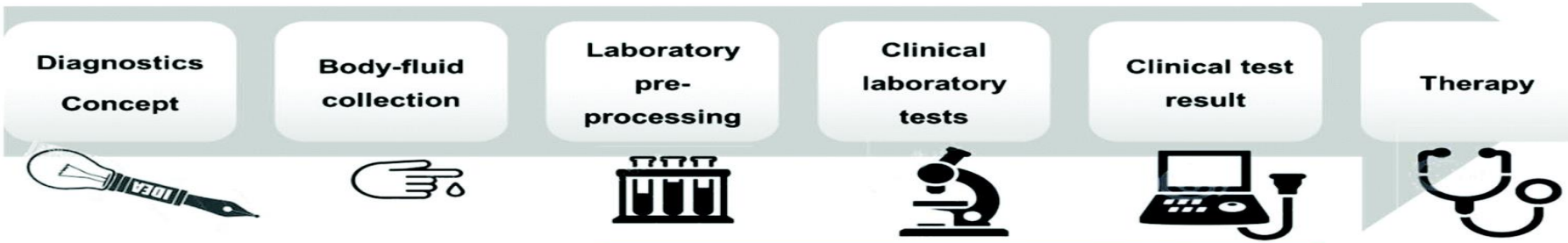
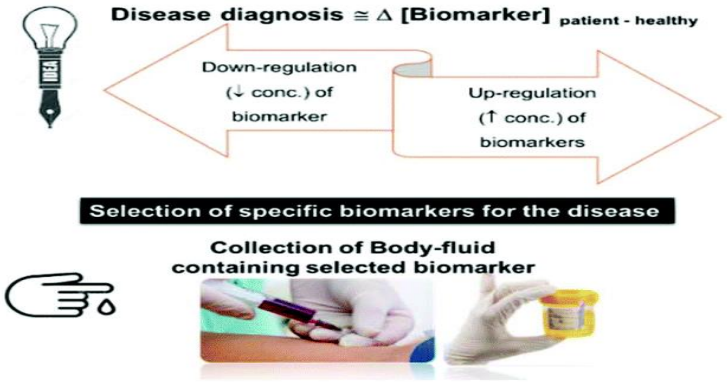
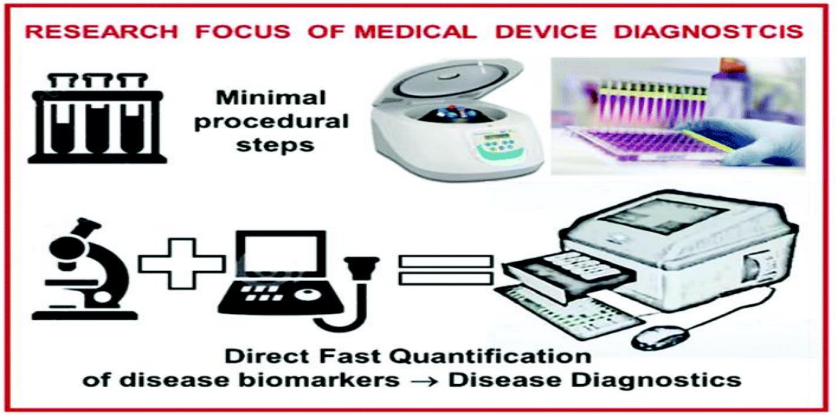
Applications of Nanobiotechnology in Diagnosis







Dr. Hisham Faiadh

Applied Nanobiotechnology

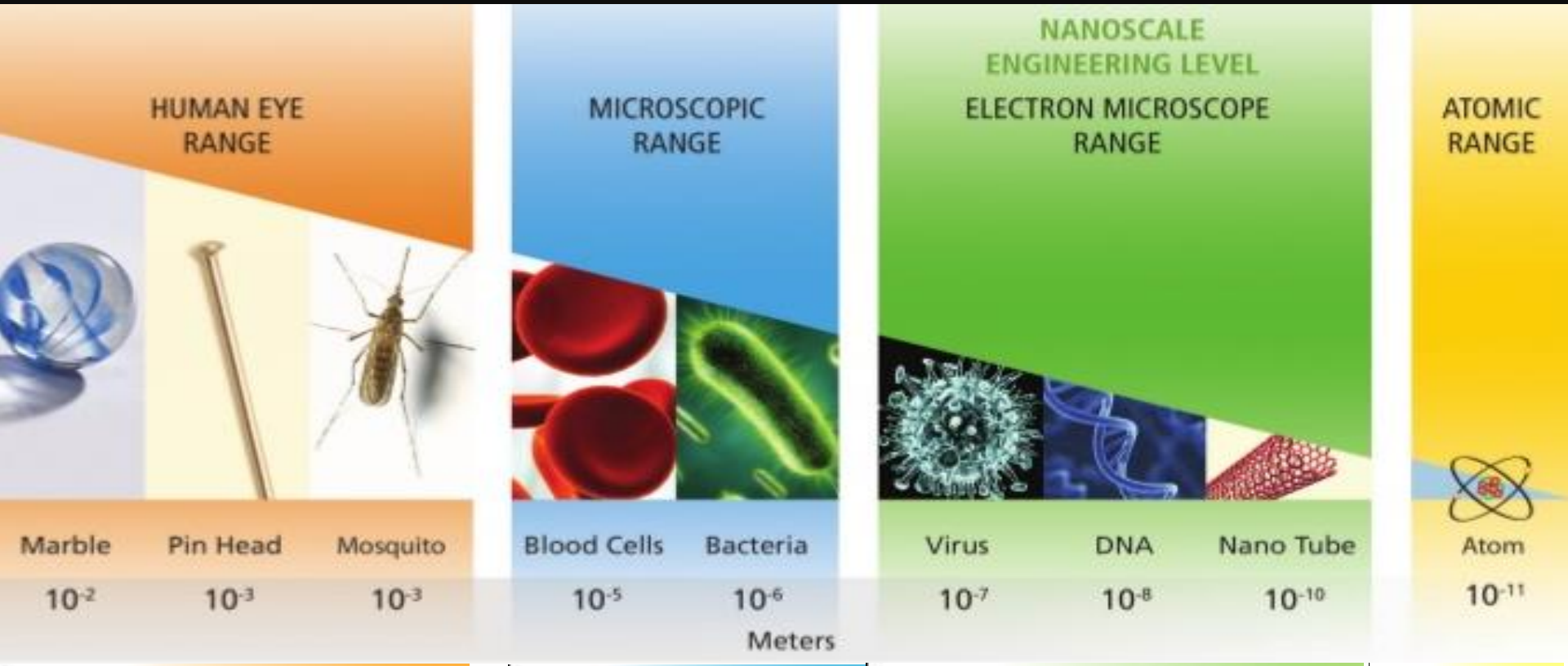
Contents

BRIEFLY REVIEW

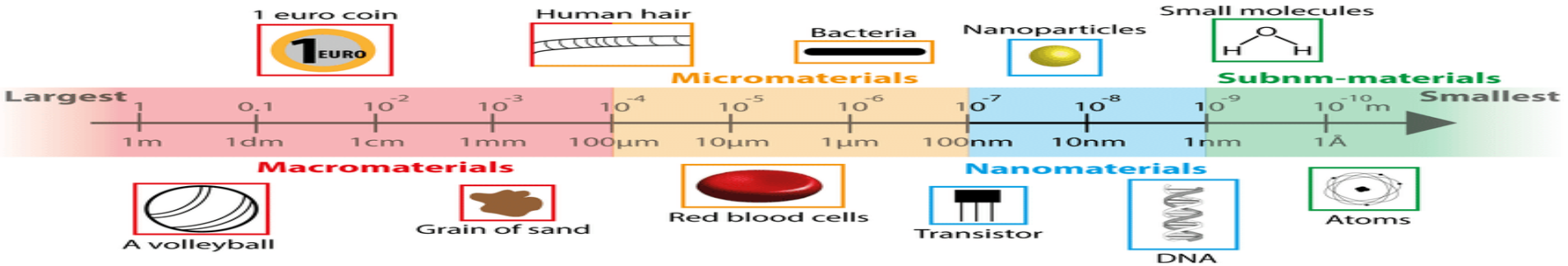
METHODOLOGY

APPLICATION

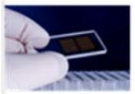
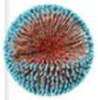
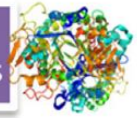
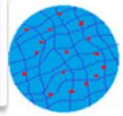
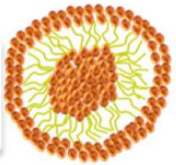
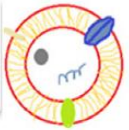
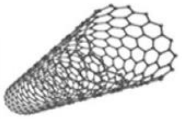
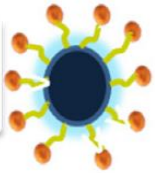
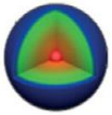
Materials scale

