BO101

Topic: Biomimicry (16-03-21)

Why study biology? for new engineering ideas

- Nature is ahead of us in technical developments
- Millions of years of evolution has generated incredible diversity of functions
- functional biodiversity can be a fertile source of ideas for new technology.
- **Biomimicry**: imitation/copying/adaptation of nature

First patented biomimicry idea: Velcro

Georges Mestral patented (1955) "Velcro,"

French words velours (velvet) and crochet (hook)

Many plant seeds have hooks (burr) that attach to an animal's fur and carried by the animal to another location

Infrasound

- Infrasound is sound lower than 20 Hz (20-20 k Hz acoustic)
- Infrasound has the ability to cover long distance and go through the obstacles without much dissipation.

- **Avalanches, earthquakes, water falls, volcanoes, hurricanes, tornadoes, upper atmospheric lightning, aurora, ocean wave and storm, meteorite strike, nuclear explosion, sea waves** etc

Some animals use infrasound

- Elephant, Whale, Rhino produce and detect infrasound to communicate, sometimes upto 100 km (whale)

- Migrating birds can hear storms at least 2 days in advance (400-900 Km away) by hearing infrasound emanating from turbulent airflow

Current Biology, 25(1) 98-102 (2015)

- Most of the elephants survived the 2004 Indian Ocean tsunami: they were reported to flee long before the tsunami wave hit the shore

Infrasound and human

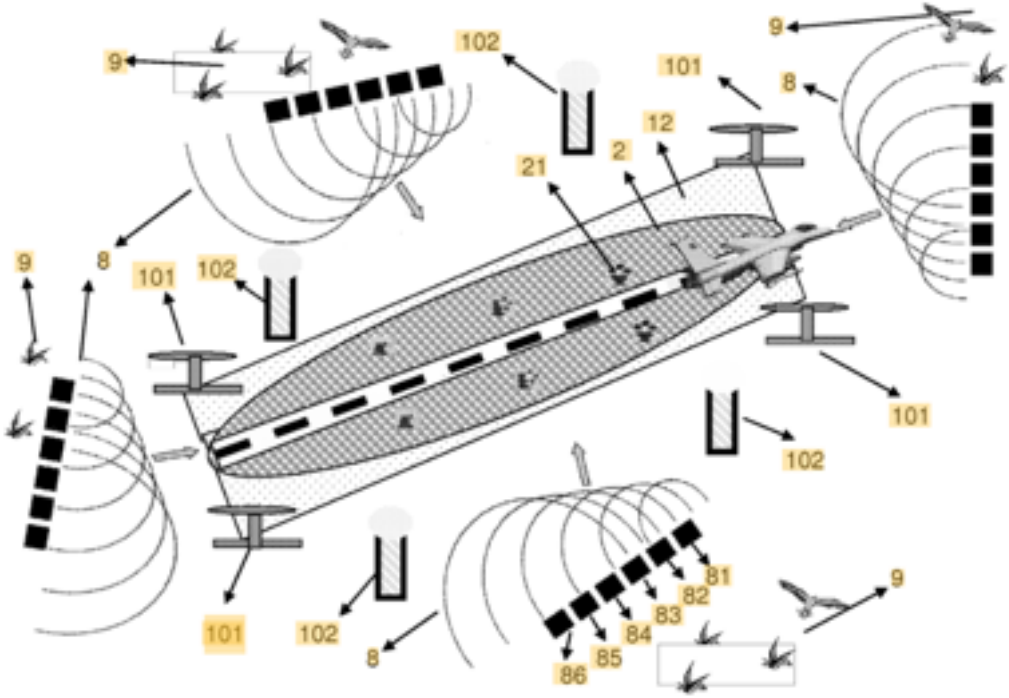
- As infrasound is not consciously perceived, it causes a feeling of motion sickness, anxiety in human
- People living close proximity to to wind turbines experience motion sickness-like symptoms

Think of one new application of infrasound that you would like to do as an engineer

1. Making infrasound-based bird hit protection

US patent
US20140185414A1

Birds responds to infrasound not-audible to human

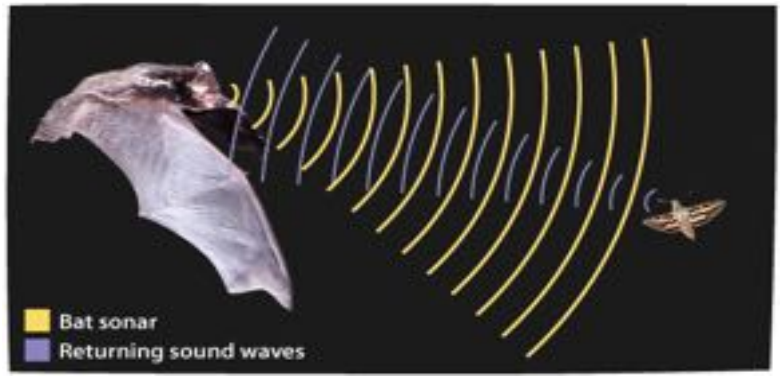


<u>Infrasound generators</u> broadcast continuous infrasound to create a bird-free area

