Fundamentals of nanotechnology

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Lec. 1

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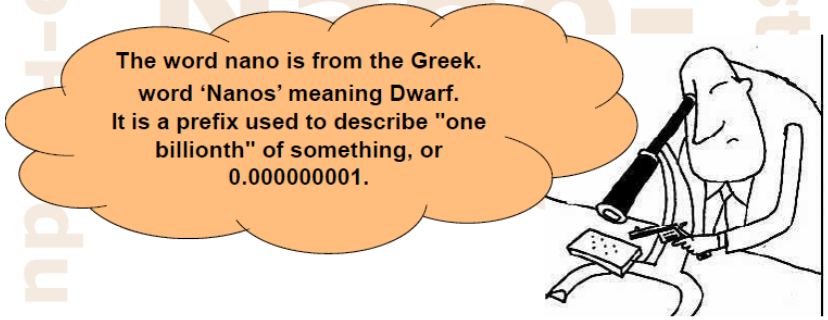
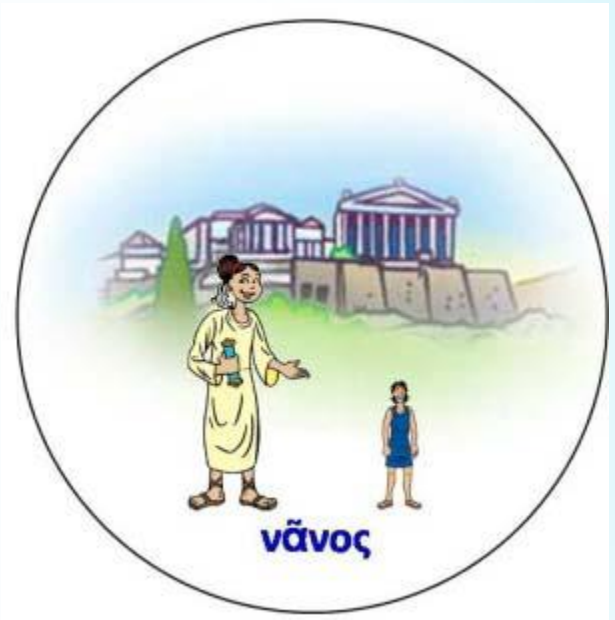
INTRODUCTION

Nano:

A prefix that means very, very, small.





Nanotechnology gets its name from the ancient Greek word *nanos*, which means 'dwarf' or 'very tiny'. However, that does not give an accurate idea of just how small a nanometre is.

What is nano?

Nano is…

*Small and different
*Studying and making tiny things
*New technologies
*Part of our society and our future

The nanoscale

1 nanometre (nm) x 1,000 = 1 micrometre (μm)

1 micrometre (μm) x 1,000 = 1 millimetre (mm)

1 millimetre (mm) x 1,000 = 1 metre (m)

Abbreviations and Size

meter	m	1	$1X10^{0}$
decimeter	dm	1/10	$1X10^{-1}$
centimeter	cm	1/100	$1X10^{-2}$
millimeter	mm	1/1000	$1X10^{-3}$
micrometer	μm	1/1000000	$1X10^{-6}$
nanometer	nm	1/1000000000	$1X10^{-9}$
angstrom	Å	1/10000000000	$1X10^{-10}$

The following diagram helps to show the size of things. When talking about nanotechnology, scientists usually mean about 1 nm to 100 nm.