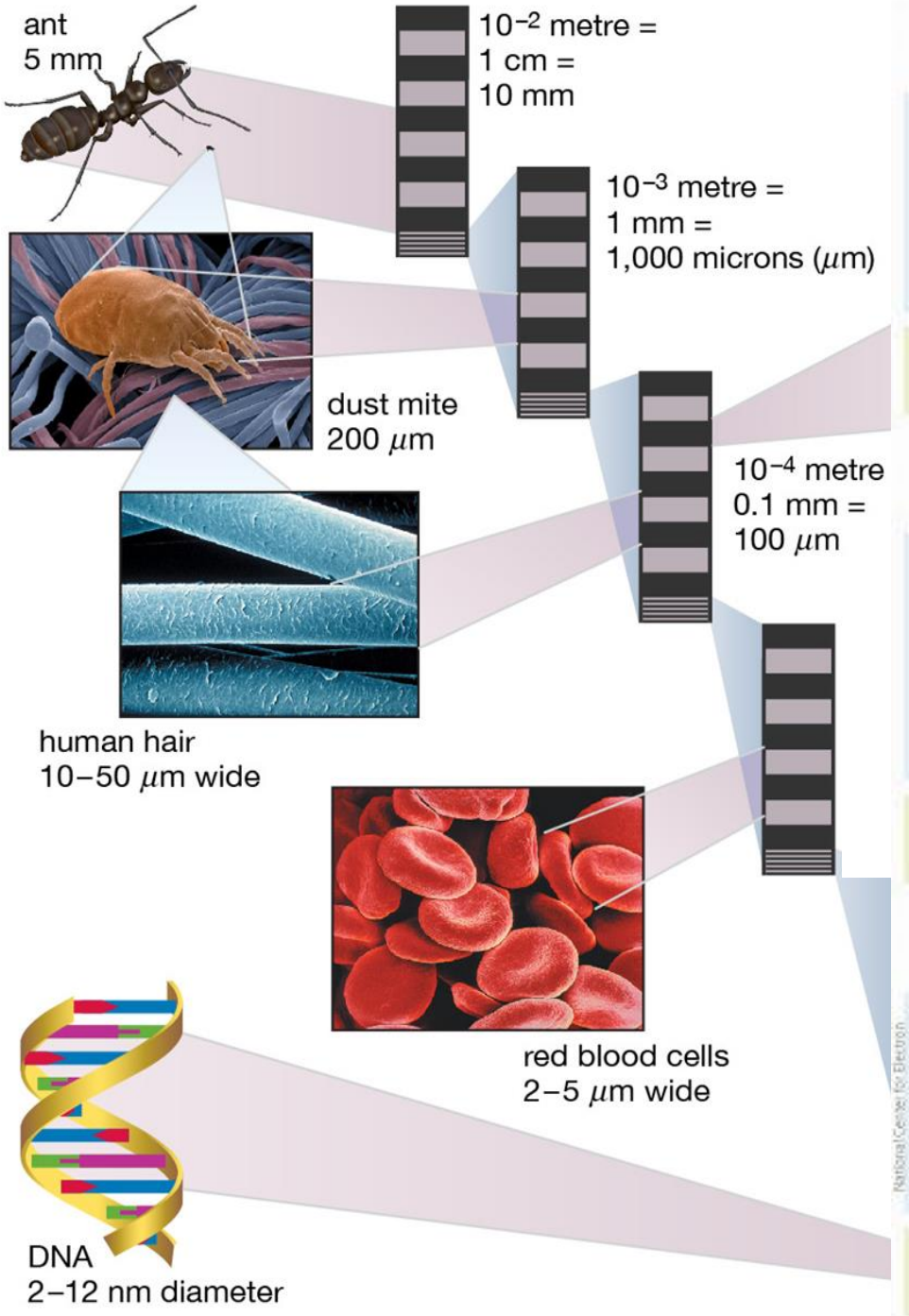


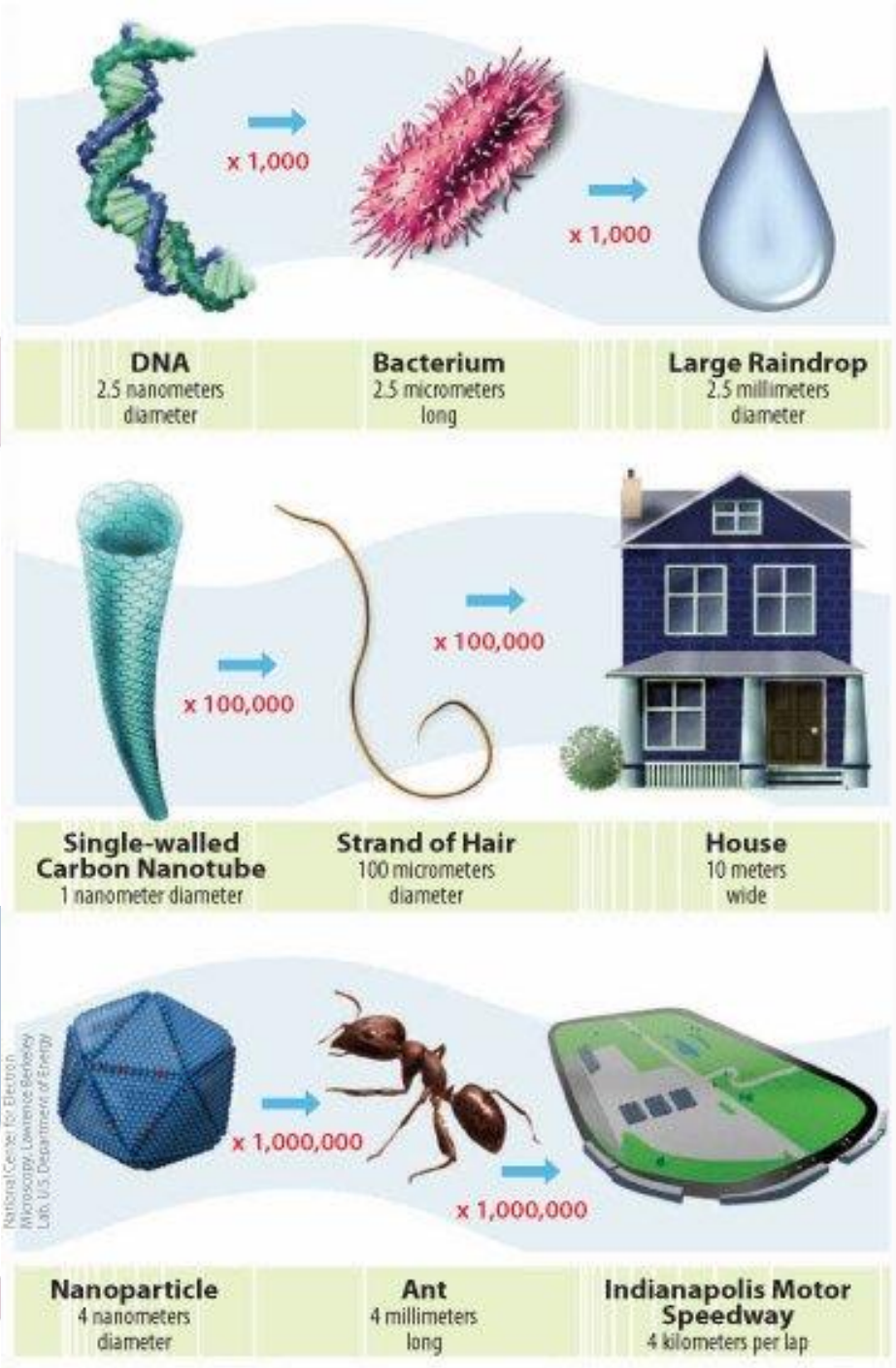
Macrometer | **Micrometer** | **Nanometer** | **Sub nano**



Nanotechnology

- Nanodevices
  - Microarrays 
  - Microscopic devices 
  - Intelligent machines 
- Nanomaterials
  - Nanostructured
    - Polymer-based
      - Dendrimers 
      - Nanoparticles 
      - Micelles 
      - Drug conjugates 
      - Protein nanoparticles 
      - Nanogels 
    - Lipid-based
      - Liposomes 
      - Exosomes 
      - Solid lipid nanoparticles 
    - Non polymeric
      - Carbon nanotubes 
      - Nanodiamond 
      - Metallic nanoparticles 
      - Quantum dots 
      - Silica based nanoparticles 
  - Nanocrystalline


ant
5 mm
10^{-2} metre =
1 cm =
10 mm
10^{-3} metre =
1 mm =
1,000 microns (μm)
dust mite
200 μm
10^{-4} metre
0.1 mm =
100 μm
human hair
10–50 μm wide
red blood cells
2–5 μm wide
DNA
2–12 nm diameter


x 1,000
x 1,000
DNA
2.5 nanometers
diameter
Bacterium
2.5 micrometers
long
Large Raindrop
2.5 millimeters
diameter
x 100,000
x 100,000
Single-walled
Carbon Nanotube
1 nanometer diameter
Strand of Hair
100 micrometers
diameter
House
10 meters
wide
x 1,000,000
x 1,000,000
National Center for Electron Microscopy, Lawrence Berkeley Lab, U.S. Department of Energy
Nanoparticle
4 nanometers
diameter
Ant
4 millimeters
long
Indianapolis Motor
Speedway
4 kilometers per lap

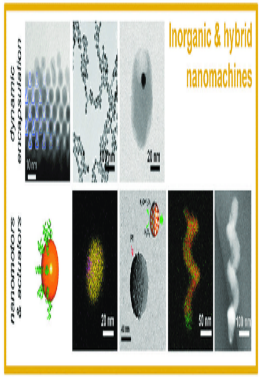
History of Nanotechnology

1959:
Richard Feynman
gave a talk on
Nanotechnology

1974:
Norio Taniguchi
coined the term
Nanotechnology

1991:
Sumio Iijima
discovered the
Carbon Nanotube

2006:
Naomi Halas and
Jennifer West
are leading the
field in Nanoparticles
combating Cancer

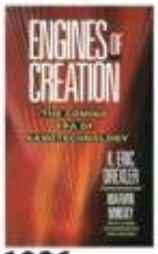


1959

2010

1960:
William McLellan
constructed the first
250-microgram motor

1985:
Researchers at
Rice University
discovered fullerenes or
more commonly know as
buckyballs

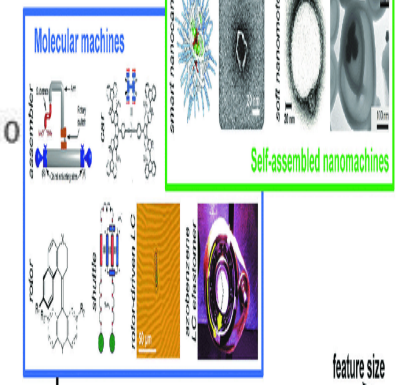


1986:
Eric Drexler
made the concept
popular with his
book *"Engines of
Creation"*

zyvex

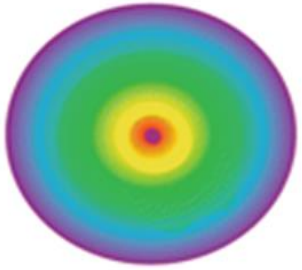
1997:
Zyvex
is founded and is
the first company
to research
Nanotechnology

