



భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Introduction of Bio-nanotechnology

BT1110

**Lecture 3 : Biologically inspired nanostructures -
introduction to biomimetics**

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- Introduction to nanotechnology and bionanotechnology,
- Biological self-assembly
- **Biologically inspired nanostructures - introduction to biomimetics**
- Nucleic acid nanotechnology
- DNA origami
- Protein engineering
- Lipid nanotechnology
- Chirality in biological systems
- Interaction of nanomaterials with biological systems
- Virology: viruses and vaccines

The minimalistic/reductionist and simple approach of nature

- Using only 20 amino acids to create all protein
- Only 5 types of nucleotide bases to all DNA/RNA
- Only handful of lipids and carbohydrates

Biomimetics vs Biomimicry

Is there any difference

Biomimicry is focused on inspiration, ideation, and education, with the explicit goal of sustainability and reconnecting people with Nature.

While **Biomimetics** is about on scientific translation, radical technological innovation, and commercialization, with the goal of developing better technologies that lead to financial success.

What would nature do ?



Janine Benyus

Science writer and Innovator

Biomimicry:

Innovation Inspired by Nature (1997)

- Beginning to remember the forgotten
- We have been fierce competitors and evolved successfully.
- We are not the first to build.

TED Talk

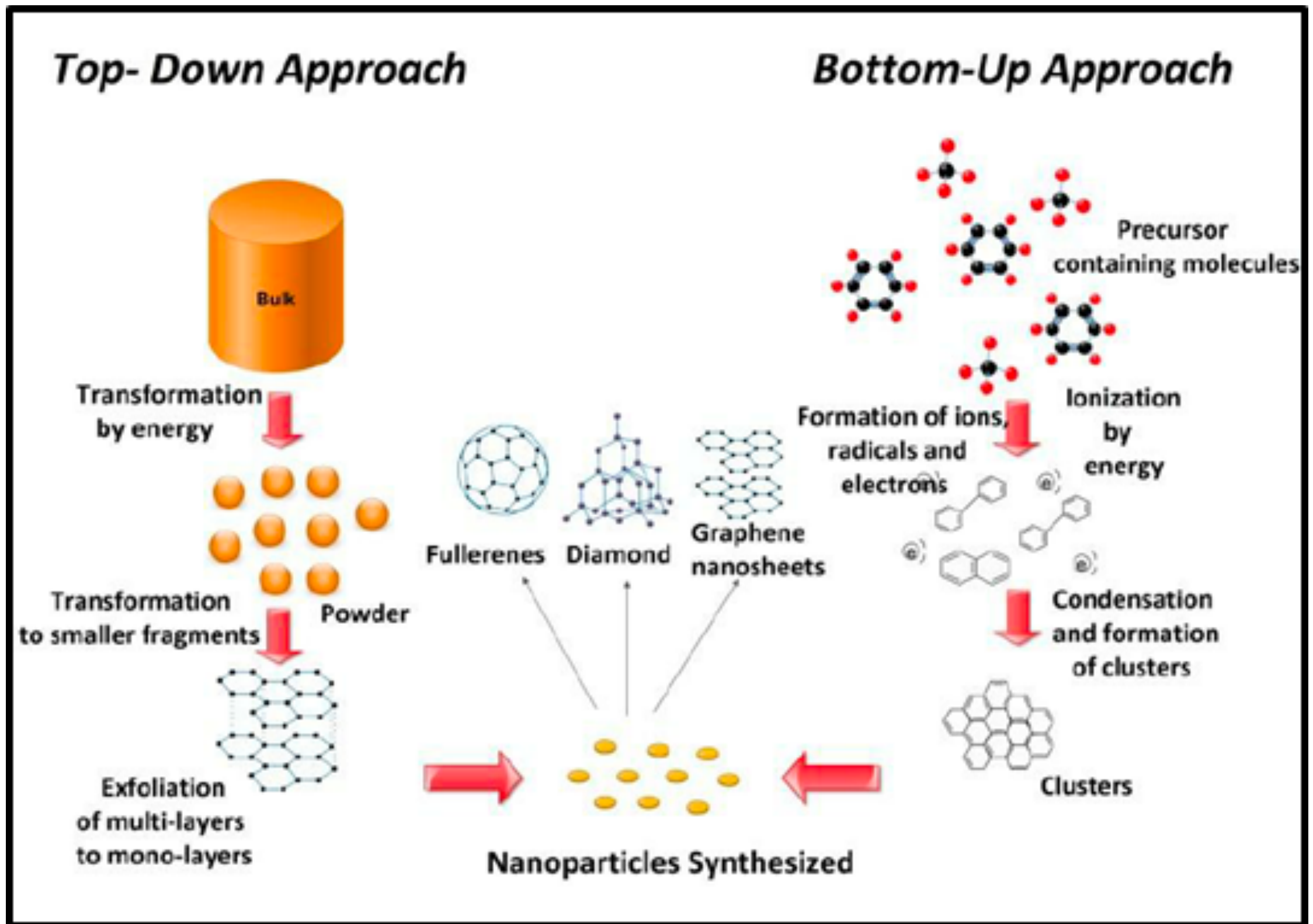
https://www.youtube.com/watch?v=k_GFq12w5WU

