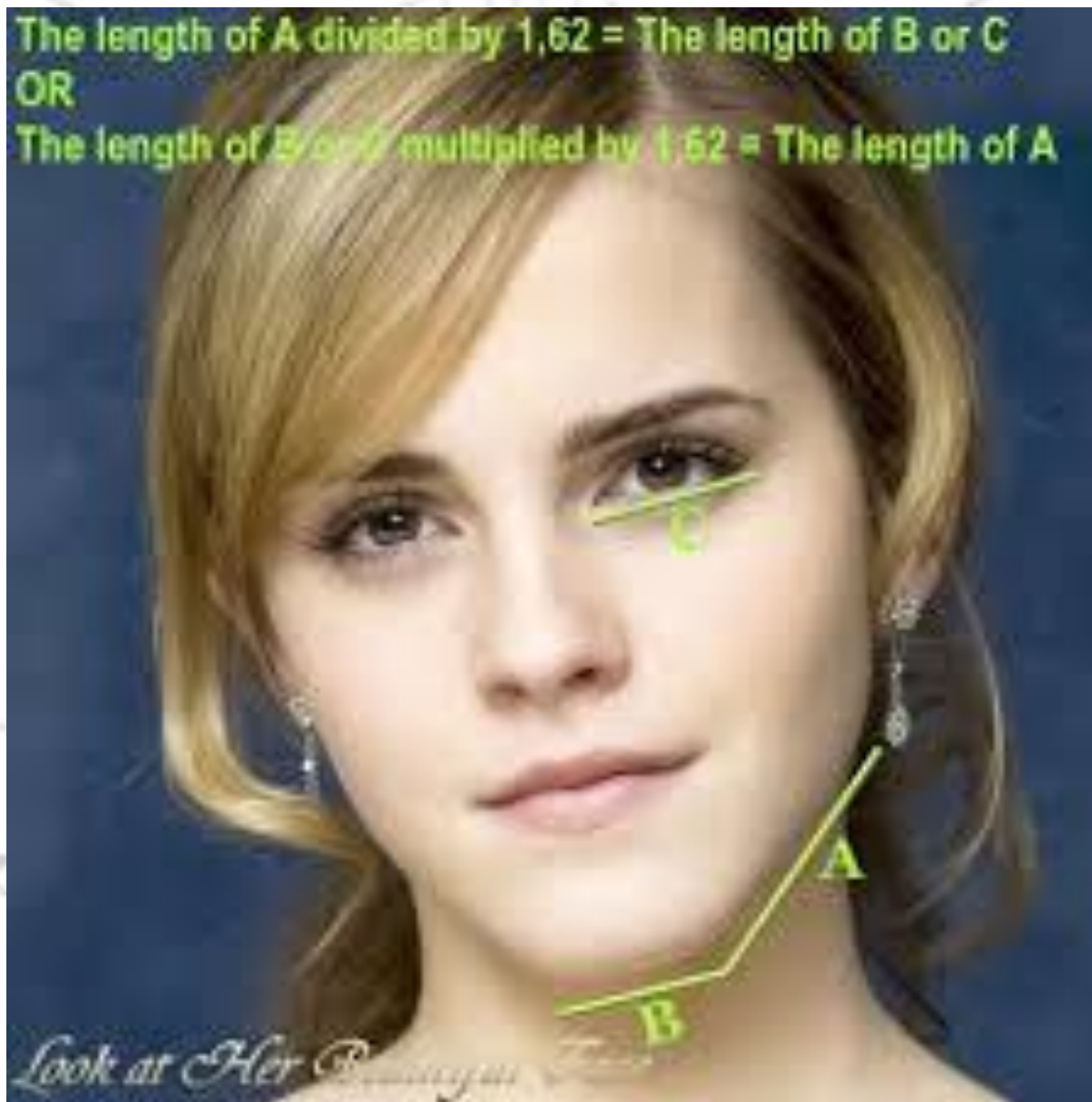


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Golden ratio



Golden ratio



Artificial Photosynthesis

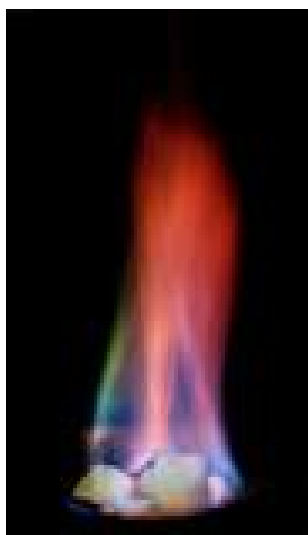