2005:
Günter Oberdörster
coined the term
"Nanotoxicology"

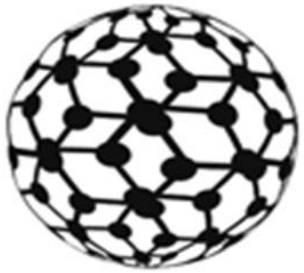


feature size

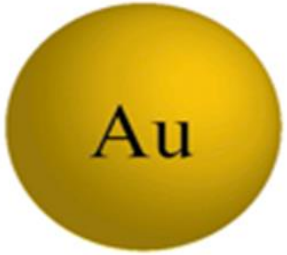
0D
Nanospheres, clusters



Quantum dots



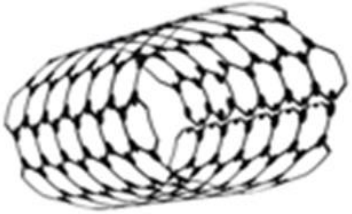
Fullerenes



Gold nanoparticles

1D
Nanotubes, wires, rods

Metal nanorods, Ceramic crystals

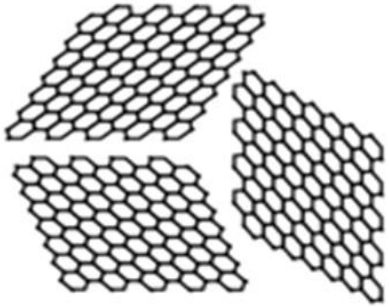


Carbon nanotubes, Metallic nanotubes

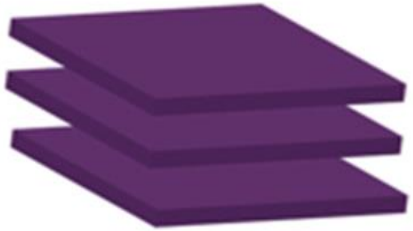
Gold nanowires, Polymeric nanofibers, Self assembled structures