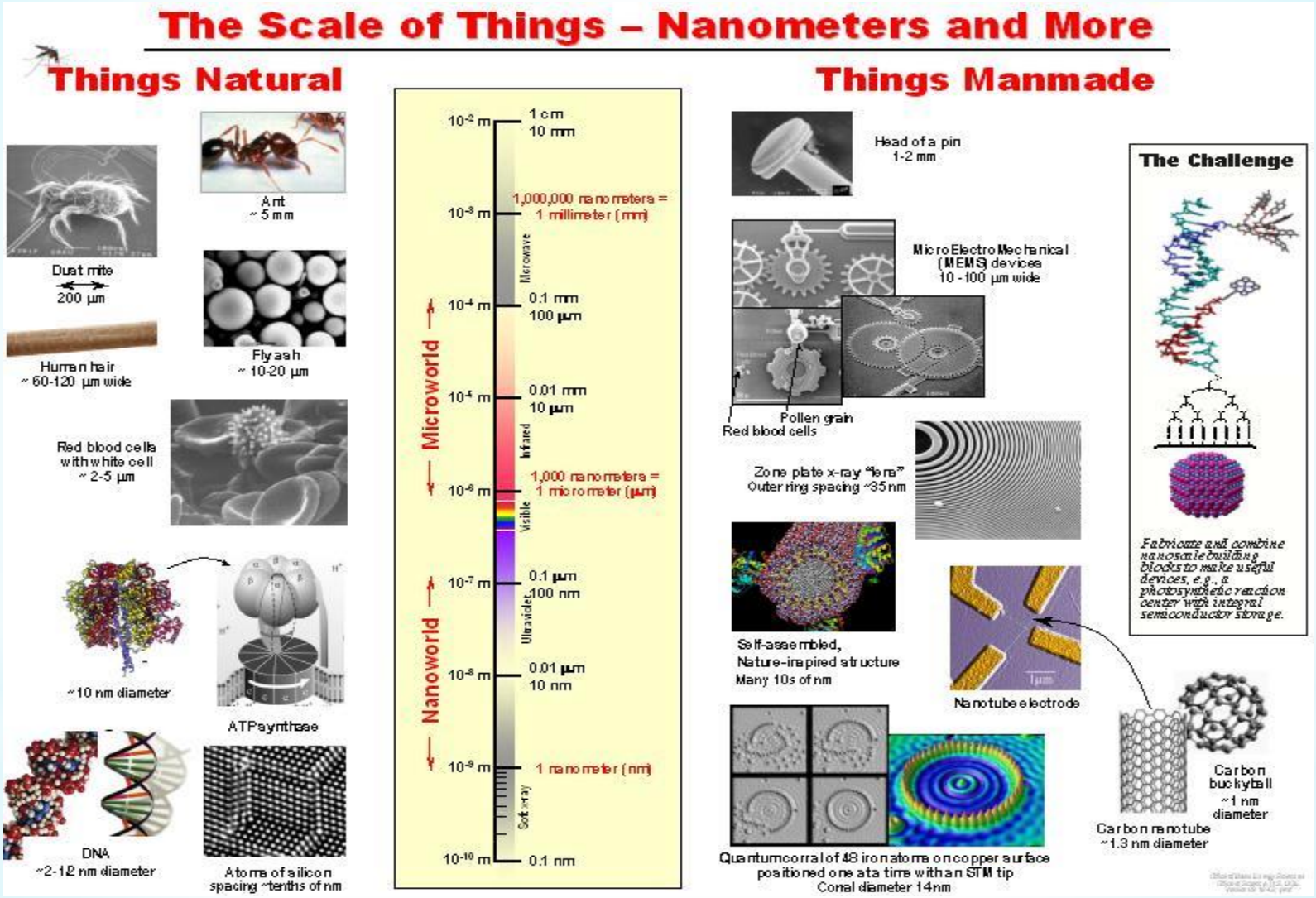


Figure 1. Size relationships from large to small to nano.

What is nanotechnology?

Nanotechnology is the science and technology of precisely manipulating the structure of matter at the molecular level. The term nanotechnology embraces many different fields and specialties, including engineering, chemistry, electronics, and medicine, among others, but all are concerned with bringing existing technologies down to a very small scale, measured in nanometers. Processes and functionality take place at the nanoscale, exhibiting properties not available in the bulk material.

What is nanoscince?

Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolular scales, where the properties differ significantly from those at a larger scale.