2. Horror film soundtrack often uses infrasound to produce unease

Echolocation by Bats

- **Sonar (SO**und **N**avigation **A**nd **R**anging**)**
- Dolphins and whales uses to locate fish
- **Echolocation** is <u>OPEN AIR sonar</u>: use of sound waves and echoes to determine where objects are in space.
- Bats use echolocation to navigate and find food (mosquitoes) in the dark.

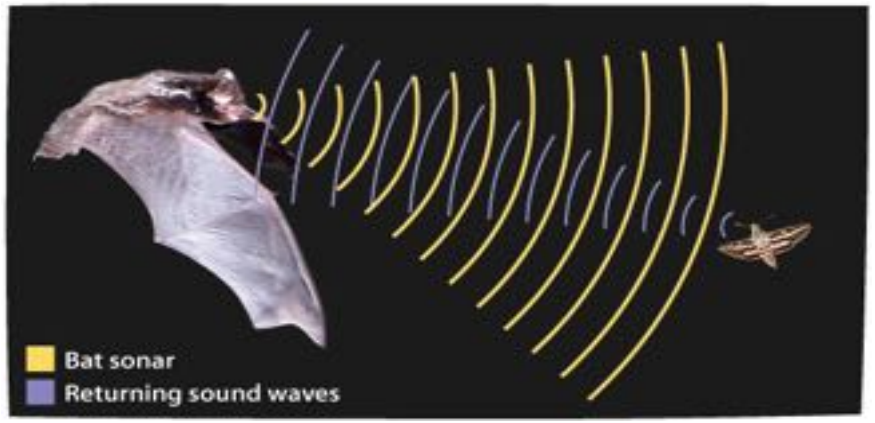


Think of one new application of Echolocation

Drone navigation by Echolocation

Drones can be piloted manually using line of sight, video cameras, global positioning satellites and laser-based radar

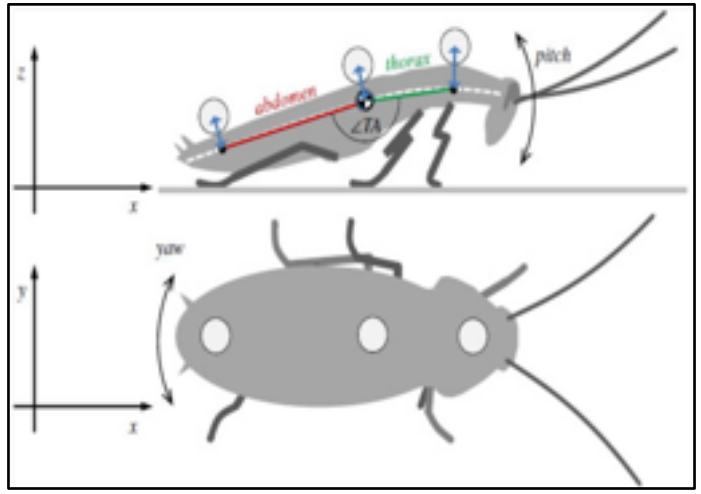
More reliable under smoky or dusty areas or inside buildings or tunnels

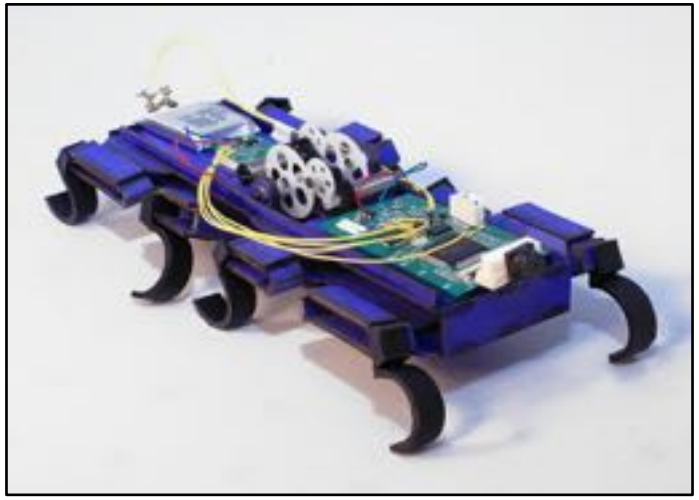


Dr Dieter Vanderelst
University of Cincinnati

Legged locomotion & milli-robots

- For smooth surfaces, wheels remain the most efficient way to move.
- But on steep or uneven terrain (e,g., in disaster zones) wheeled bots are limited.