2D
Thin films, plates, layered structures

Carbon coated nanoplates



Graphene sheets

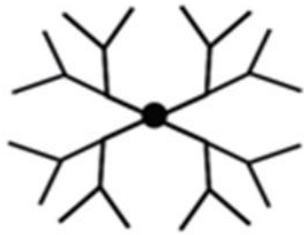


Layered nanomaterials

3D
Bulk NMs, polycrystals

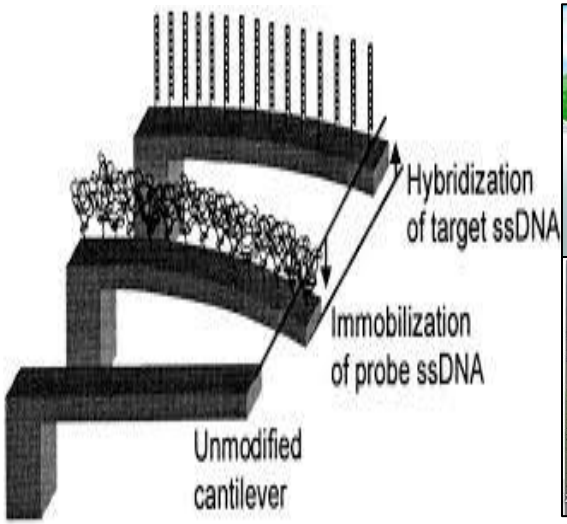
Liposome

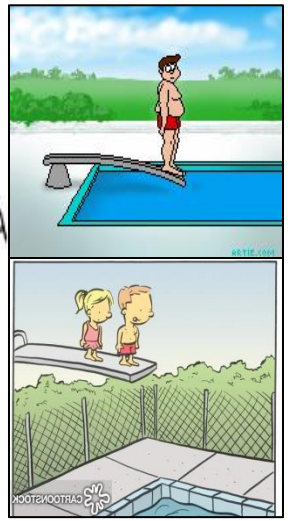
Polycrystalline

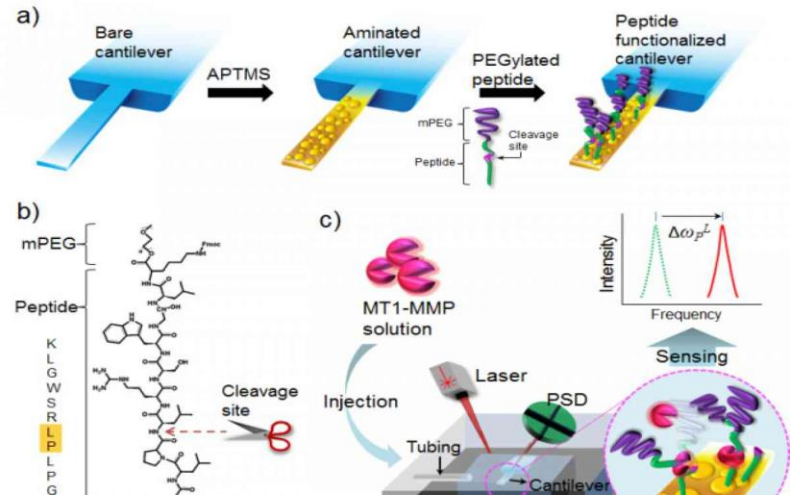


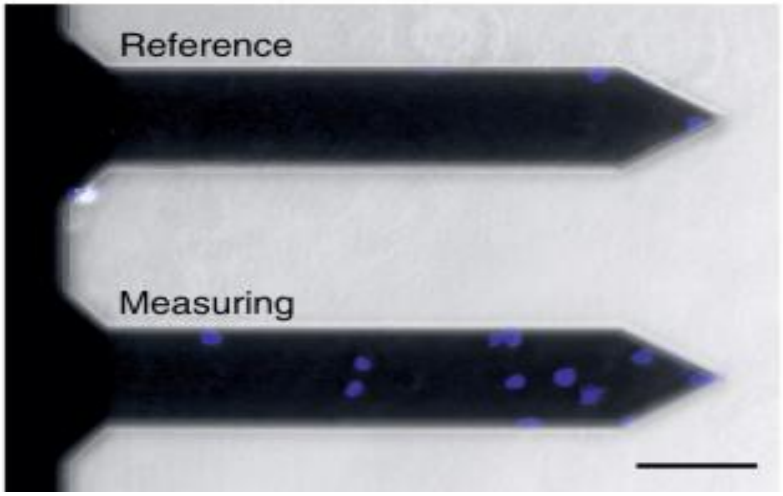
Dendrimer

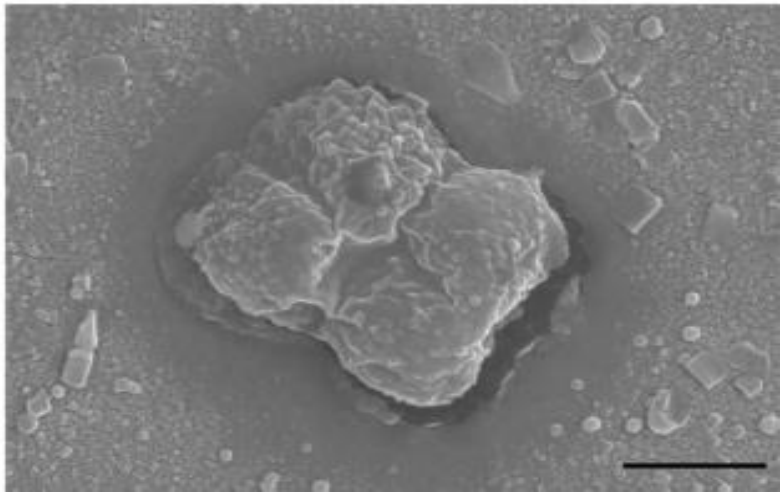
Nanocantilevers



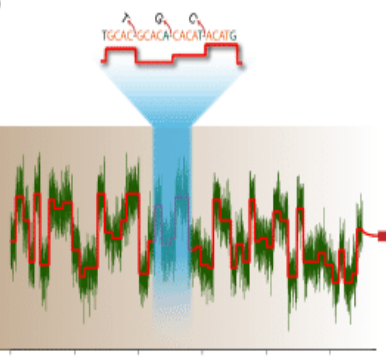




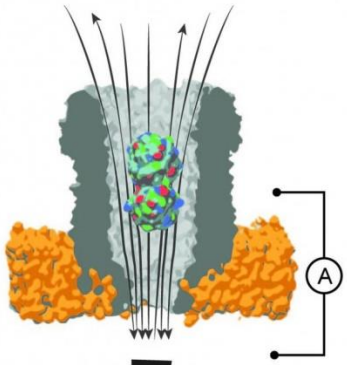


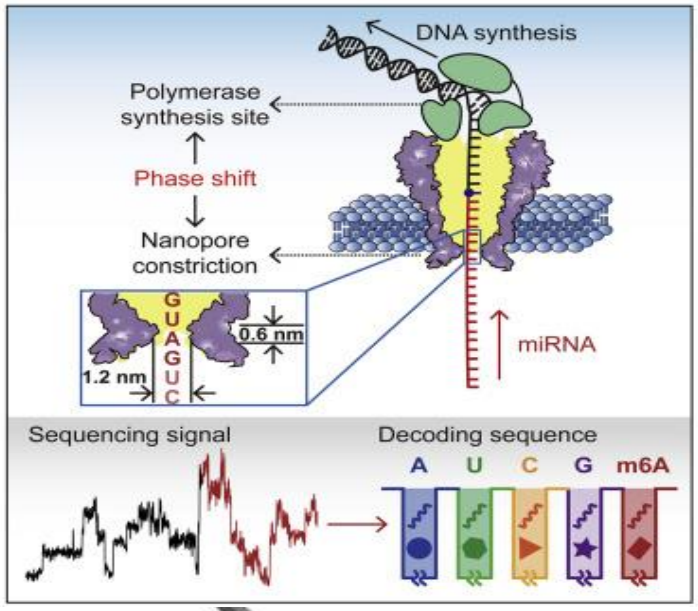