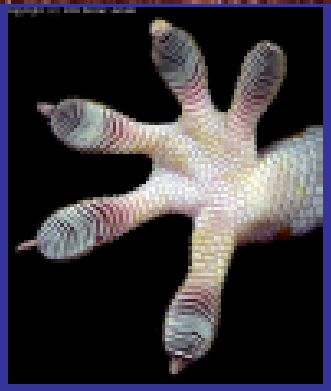
Table 2. Definitions of general nanotechnology-related terms

Term	Definition
nanomaterial	Material with one or more external dimensions, or an internal structure, on the nanoscale, which could exhibit novel characteristics compared to the same material without nanoscale features NOTE Novel characteristics might include increased strength, chemical reactivity or conductivity.
nanoparticle	Particle with one or more dimensions at the nanoscale NOTE 1 Also referred to as nanoparticulate, although this term is more often used adjectivally. NOTE 2 Novel properties that differentiate nanoparticles from the bulk material are typically developed at a critical length scale of under 100 nm.
nanoscale	Having one or more dimensions of the order of 100 nm or less NOTE Also referred to as nanosize.
nanoscience	Study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale
nanostructured	Having a structure at the nanoscale NOTE Agglomerates and aggregates of nanoparticles are examples of nanostructured particles.
nanotechnology	Design, characterization, production and application of structures, devices and systems by controlling shape and size at the nanoscale

Examples of Nanotechnology in Nature:The Gecko Phenomenon

Nanomaterials and Nanostructures in Nature

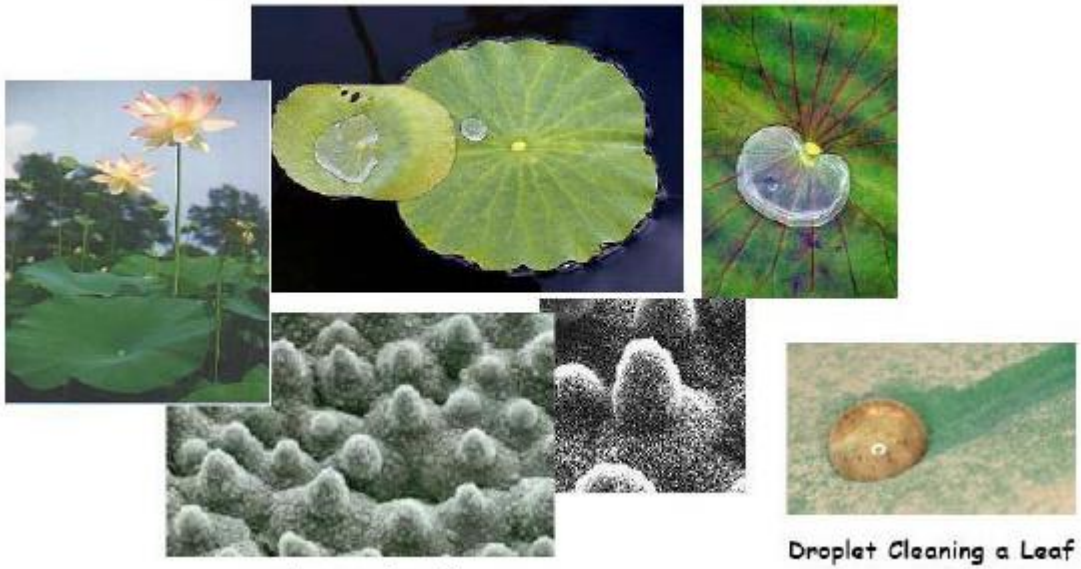
Geckos have an extraordinary ability to adhere to surfaces. This behavior is due to keratin hairs, 200 nm in diameter, that cover their feet. Each hair produces a very small force of 10^{-7} N/. Half a million of these tiny hairs produce an extremely strong adhesive force, as high as $10 N/cm^2$!