o Photosynthesis

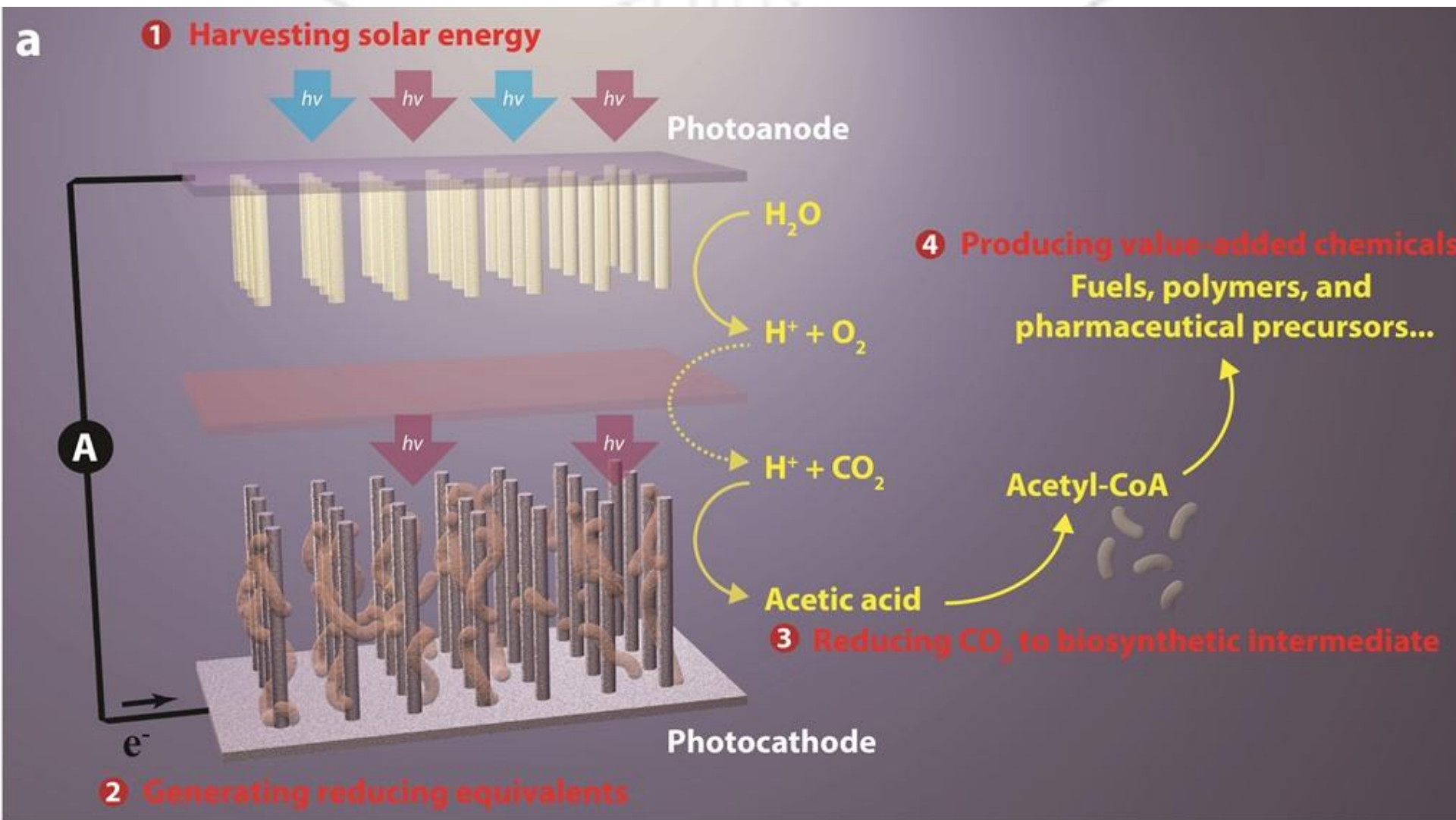
- » The way that green plants use chlorophyll to convert sunlight, water and carbon dioxide into carbohydrates and oxygen