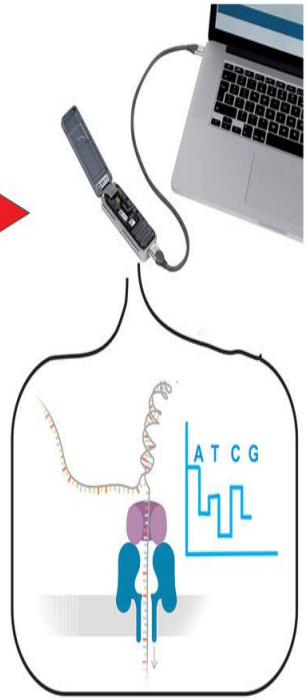
Nanopores



Nanopore transducer



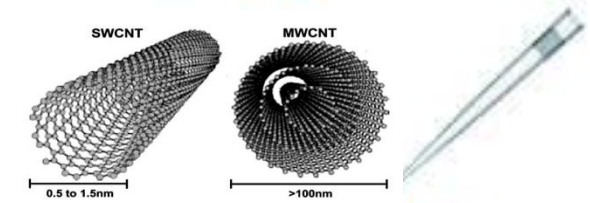


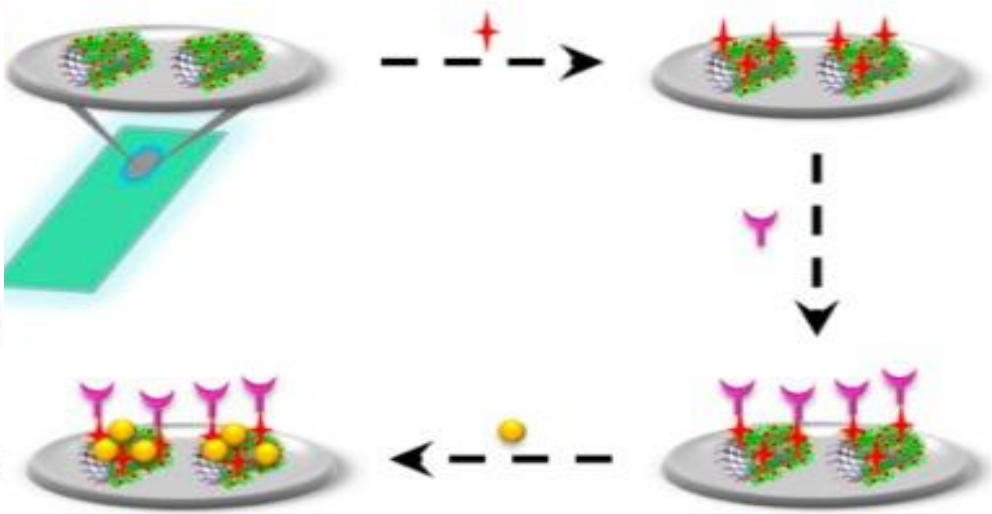


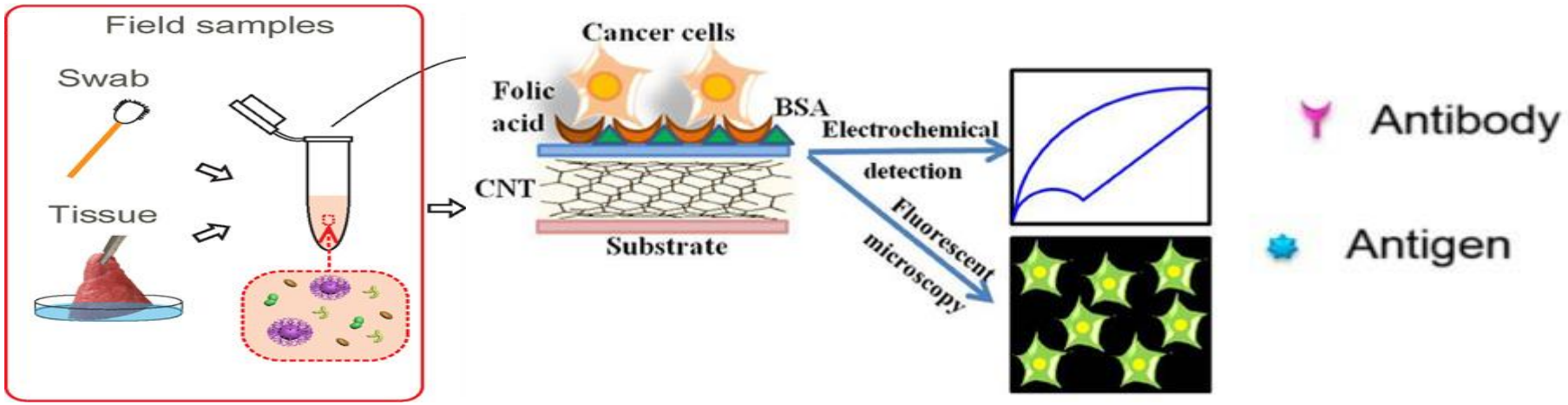
Nanopore Sequencing

Oxford NANOPORE Technologies

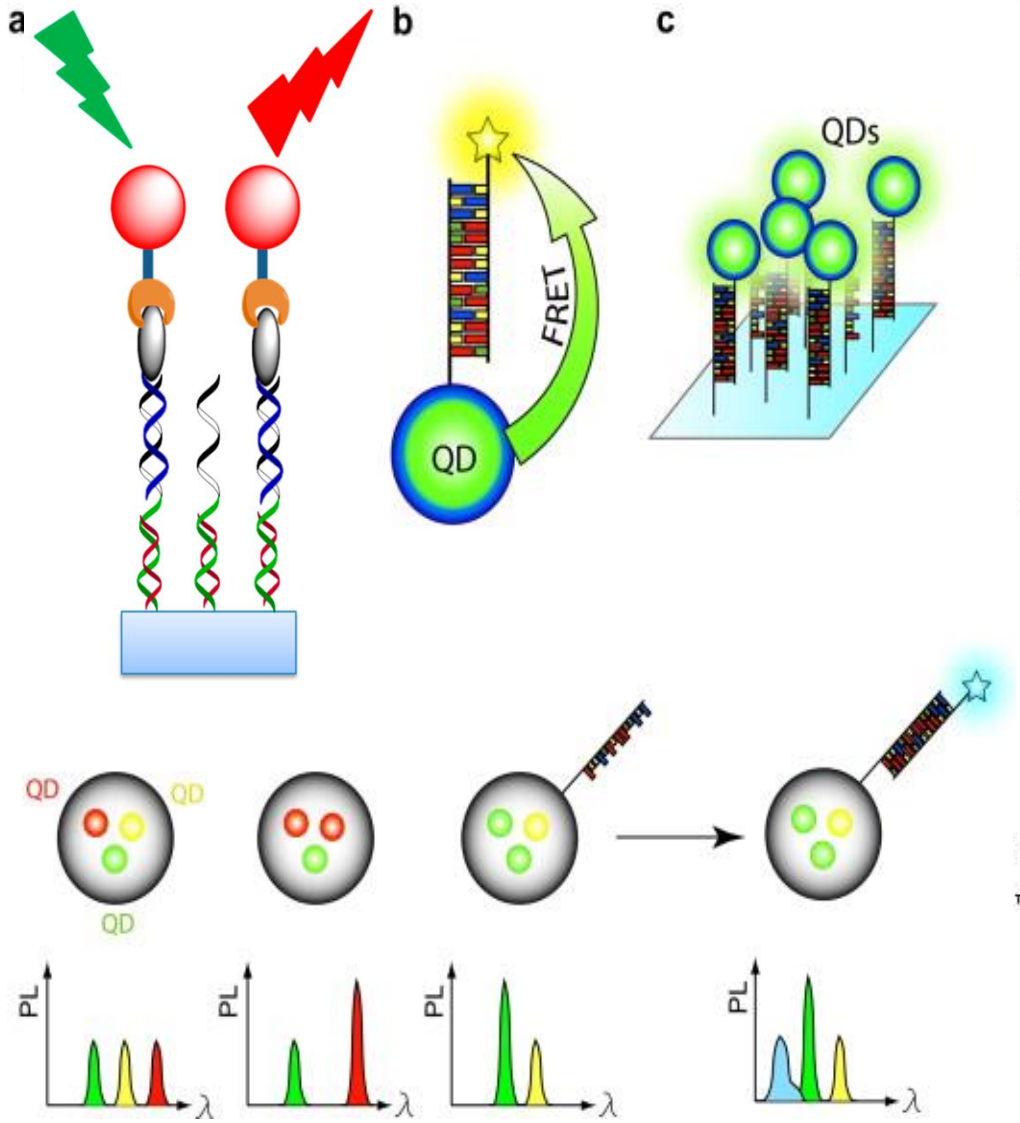
CarbonNanoTubes

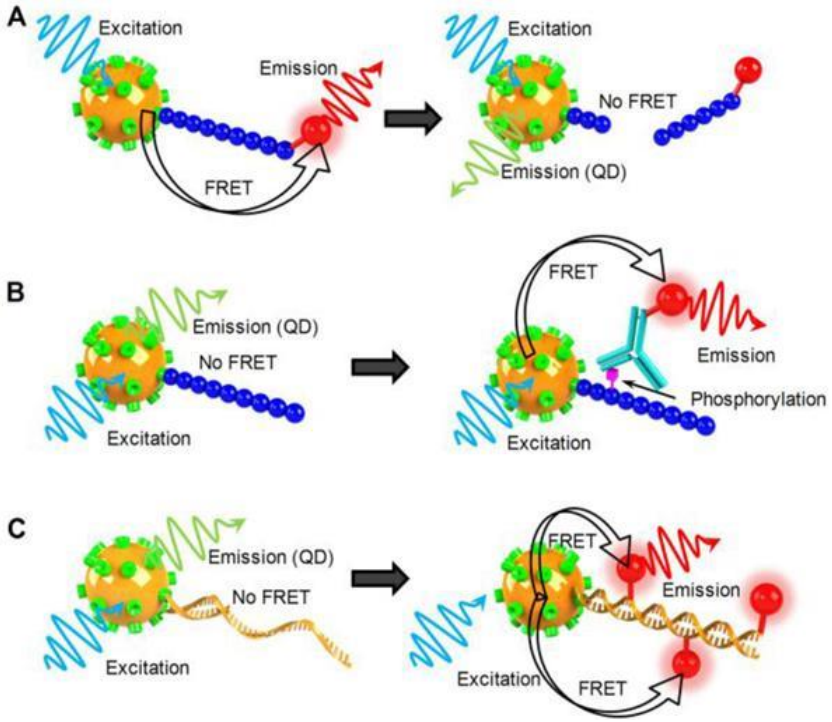


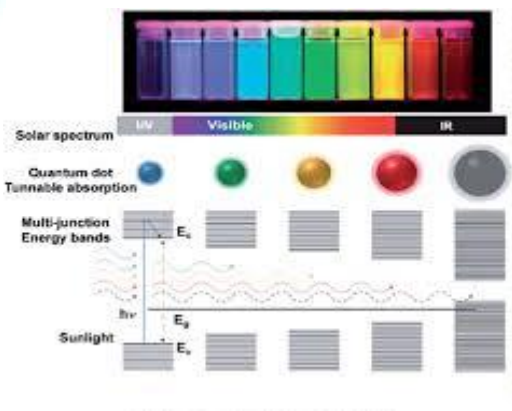


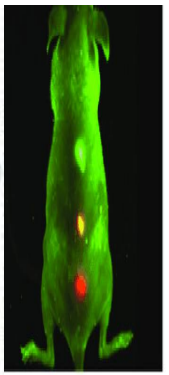


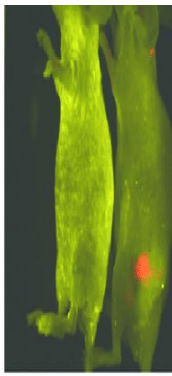
Quantum NanoDots



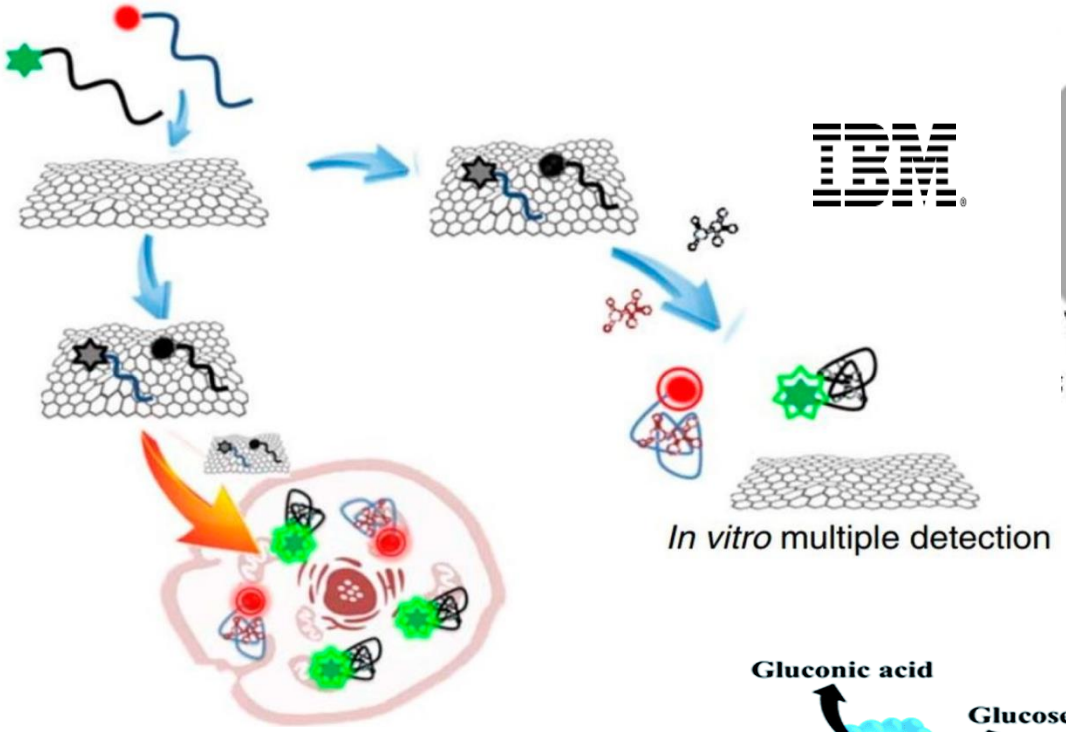