Examples of Natural Nanotechnologists

* Examples of Nanotechnology in Nature:The Lotus Leaf Effect

surface morphology + chemistry to control fluid interactions



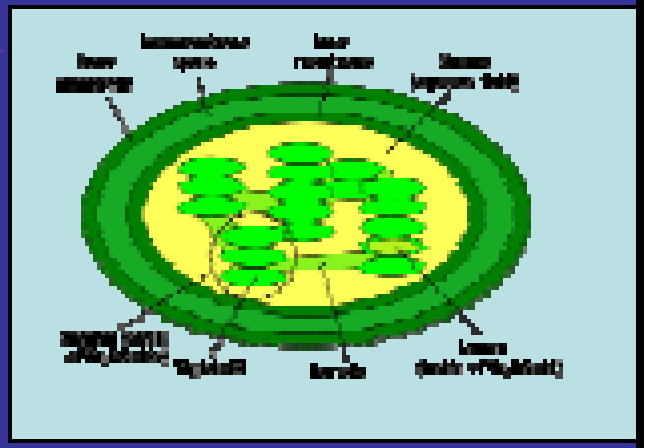
Droplet Cleaning a Leaf

Lotus leaf

Through the combination of micro- (cells) and nano-structure (wax crystals) contact areas are minimized. Any hydrophilic contamination on the leaf adheres to the water rather than the leaf itself and rolls away with the droplet.

Nanomaterials and Nanostructures in Nature

Another example of the role of nanostructures in nature is photosynthesis.
Photosynthesis happens in the chloroplasts. Each reaction center is composed by 10,000 atoms and 200 pigments.
Efficiency of the process about 95%.



Examples of Natural Nanotechnologists

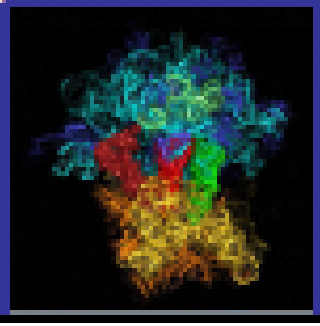
The water strider did break the water tension and take a plunge, because its so small, the water strider would float gently down because the frictional forces acting upon the water strider's surface overcome the weak influence of gravity at this size. Also adhesion forces would keep the suit on the strider for life.

Examples of Natural Nanotechnologists

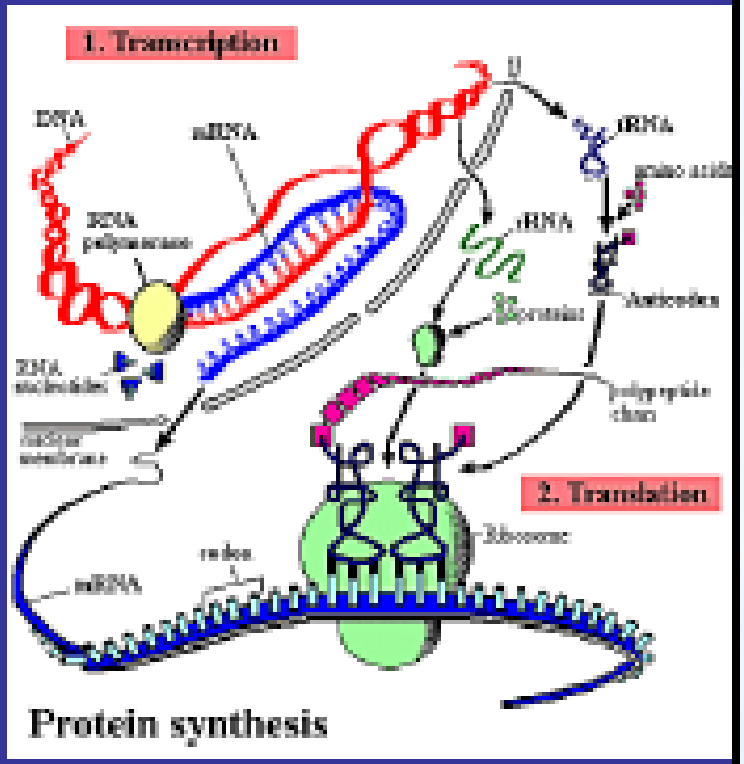
*Our physical bodies are amazing Nanotechnology machines. We feed our bodies food, water and air. The body converts these raw materials into a variety of amino acids, sugars and minerals.From these materials **DNA, cells, blood, muscle, bones** etc are all created. Other processes convert these inputs into energy that is used to power our bodies.