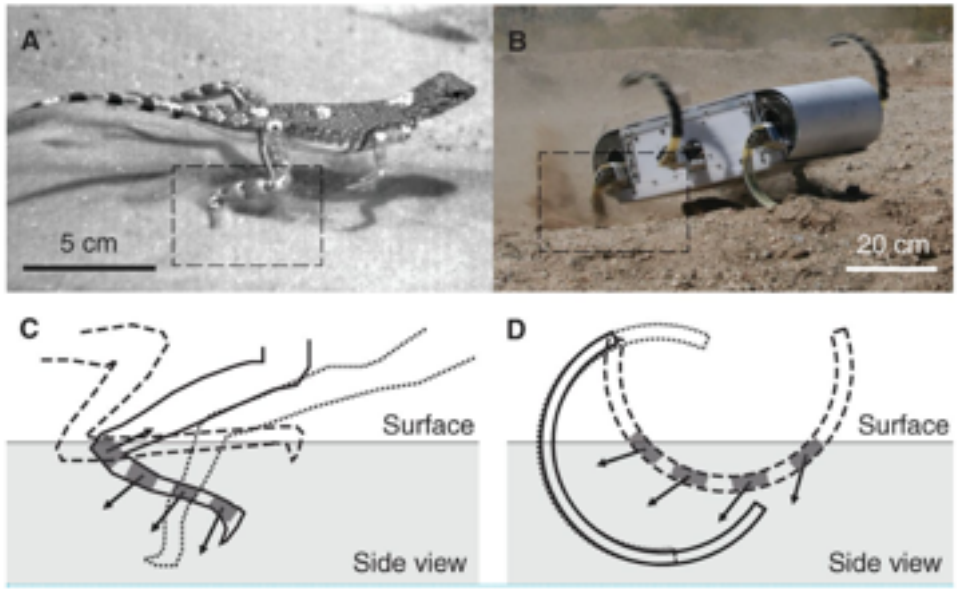




- Biomimetic Millisystems, UC Berkeley

Legged locomotion on sand

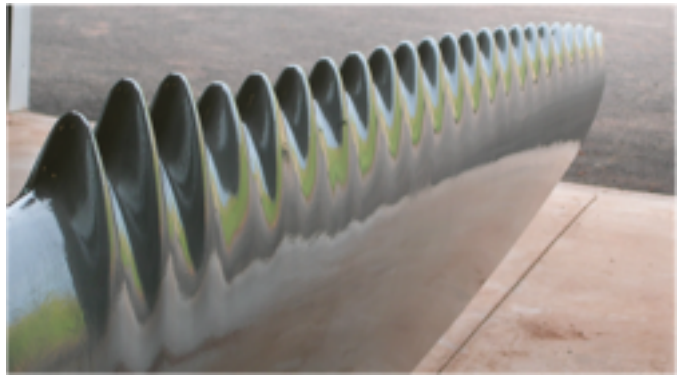
- Locomotion mud or sand is not efficient with wheel



- *UC Berkeley*

Li et al Science (2013), 339 (6126) 1408-1412.

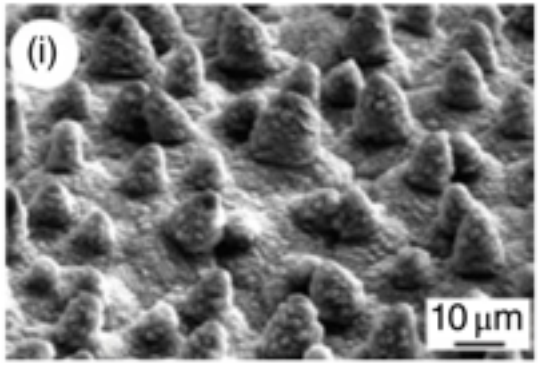
Whale-inspired wind turbines and fan blades