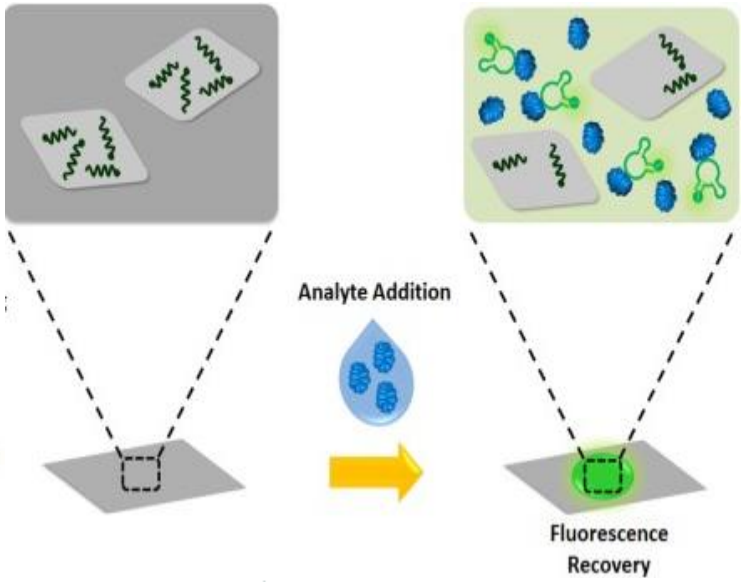


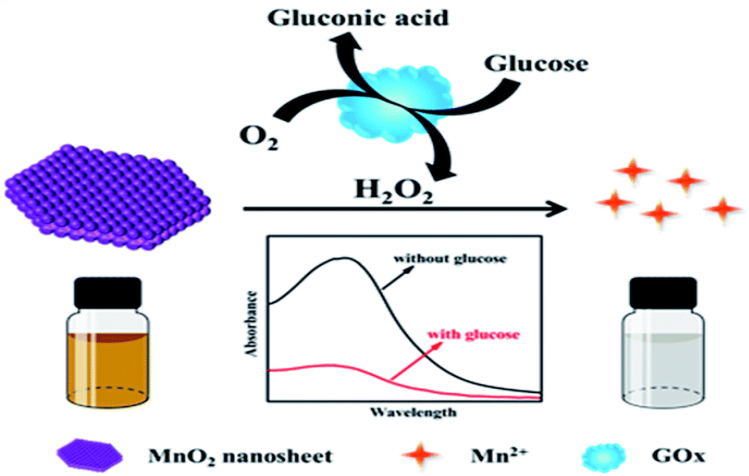


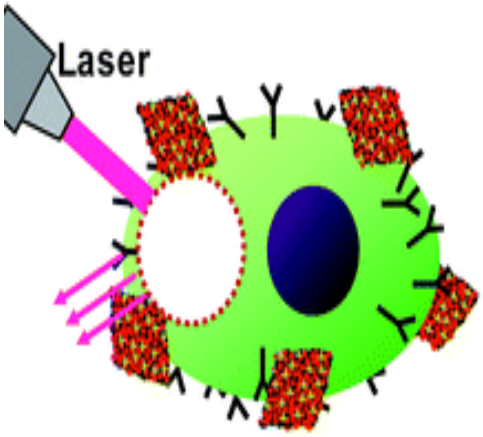
Nanosheets



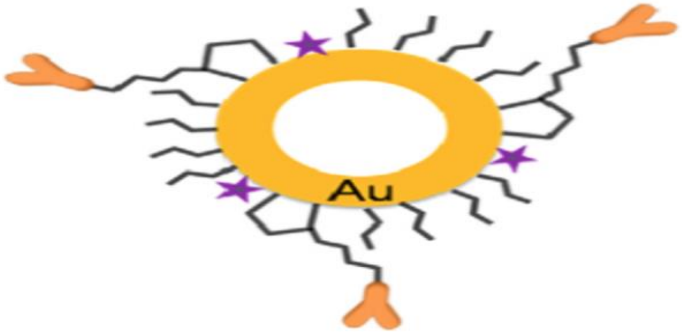
In vitro multiple detection

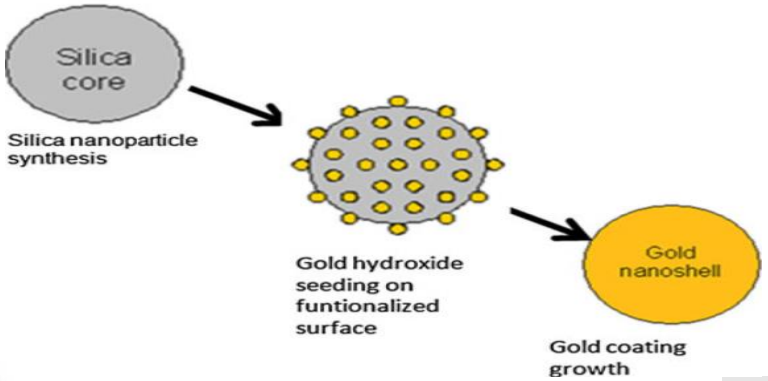


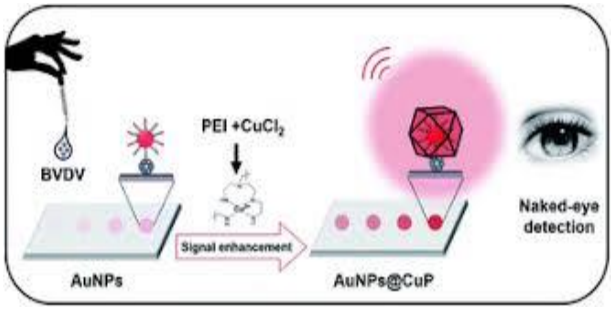


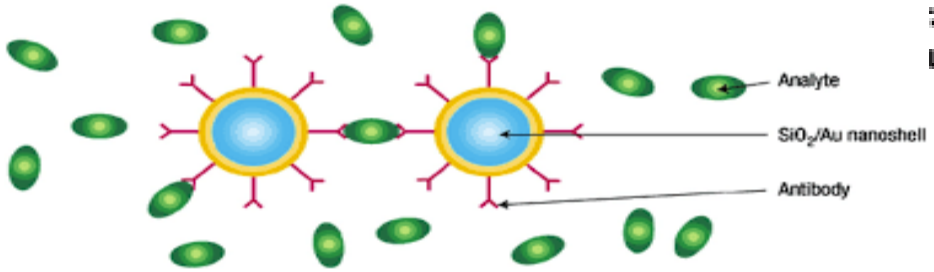


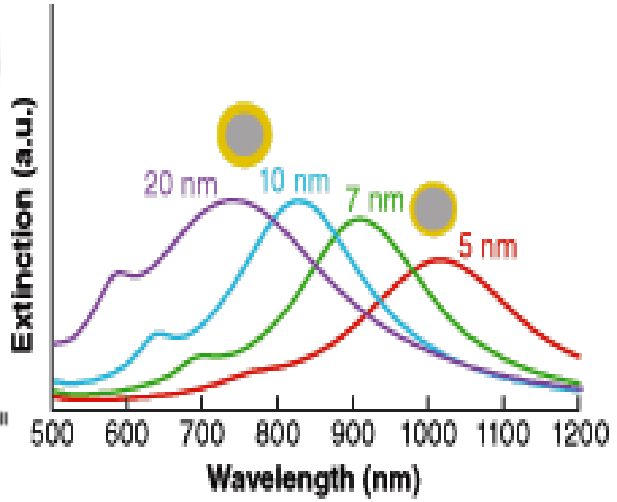
Nanoshells


Au

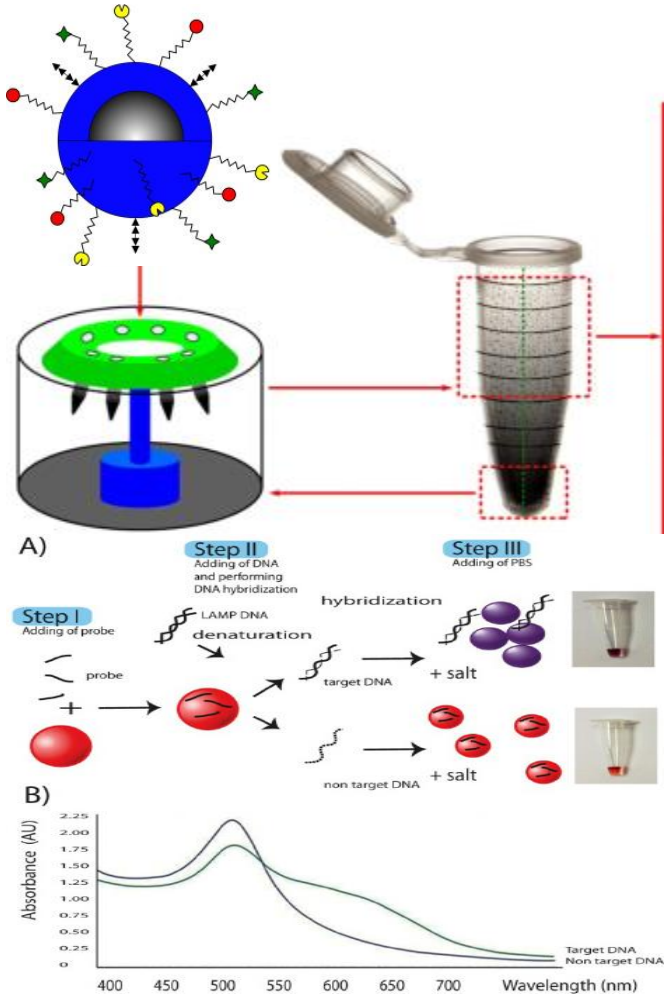

Silica core
Silica nanoparticle synthesis
Gold hydroxide seeding on funtionalized surface
Gold nanoshell
Gold coating growth