GOAL



To create nanomachines that can do desired function as Feynman proposed

Creating nanostructure



Biomimetics : The idea

- We are not the first one to built nanostructure, nature has optimized it over the billion of years.
- Every-time, we want to invent or solve something, we can ask the question “how nature would do it”
- Biology provides outstanding examples of what can be accomplished.
- From a flight of a bee to a beating of a flagellum, the ability of tiny creatures to perform seemingly impossible tasks inspire us.

Biomimetics

- Designing products to mimic the natural world's structures and functions. Take inspiration from nature.
- Studying animal behaviour and applying that knowledge to product design.
- Using natural designs to create new technologies.
- Understanding the principles of life through observing living organisms.
- Observing the environment around you and learning from it.
- Applying the lessons learned from nature to solve real-world challenges.

Source

<https://www.qualitygurus.com/>

Biomimetics : Advantages

Biocompatible, no toxicity

Environmentally friendly and sustainable product

Ease of building by molecular self-assembly

Biomimetics by example

Vaccines

Gecko

Artificial water channel

Bullet train

Vaccines: An early example of biomimetics



*Edward Jenner
(1747- 1823)*



- The kingdom of Bavaria was one of the first countries to introduce compulsory vaccination in 1807 using Jenner's method against smallpox which is one of the deadliest disease caused millions of death before it was completely eradicated in 1980.
- Vaccines work by exploiting the immune system's memory.
- Vaccine emulate the immune system by training it to develop antibodies using a dead or inactive part of the germ.

Bullet train and sonic boom

Biomimicry

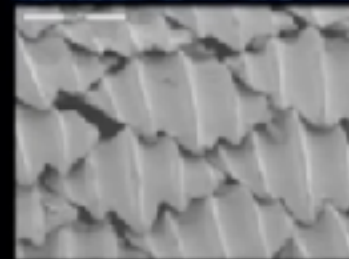
How Does
Nature
Flow without
Turbulence?



Source

https://www.youtube.com/watch?v=k_GFq12w5WU&ab_channel=TED

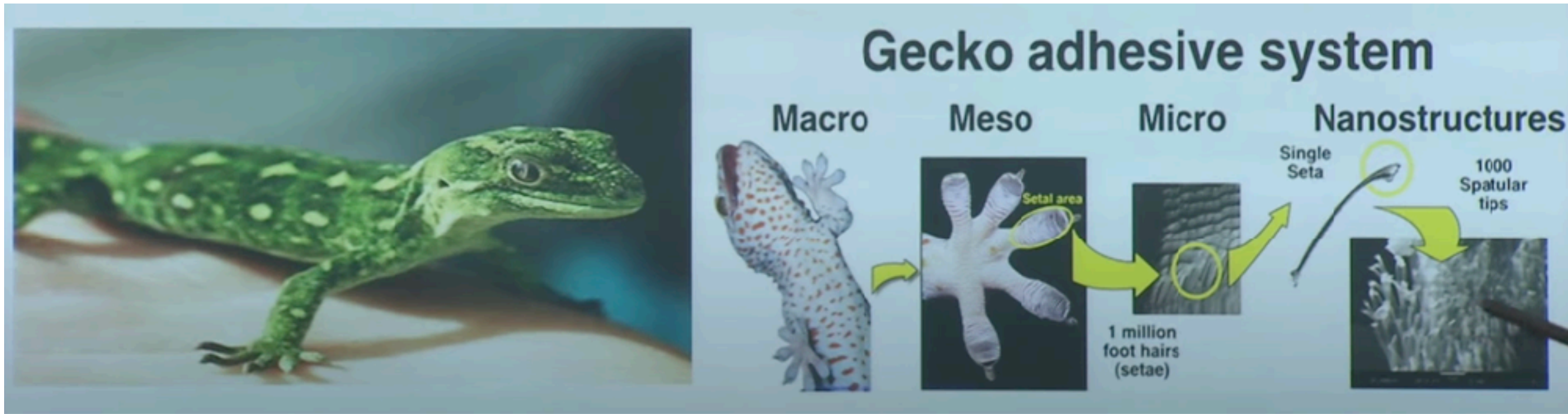
How Does Nature Repel Bacteria?