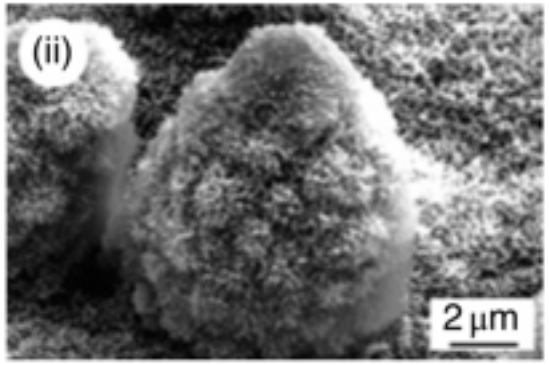


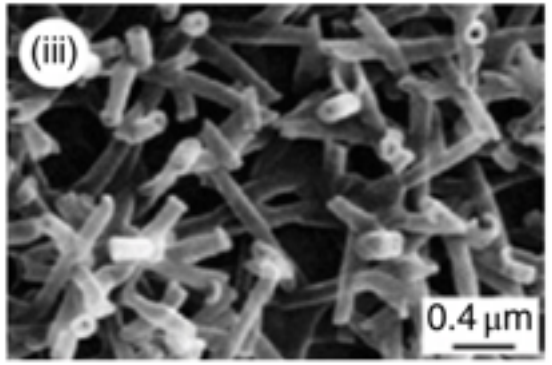
- conventional aerodynamics: the leading edge of propellers, blades and turbines should be **as smooth as possible** to limit air resistance.
- **Humpback whale** flippers have tubercles or bumps.
- Specially placed bumps can deliver **32% less drag** and an **8% more lift** compared to the smooth leading-edge
- Patented (2018)

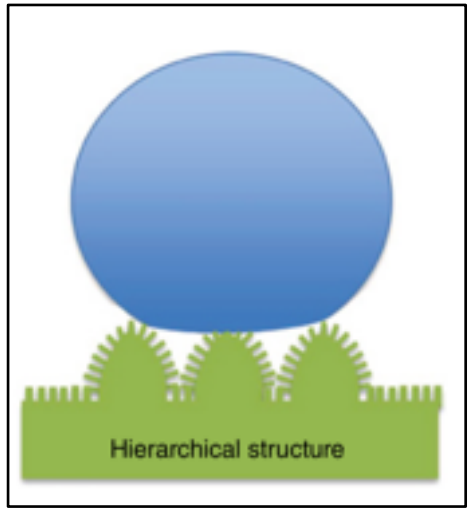
Self-cleaning materials

- Some biological materials exhibit a superhydrophobicity-induced self-cleaning property,
- Example: lotus leaf is the best self-cleaning model.