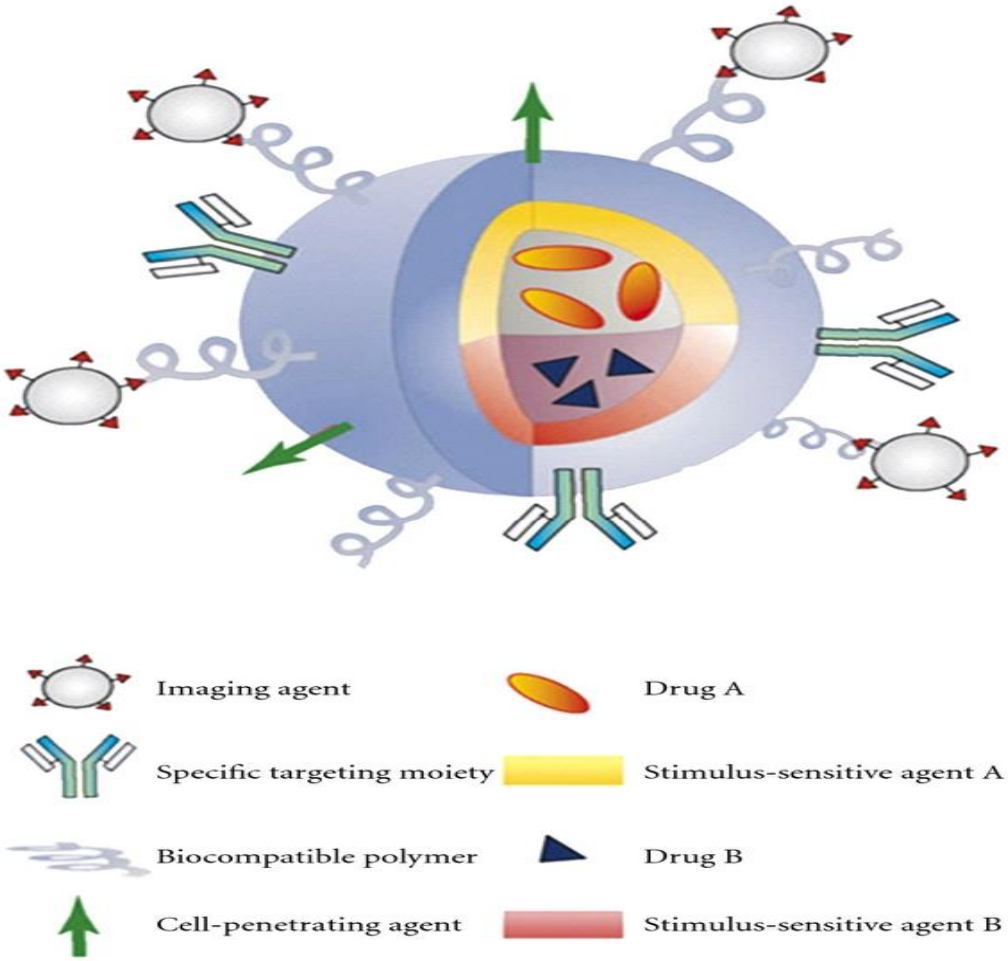

BVDV
PEI +CuCl2
Signal enhancement
AuNPs
AuNPs@CuP
Naked-eye detection


Analyte
SiO2/Au nanoshell
Antibody

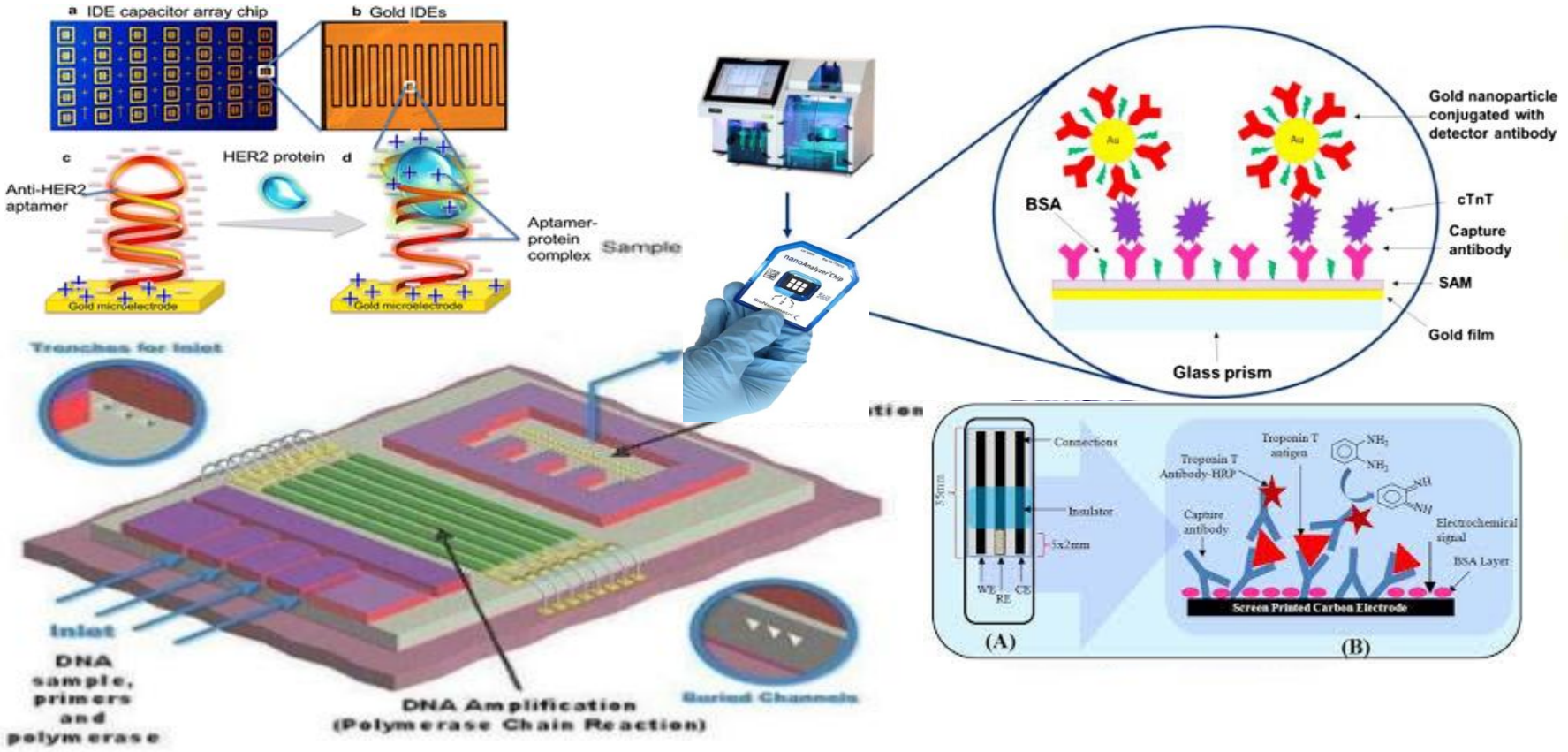

Extinction (a.u.)
20 nm
10 nm
7 nm
5 nm
500
600
700
800
900
1000
1100
1200
Wavelength (nm)

Magnetic Nanoparticles

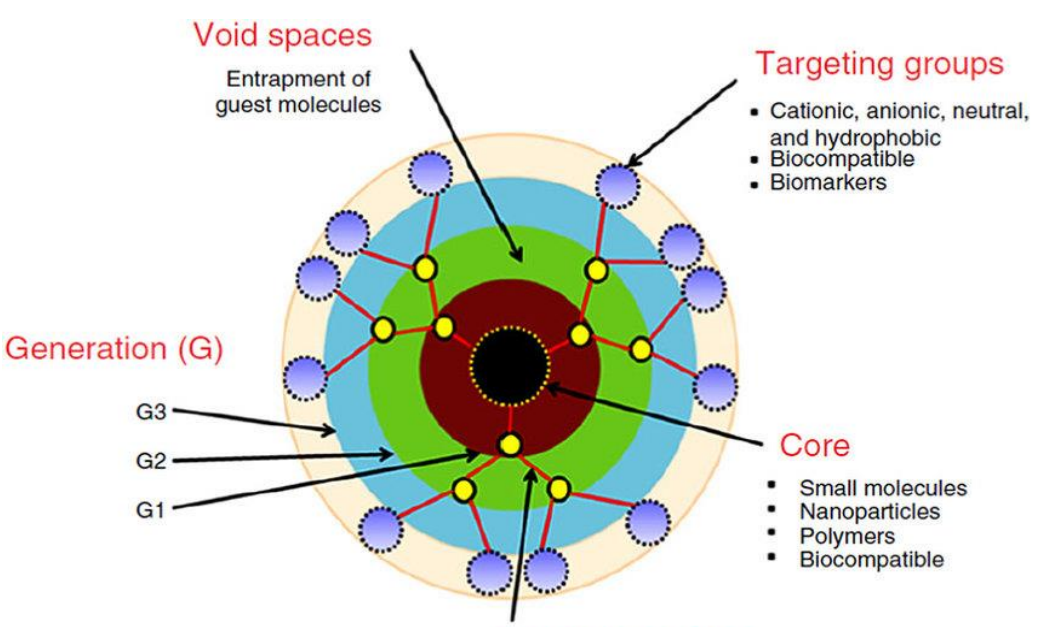


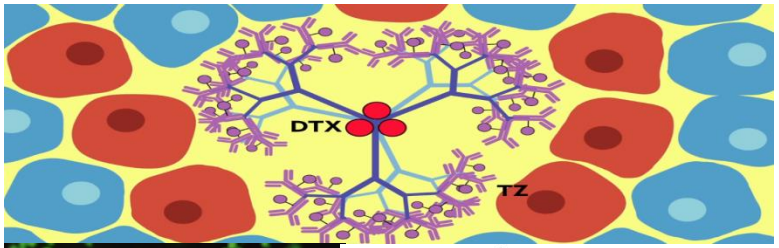


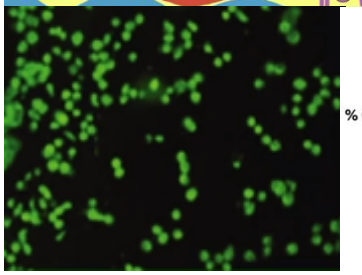
Bio-NanoChip

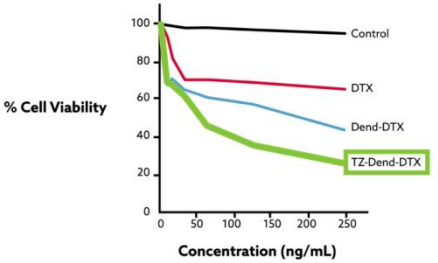


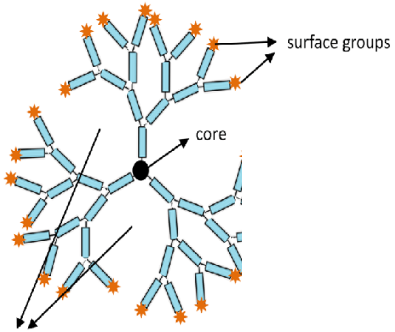
Dendrimers

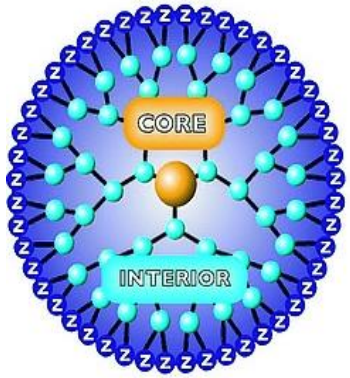

Void spaces
Entrapment of guest molecules
Targeting groups
Cationic, anionic, neutral, and hydrophobic
Biocompatible
Biomarkers
Generation (G)
G3
G2
G1
Core
Small molecules
Nanoparticles
Polymers
Biocompatible
Interior branching
Covalent structure
Connect core to surface group

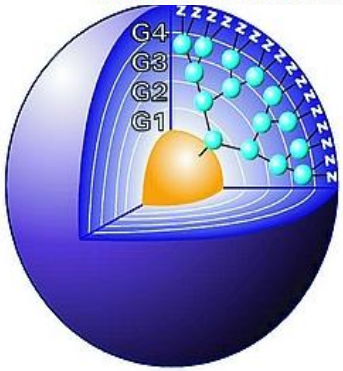

DTX
TZ

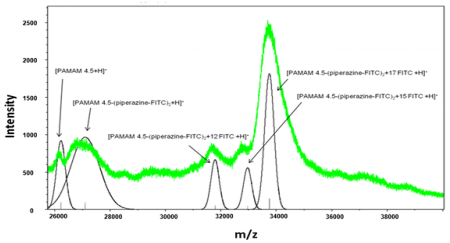


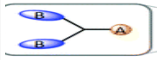

% Cell Viability
100
80
60
40
20
0
0
50
100
150
200
250
Concentration (ng/mL)
Control
DTX
Dend-DTX
TZ-Dend-DTX