Nanomaterials and Nanostructures in Nature

The best-known biological example of molecular machinery is the ribosome, which is a nanoscale assembler. It acts as a factory of proteins by combining aminoacids together.



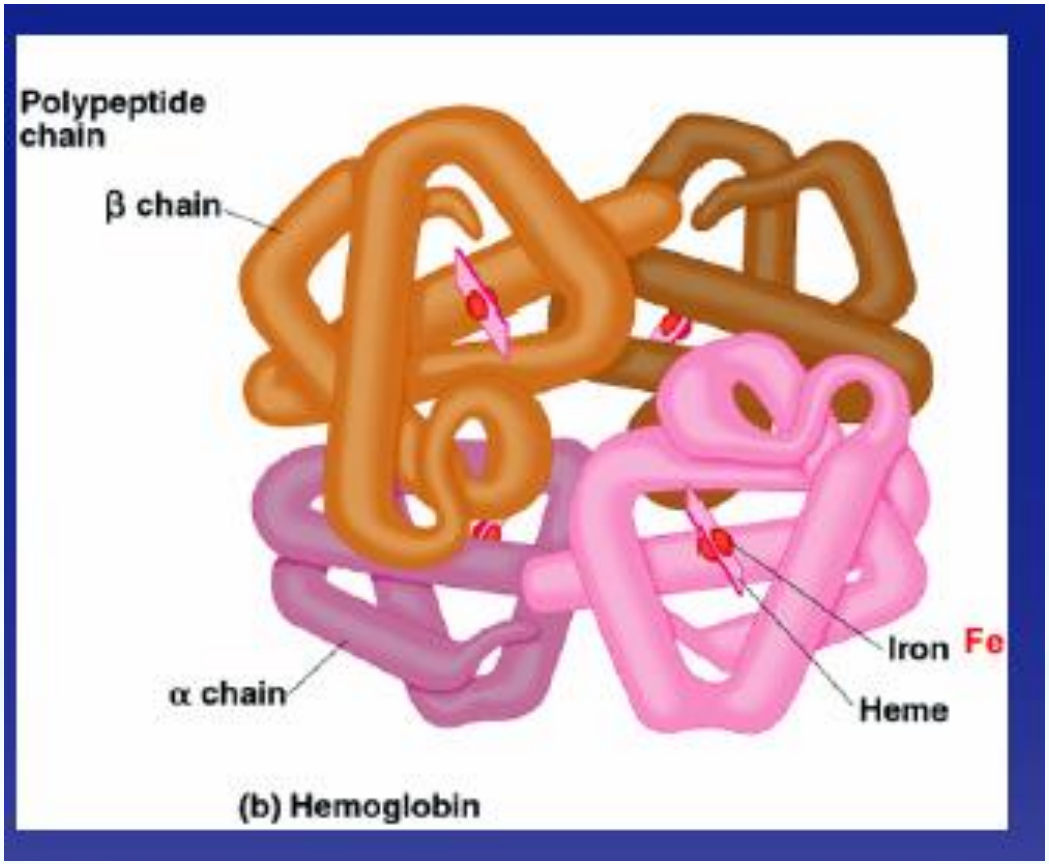
Molecular model



Protein synthesis

Red Blood Cell (3,000 nm)

Hemoglobin Molecule (5 nm)