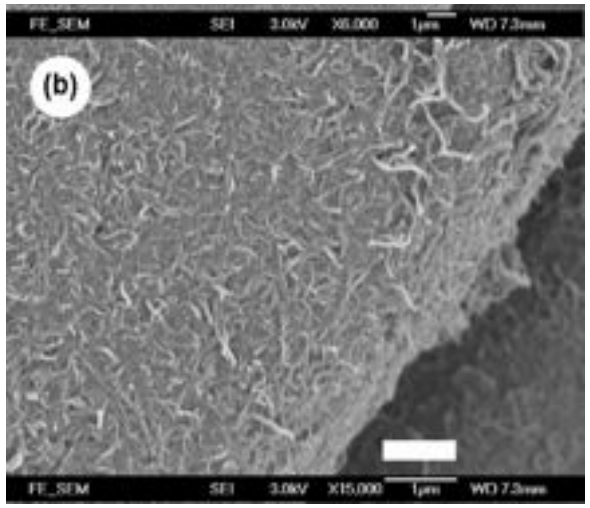


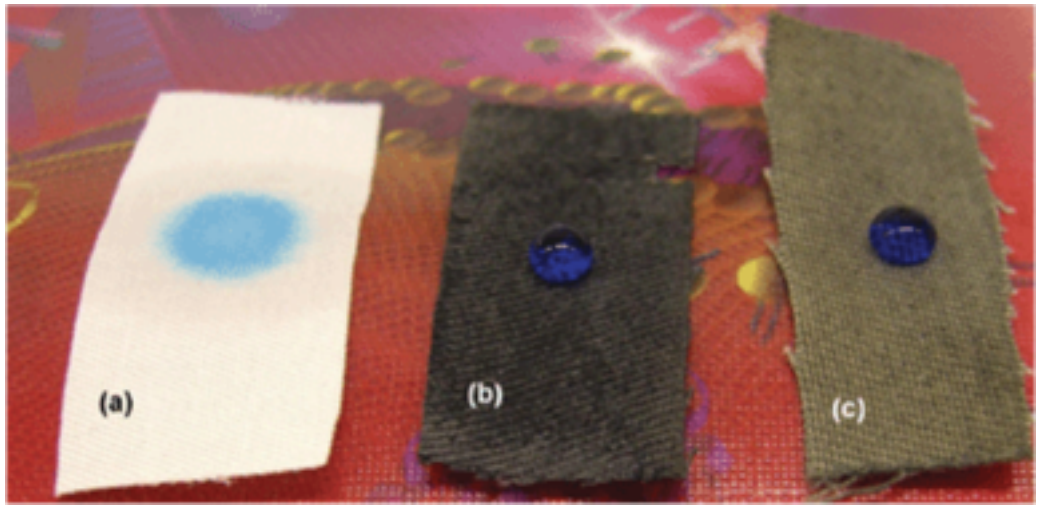




Nature-inspired self-cleaning textiles

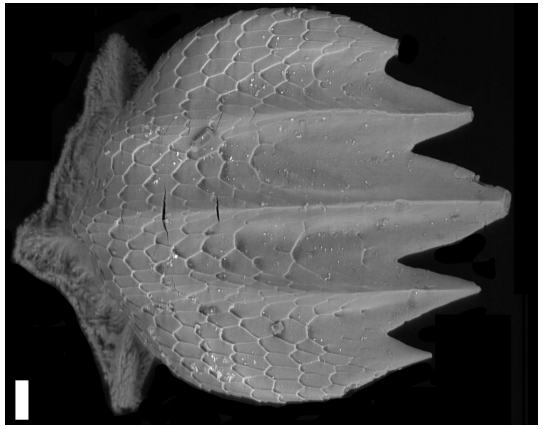
- **Carbon nanotubes (CNT)** with **poly-butylacrylate (PBA)** were prepared and these PBA-carbon nanotubes (PBA-CNTs) were applied to the surface of cotton textiles





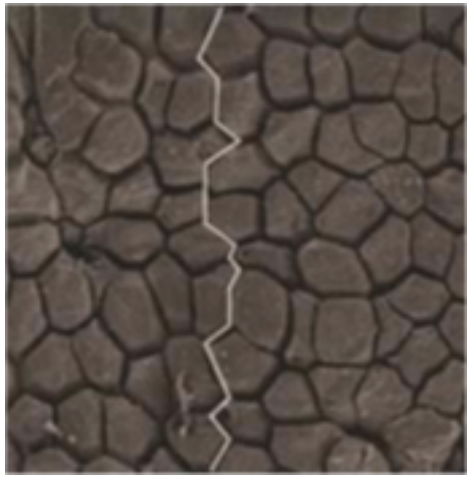
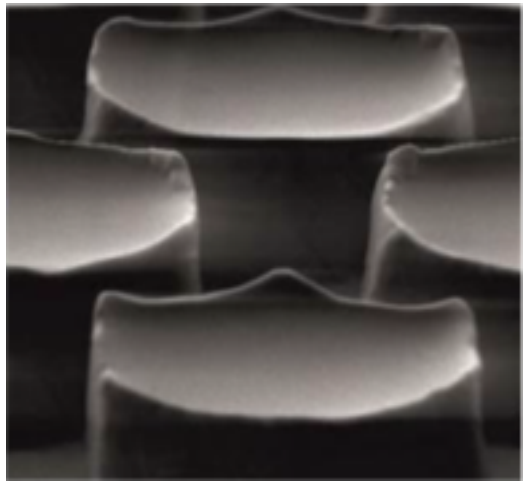
J. Mater. Chem., 2007,**17**, 1071-1078

Shark-skin and Riblet surface

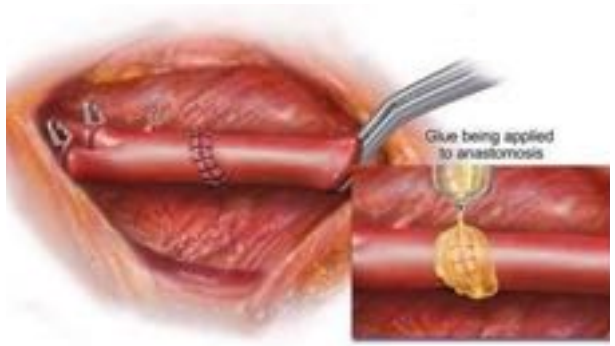
- Microscopic scales allow the water flow through the grooves without whirling and they effectively **reduce the drag**
- Riblet effect is inspired by the unique structure of shark skin.
- Riblet effect is used for the development of the **wing skin of Airbus** aircrafts
- The effect of **6 % less air drag** & significant fuel savings.
- At the Beijing Olympics in 2008, two-thirds of the swimmers wore swimsuits with Riblet effect and a large number of world records were broken

Tree frog and Car tire


- Biomimetic tire: Patented by Continental tire has a better performance on icy surfaces, the optimal grip and reduced stopping distance.
- These is a replica of the surface structure of the **toe pads of tree frog** which lives on trees and is known for its climbing skills in wet conditions near waterfalls