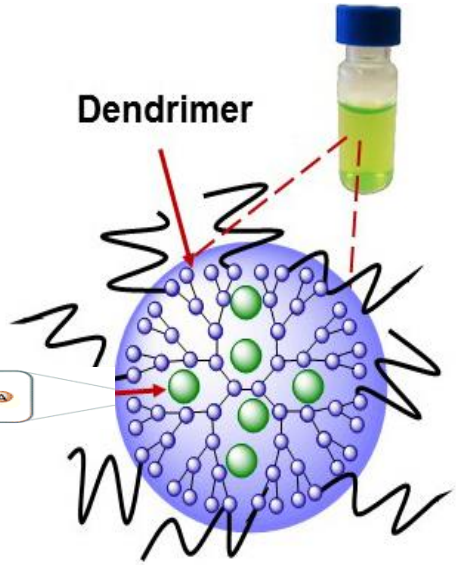

surface groups
core
internal cavities


CORE
INTERIOR

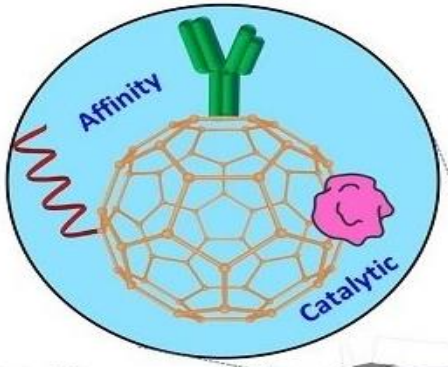

G4
G3
G2
G1

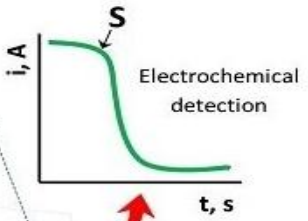

Intensity
m/z

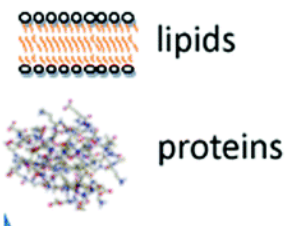


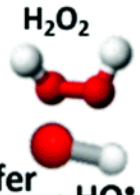

Dendrimer

Fullerenes C60

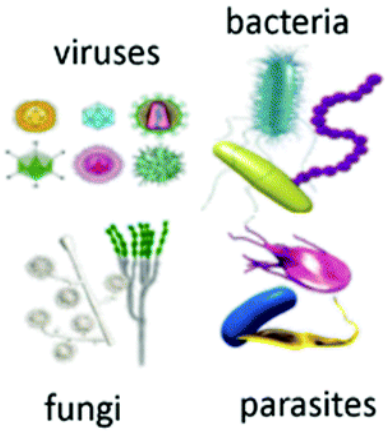


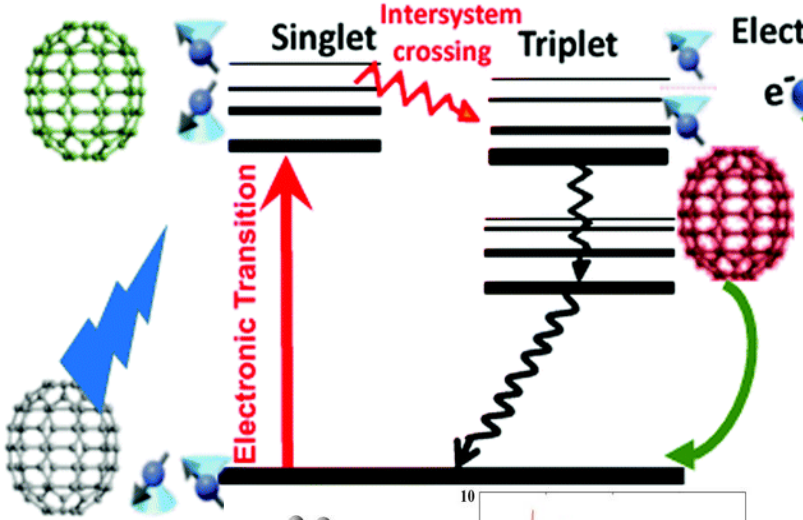


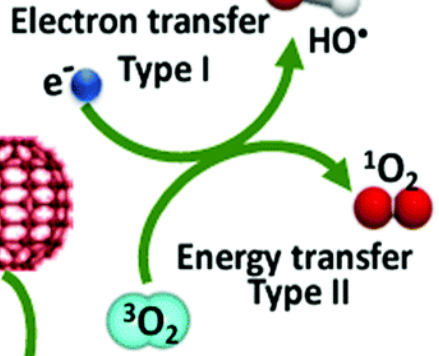


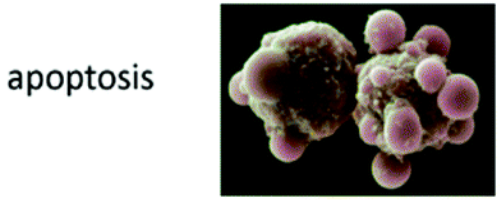


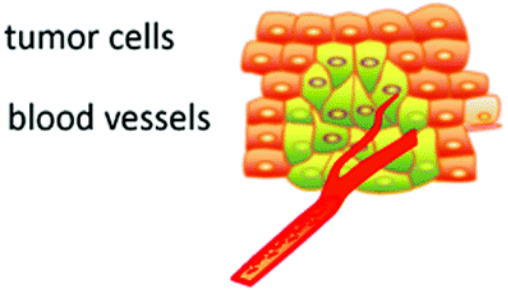
Biomolecules

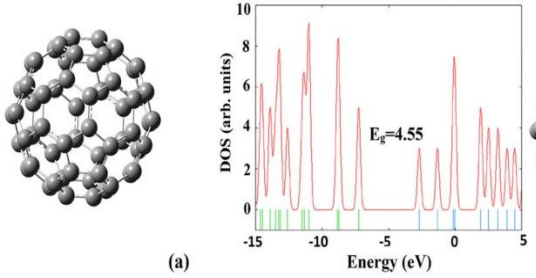


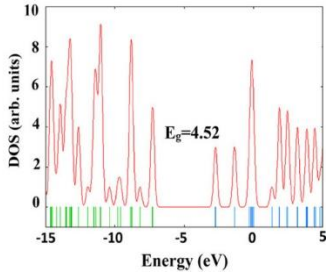








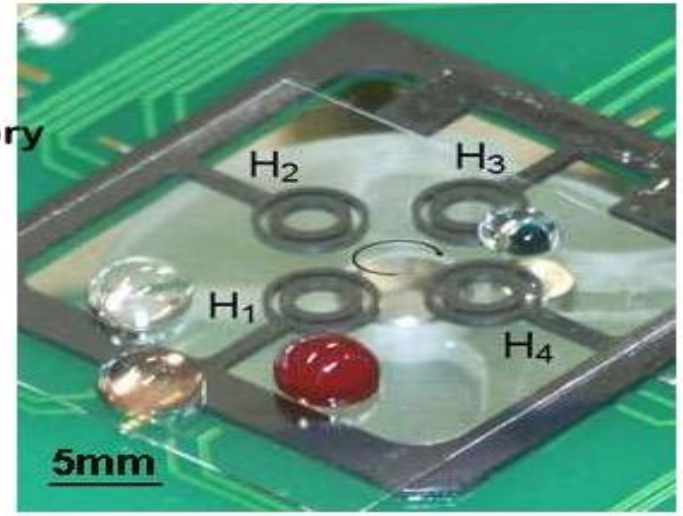




Lab on Chip

Lab on Chip

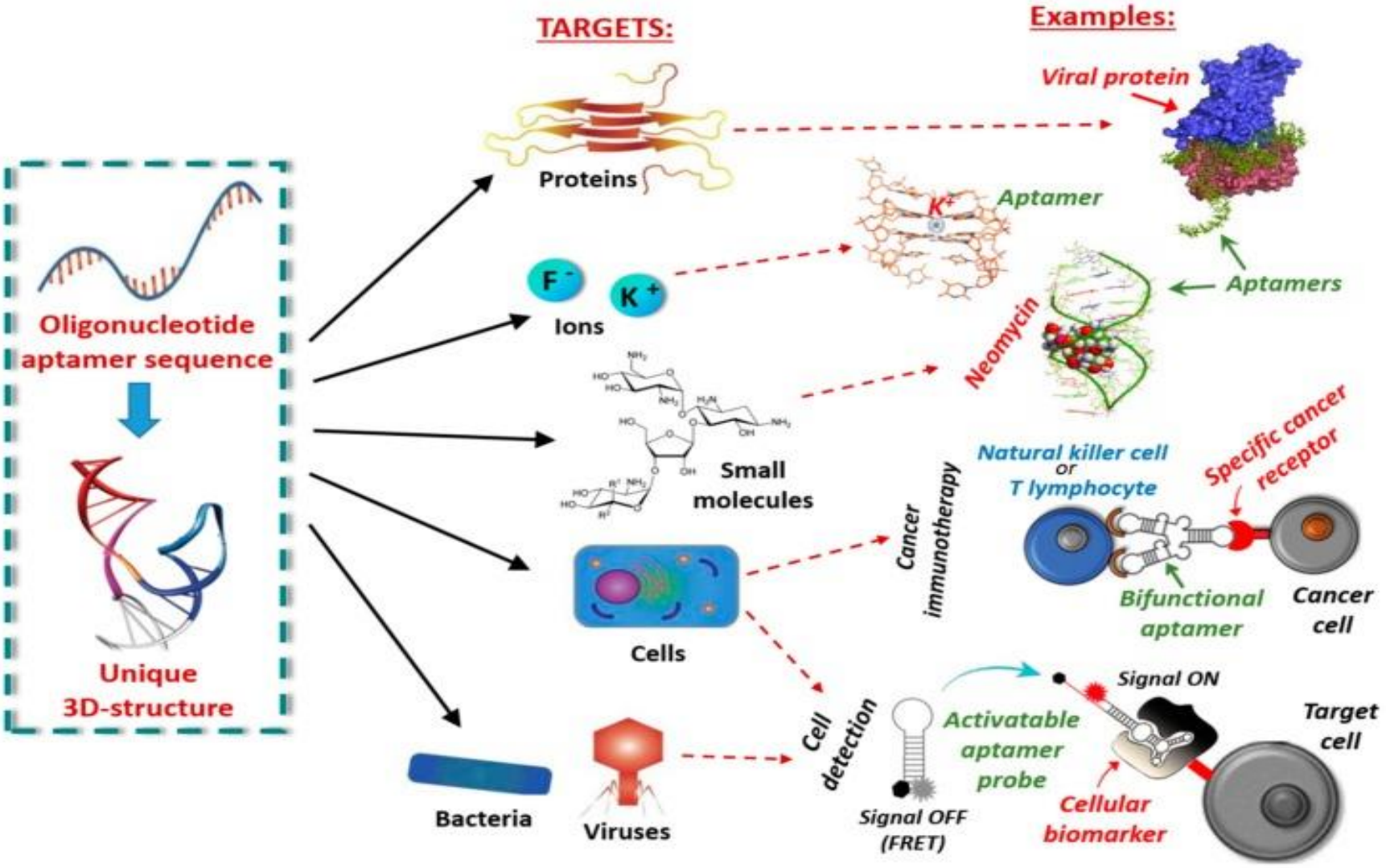
- A lab on chip integrates one or more laboratory operation on a single chip
- Provides fast result and easy operation
- Applications: Biochemical analysis (DNA/protein/cell analysis) and bio-defense



Fabrication of Gene chip

Potential applications:
(1) Lab-on-a-chip applications
(2) Early cancer detection
(3) Infectious disease detection
(4) Environmental monitoring
(5) Pathogen detection

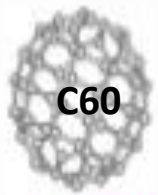
Aptasensors



NanoQuiz ???

12,756 Km

22 cm



0.7 nm

10^{16}

1.27 × 107 m → 0.22 m → 0.7 × 10-9 m

10 millions times smaller

1 billion times smaller