How Does Nature Use CO₂ as a Building Block?



Gecko adhesive : Biomimetics example



Gecko can lift unto 130 Kg of weight due the ultra sticky feet.

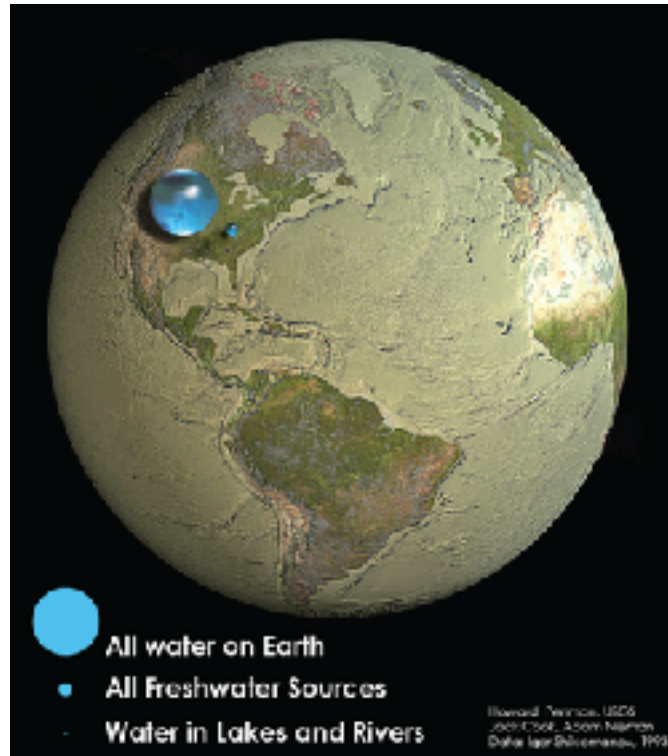
It can walk over surface of the water using a combination of water-walking strategies.

References

<https://people.eecs.berkeley.edu/~ronf/Gecko/index.html>

<https://youtu.be/2t1HBxJS5ac>

Example: Artificial water channels



Source: U.S. Geological Survey

- Less than 1 % of the total water on earth is available for drinking.
- 3.4 M people die every year due to water related diseases.
- 11 % of the world population lack the access to clean water.

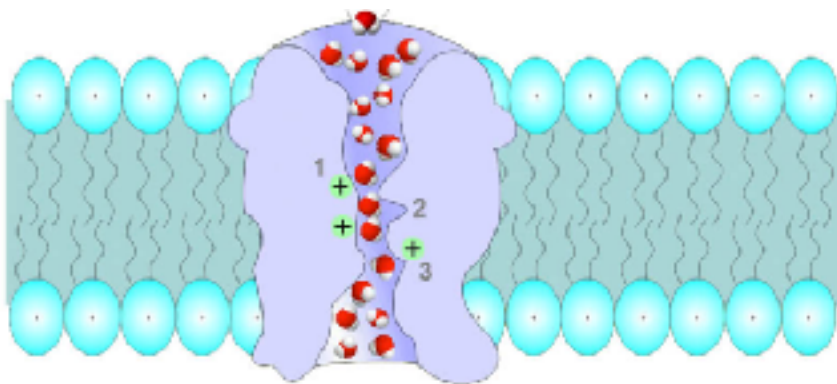


*Peter Agre
Nobel Prize 2003
for the discovery of water channels*

Solution: water desalination

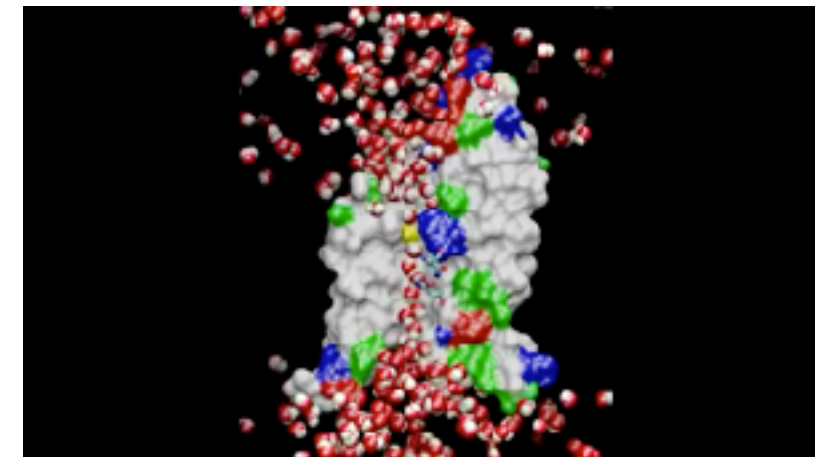
- Current desalination techniques are power consuming and slow.
- Inspired by aquaporins, biomimetic approaches combined with supramolecular chemistry shows great promise for desalination.