Vascular Surgery glue from sandcastle worm



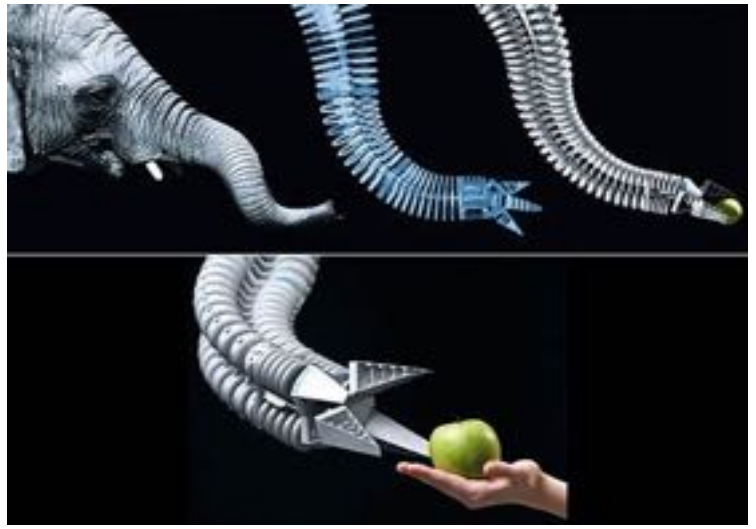
- **Sandcastle worm** use an instant glue-like secretions to make underwater sandcastle using sand grains
- Vascular surgery is very difficult due to constant blood flow, Setalum being hydrophobic and instant, very useful in joining veins and arteries.
- Biomimetic surgical sealant Setalum: Patented by French company Tissium

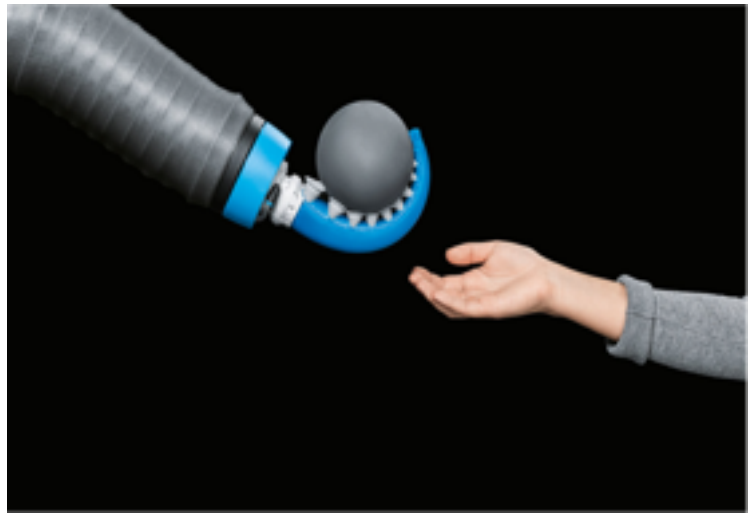
High speed train design

- High speed bullet train heads are inspired by Kingfisher bird
- The bird does not make noise as it has very little air resistance
- Bullet train design mimics this to increase speed

Robotic Arm inspired by elephant

- The elephant's trunk inspired this versatile robotic arm.
- Just as an elephant can stretch its trunk in any direction to reach out and grab something a bionic trunk which is quite different at end, as it has variable design to pick up things.