Abalone

Examples of Natural Nanotechnologists

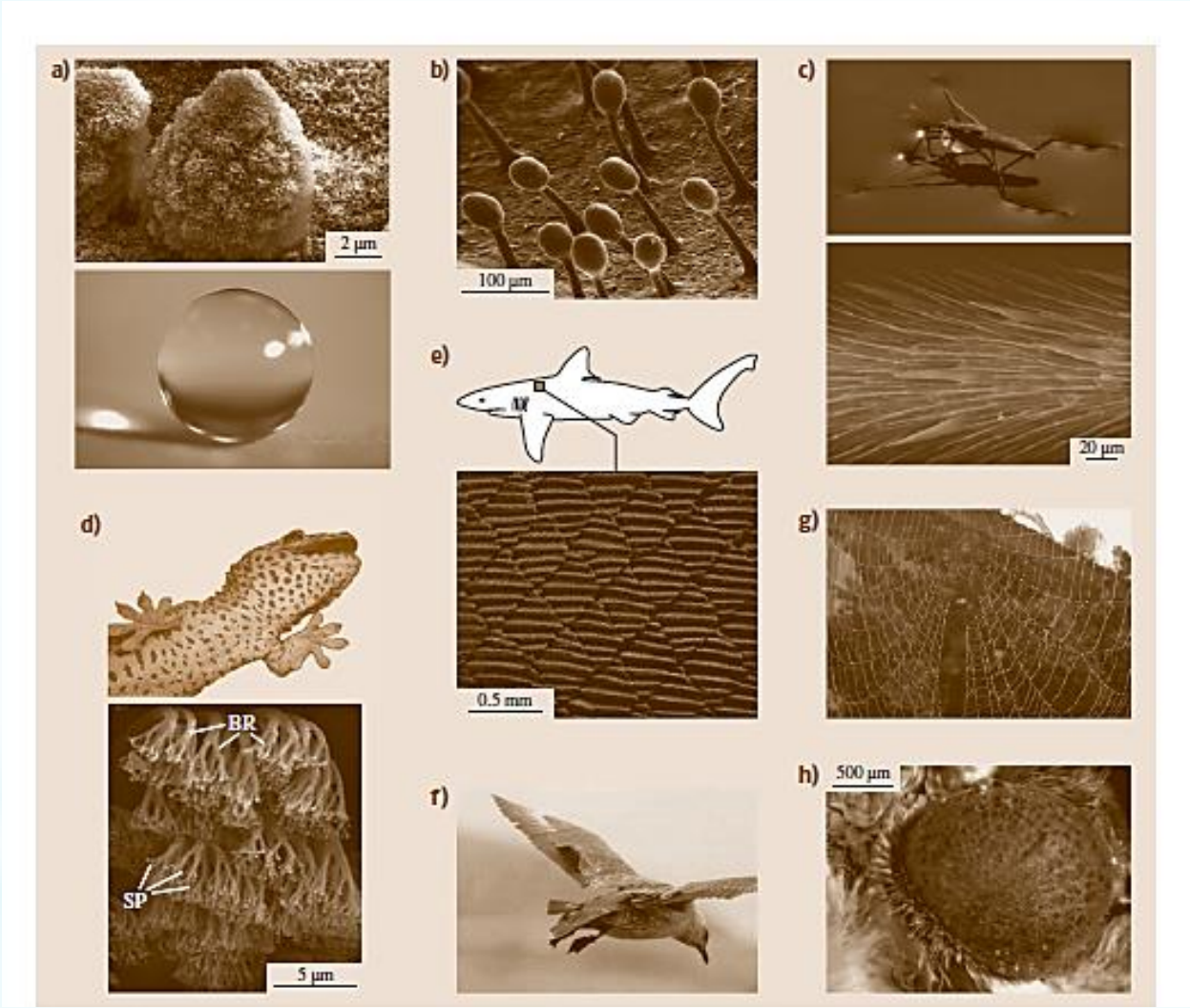


Fig. 1.8 a–h Montage of some examples from nature:
(a) lotus effect, (b) glands of carnivorous plant that secrete adhesive to trap insects, (c) water strider walking on water, (d) gecko foot exhibits reversible adhesion, (e) scale structure of shark reduces drag, (f) wings of a bird in landing approach, (g) spider web made of silk material, (h) moth's eyes are antireflective

Home work

1. Write a scientific report about nanotechnology illustrated its uses and applications in our life?

2. List with explaining five examples of natural nanotechnologists?