o Artificial Photosynthesis

- » An envisioned means of using sunlight to split water into hydrogen and oxygen for use as a clean fuel for vehicles as well as a way to use excess carbon dioxide in the atmosphere
- » The process could make hydrogen fuel cells an efficient, self-recharging and less expensive way to create and store energy applicable in home and industrial systems.

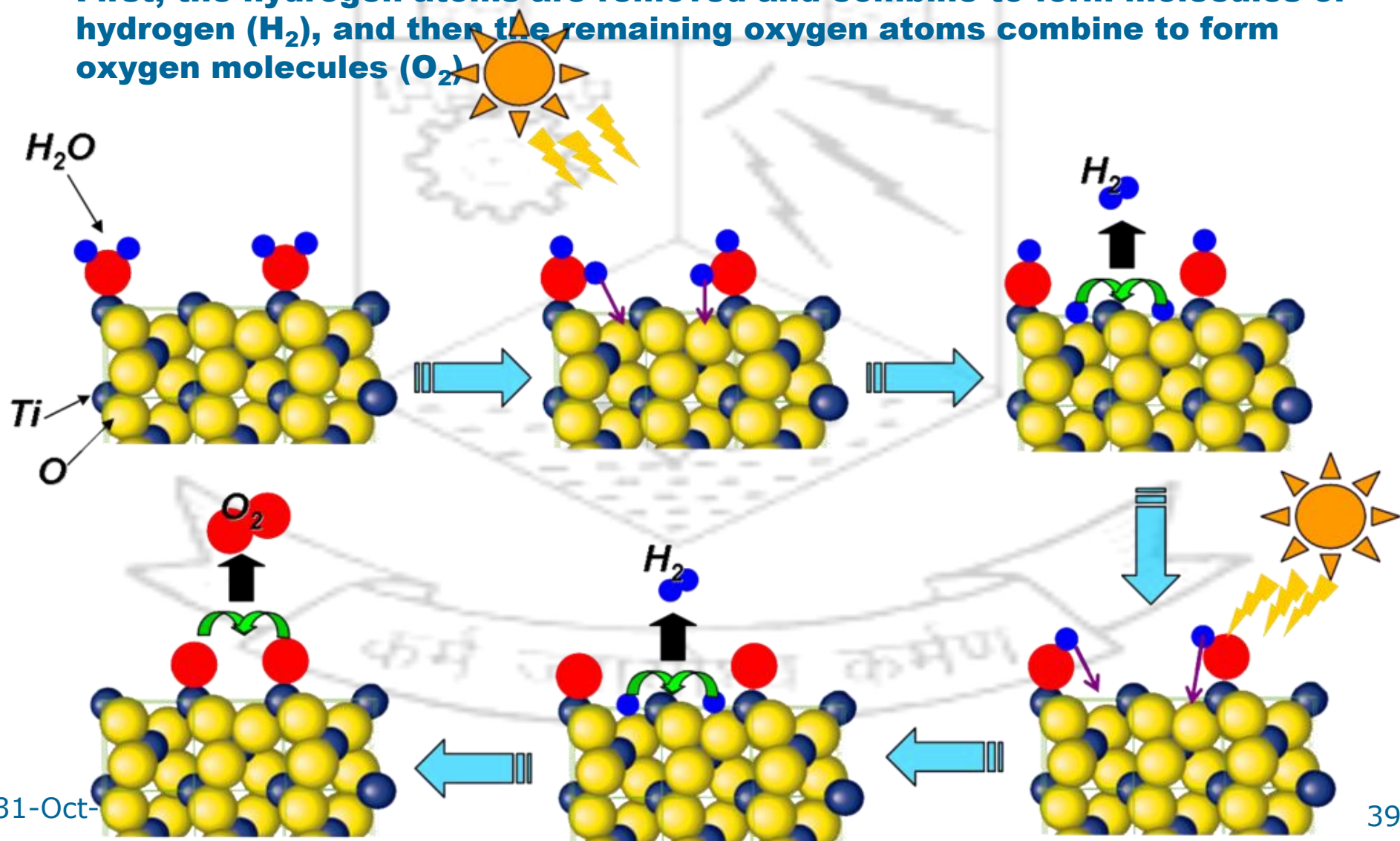


Artificial photosynthesis (Contd.)

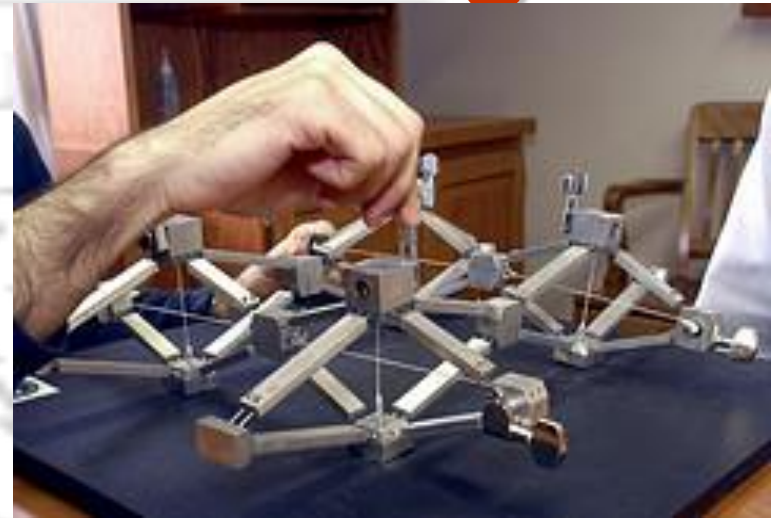


Artificial photosynthesis

- » Water molecules (H_2O) attach themselves to the surface of the catalyst and are then, with the help of sunlight, broken down into their component parts: First, the hydrogen atoms are removed and combine to form molecules of hydrogen (H_2), and then the remaining oxygen atoms combine to form oxygen molecules (O_2)



Morphing Aircraft Wings



- ❖ **Using inspiration from both birds and fish, scientists from Penn State University developed Morphing Airplane Wings that change shape depending on the speed and duration of flight. Different birds have differently shaped wings useful for the speeds at which they fly, as well as for sustaining flight speeds over long distances using the least amount of energy. The scientists built a compliant, shape-changing truss understructure for the wings, then covered it with scales that can slide over one another to accommodate the in-flight shape changes. When deployed in new aircraft (and drone) models, the wings are expected to conserve fuel and enable faster flights over longer distances.**