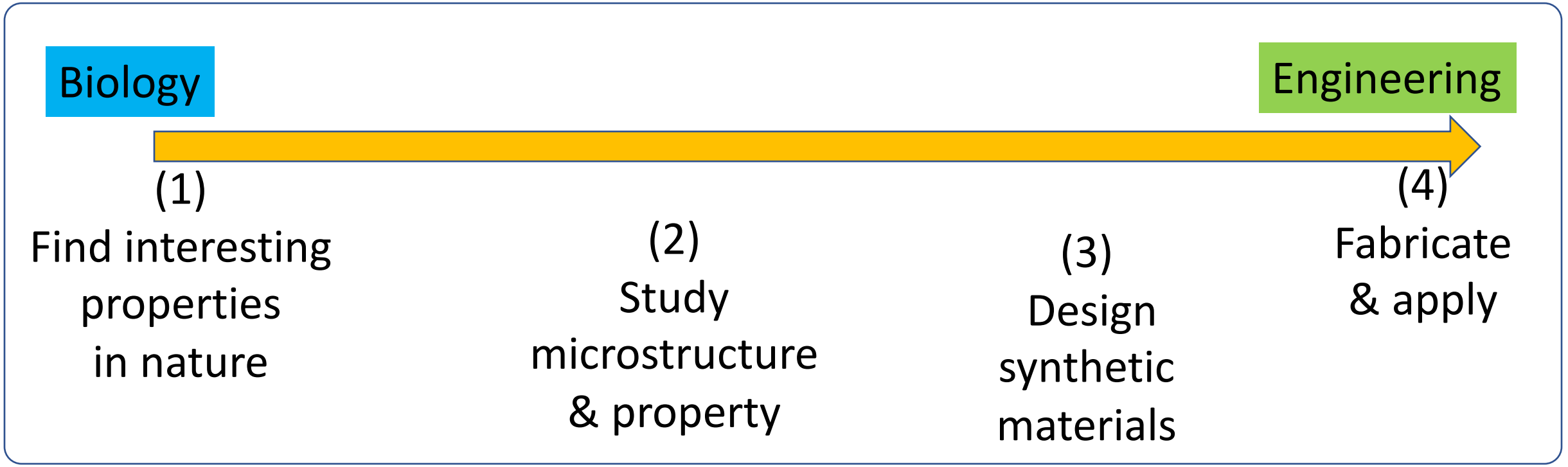


Wind converter

- Basing on humming bird wing movement, the Tyer wind converter perfectly mimicked the motion
- Tyer machine does not use rotating blades like a traditional wind turbine. Instead, it flaps its “wings”, converting that energy into green energy
- And as a result, it is more effective and efficient than that of the bladed one

Summary

How to do biomimicry?



Assignment: Any one

Assignment: 1

BT-101

Flight of Amur falcons

- Amur falcons are one of the nature's amazing wonder.
- They are found in Nagaland they come in hundreds of thousands.
- Two such birds were radio tagged by WII in Manipur. It went to South Africa, covered 29,000 km & back to Manipur.
- In a single stretch, they flew from Nagaland in India to Somalia in eastern Africa for days, each days 10 hours non-stop

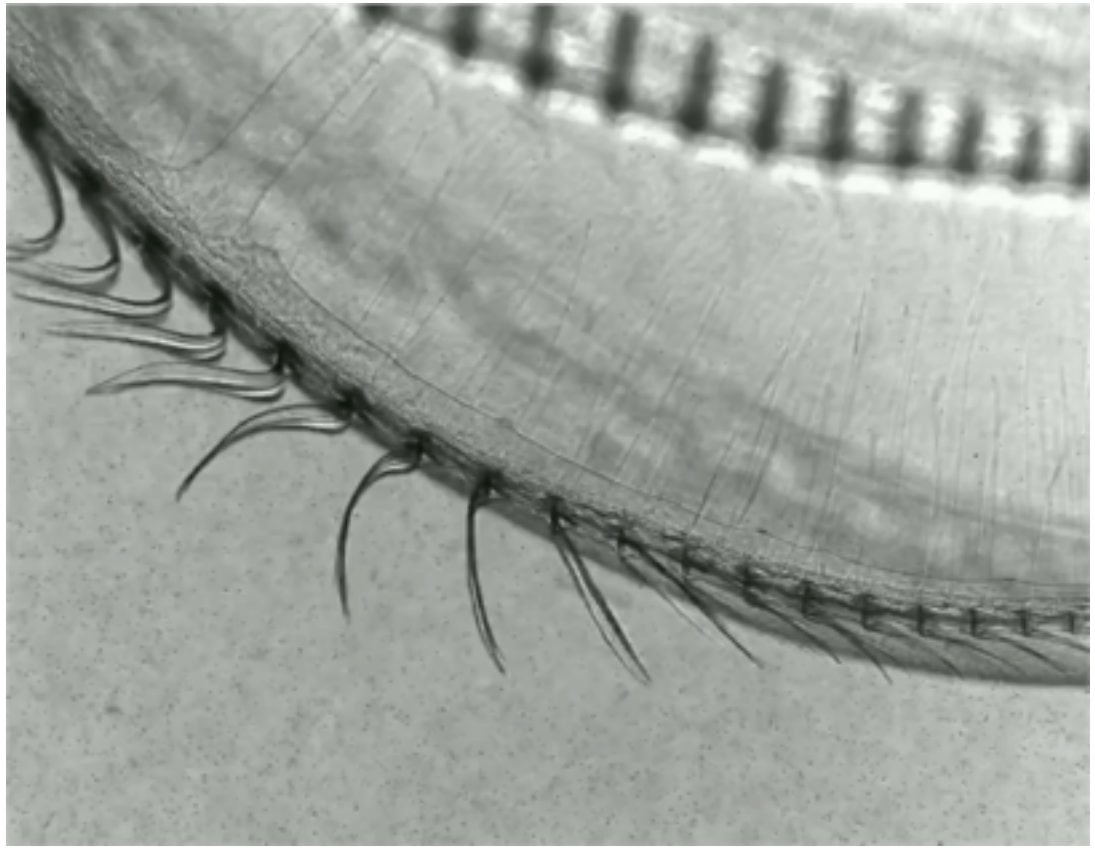
Propose a drone navigation strategy which will fly 10h/d inspired by Amur falcons

Assignment-2

BT-101

SUPERB swimmers

- A **metachronal wave** refers to wavy movements produced by the sequential action of structures
- Many swimming animals have a common swimming strategy using coordinated metachronal waves.