Aquaporins

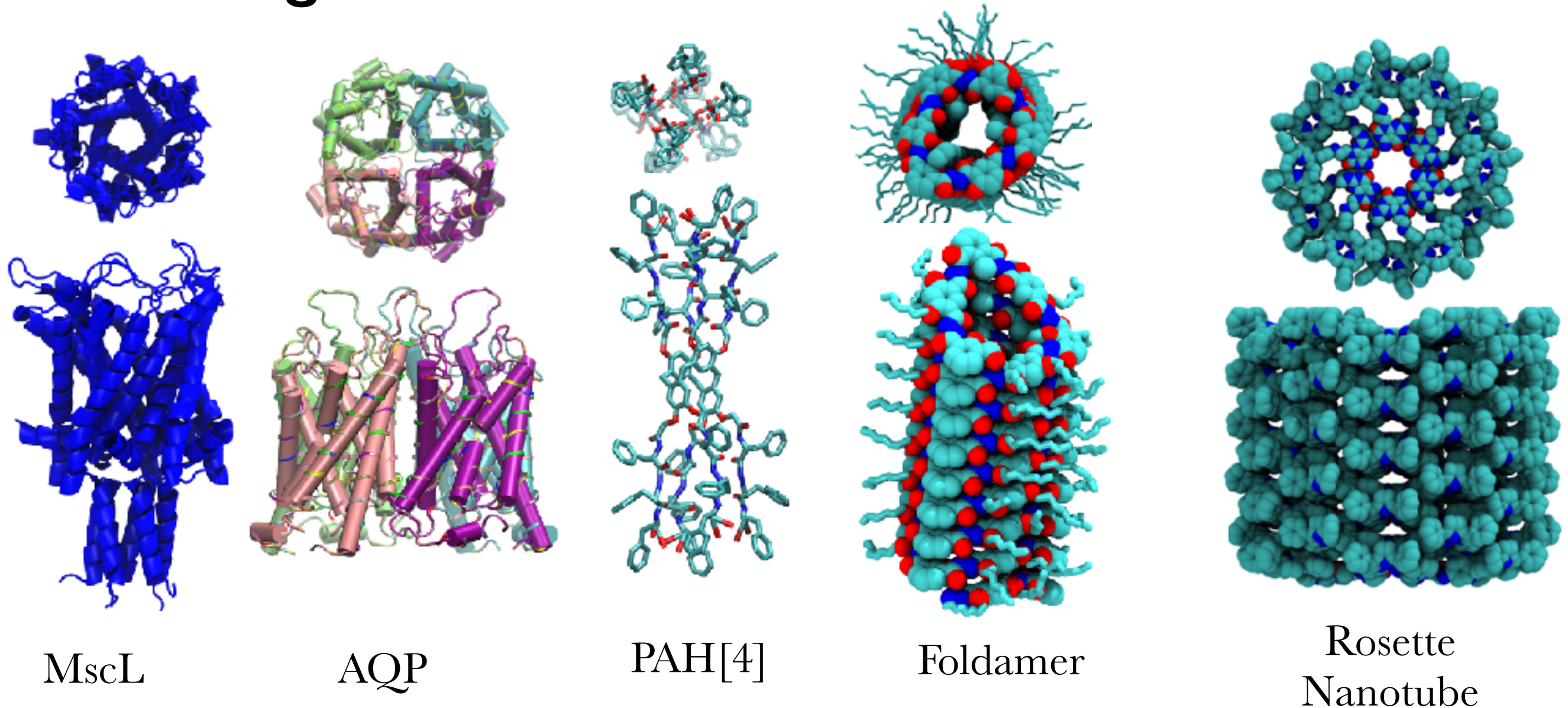


source: socratic.org

Source:
TCBG
UIUC



Biological and Artificial water and ion channels



- Membrane protein channels regulate the transport of ions and water across a cellular membrane.
- Inspired from a biological water channels such as Aquaporins (AQP), several type of artificial water channels (AWC) have been synthesized.
- The aim of these AWC is to create customized water channels for in-vitro application such as AWC-based desalination and water treatment membranes.

Polymeric organic nanotubes :Foldamers