Friction-Reducing Sharkskin

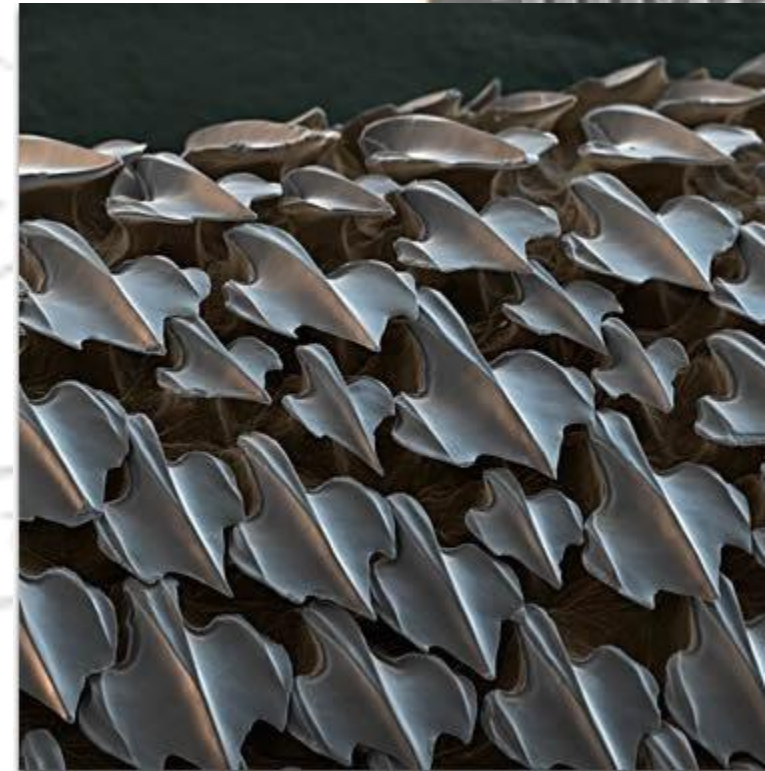
❖ Inspired by the evolved ability of shark's skin to reduce drag by manipulating the boundary layer flow as the fish swims, researchers are developing coatings for ship's hulls, submarines, aircraft fuselage, and even swimwear for humans

❖ Based on the varying shape and texture of shark's skin over its body, Speedo's Fastskin FSII swimsuits made their appearance at the Beijing 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. And now there are the new suits (43 world records at the 09 world championships)!