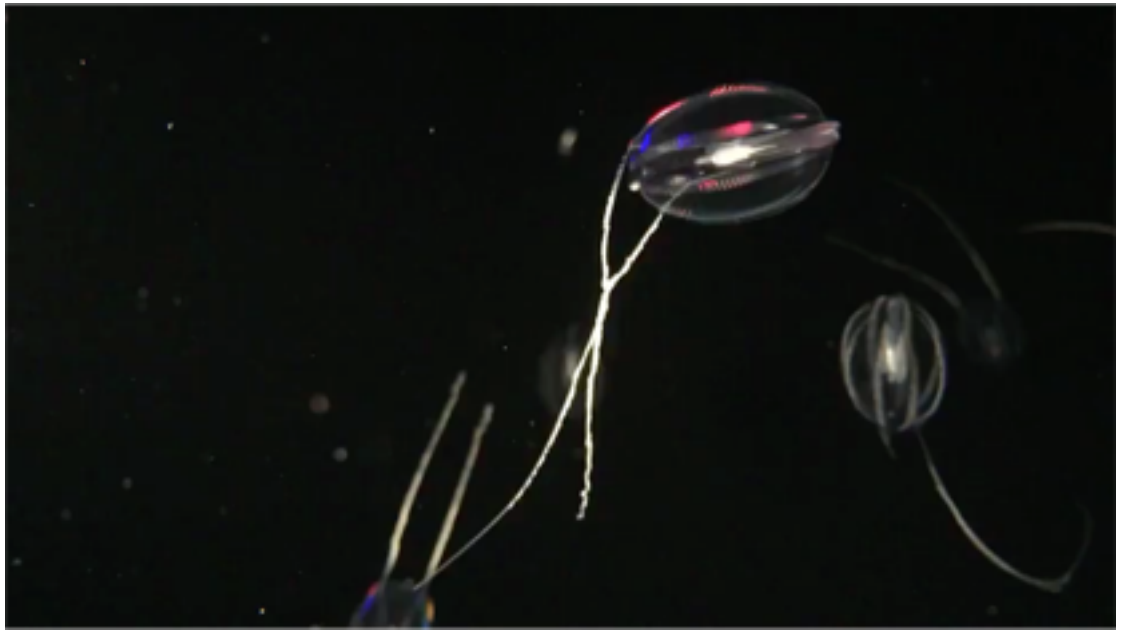
Explain the fluid dynamic of **metachronal wave** to generate thrust?

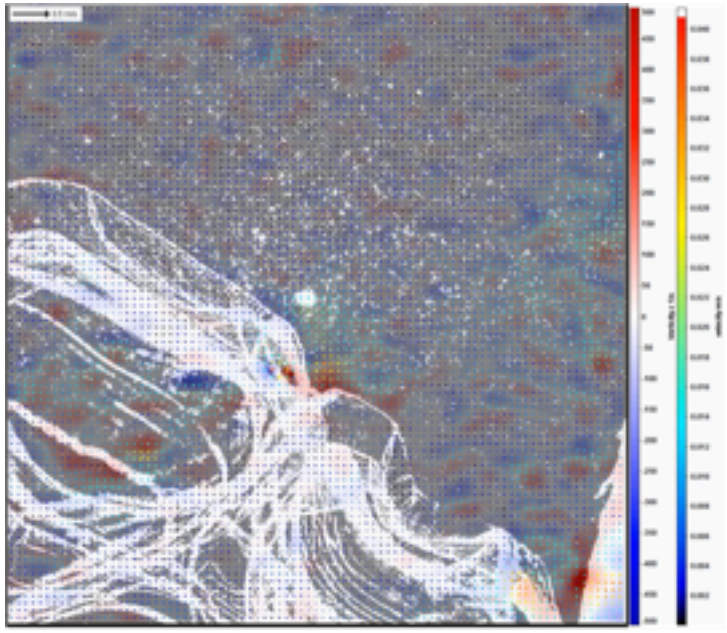
Assignment-3

BT-101

JET propulsion and jellyfish

- Jelly fish move by coordination of multiple jet propulsion
- These class of animals are called Siphonophores: they suck water in and throw it out again to get the movement





Propose a marine navigation strategy mimicking siphonophore movement of jellyfish