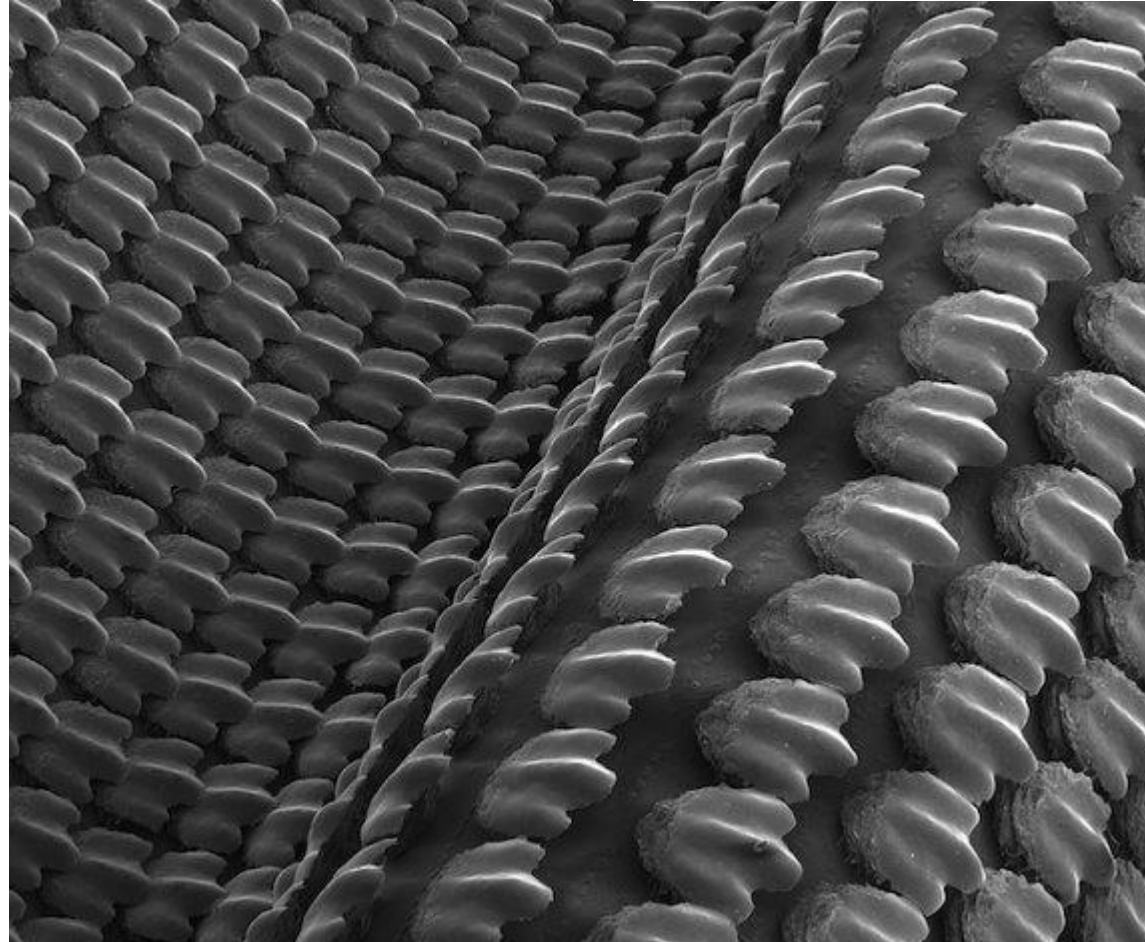
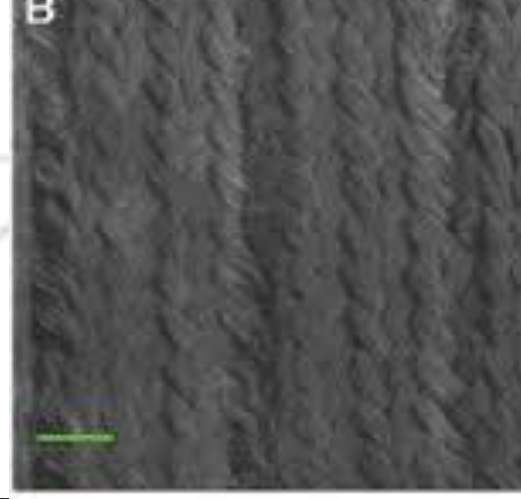
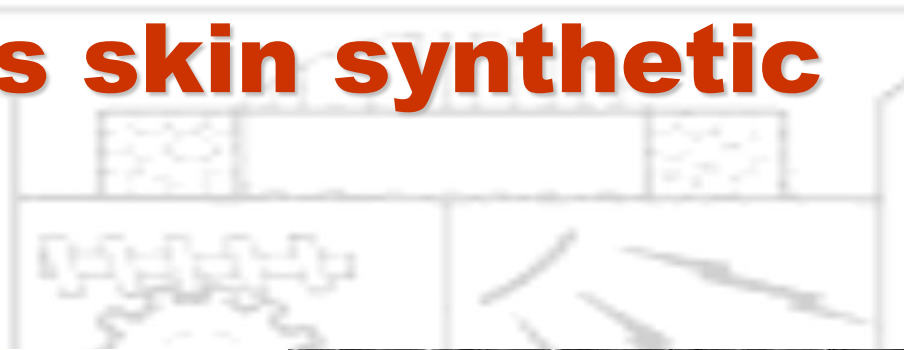


Shark's skin

- **A shark's skin is covered in miniature teeth called denticles**
- **Aids in streamlining the fish while it glides through the water as they reduce turbulence**
- **This is done by directing the water through the grooves and thereby decreasing the friction of the water against which the body travels**

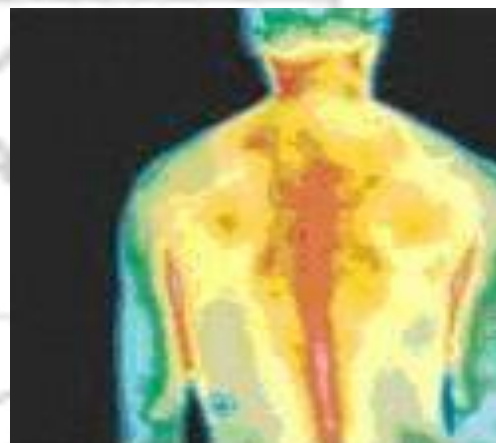


Shark's skin synthetic



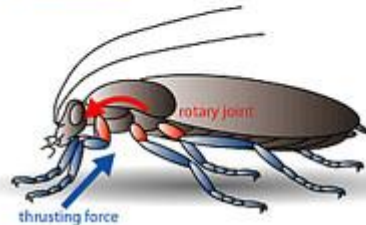
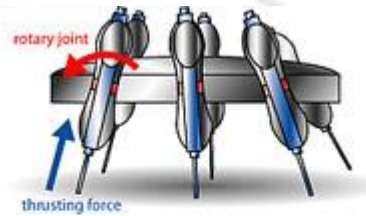
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Glo-Fish



- o **Glow-in-the-dark aquarium fish may not fulfill a needful ecological role at the present time, but they're a fun - and lucrative - application of fluorescent proteins discovered in jellyfish while researchers are busily developing further biochemical tools from this Nobel Prizewinning discovery. The protein can be attached to other molecules of interest so they can be followed for understanding of their functions in living organisms, very useful in medical research. For the fish, the proteins serve the purpose of simply being very cool - they come in several colors!**

Insect-Inspired Autonomous Robots



- ❖ While most of us are accustomed to thinking about futuristic robotics as something that looks and moves just like a human, humans are probably not the best biological model for really useful robots. For mobility, insect-like ability to cover varied terrain, climb surfaces and provide stability seems to work better. Insect eyes offer greater resolution and panoramic range for exploring places people cannot go, and the ability to quickly adapt to changing environments (or even to spy on enemies undetected) make those annoying toy insect robots a forerunner for future applications in exploration and defence.

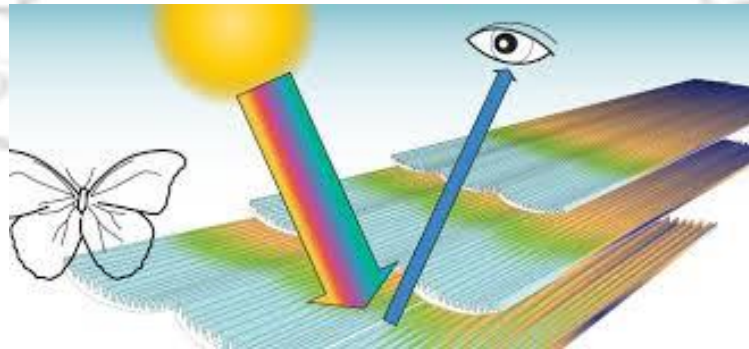
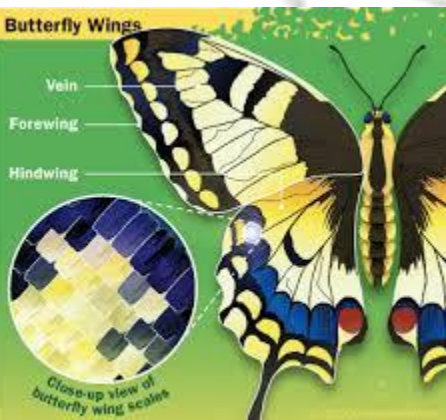
Butterfly-Inspired Displays

- ❖ By mimicking the way light reflects from the scales on a butterfly's wings, the Qualcomm company has developed Mirasol Displays that make use of the reflected light principle with an understanding of how human beings perceive that light. Using an interferometric modulator [IMOD] element in a two-plate conductive system, the display uses near-zero power whenever the displayed image is static while at the same time offering a refresh rate fast enough for video. Perfect for 'smart' handheld devices, already deployed in many, and a battery-saver extraordinaire!



Butterfly wings

- **Butterfly wings, which are translucent membranes covered in microscopic light-reflecting scales**
- **As light passes through a butterfly wing and the wing flaps, sunlight refracts and different wavelengths, making a wing look iridescent**



Mirasol display

- The Mirasol screen achieves a similar effect with two glass panels and tiny mirrors that reflect colors onto the screen. This means that the screen delivers bright color in strong light, making it easier to see in the sun, using natural light from the environment rather than lighting

