

THE ROLE OF NANOBIOTECHNOLOGY FOR PATHOLOGICAL ANALYSIS DIAGNOSIS

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PhD. Applied Bionanotechnology

HD and MSc Genetic engineering

Contents



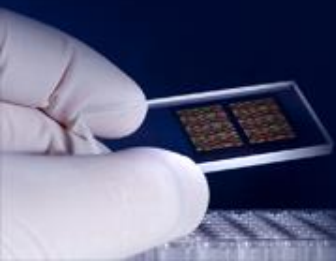
BRIEFLY REVIEW



METHODOLOGY



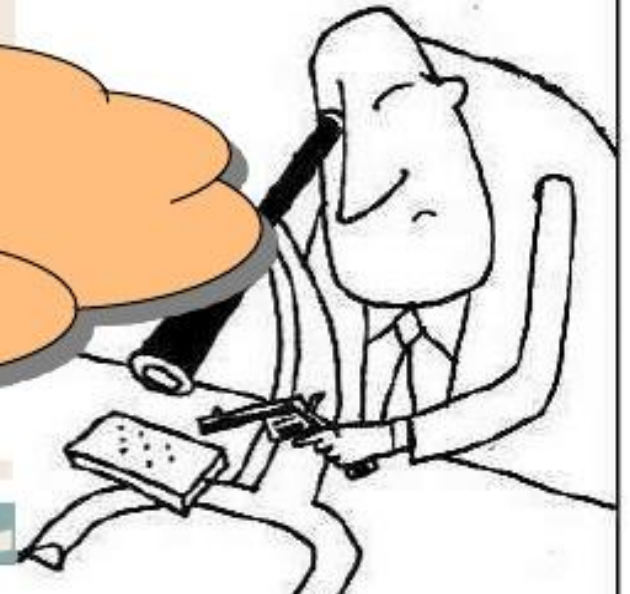
APPLICATION



Nano:

A prefix that means very, very, small.

The word nano is from the Greek word 'Nanos' meaning Dwarf. It is a prefix used to describe "one billionth" of something, or 0.000000001.

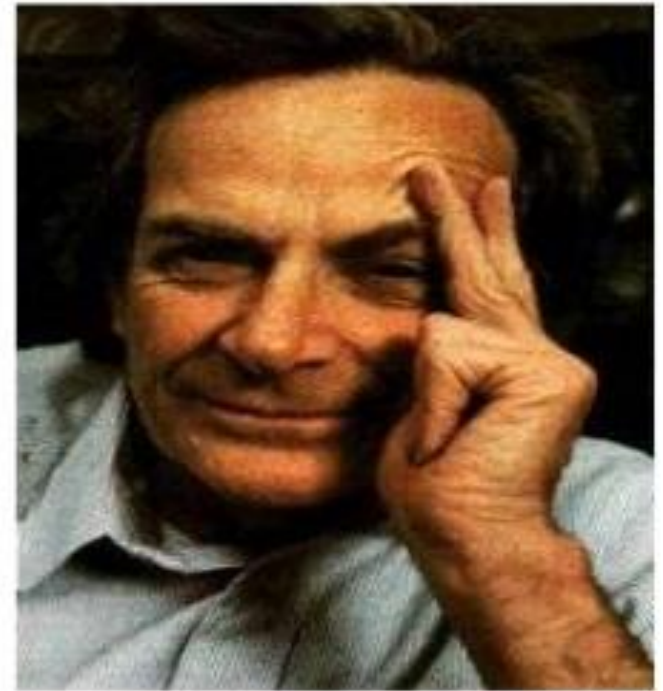


Things scale



History

- The first ever concept was presented in 1959 by the famous professor of physics **Dr. Richard P. Feynman**.
- Invention of the **scanning tunneling microscope** in 1981 and the discovery of **fullerene**(C₆₀) in 1985 lead to the emergence of **nanotechnology**.
- The term **“Nano-technology”** had been coined by Norio Taniguchi in 1974

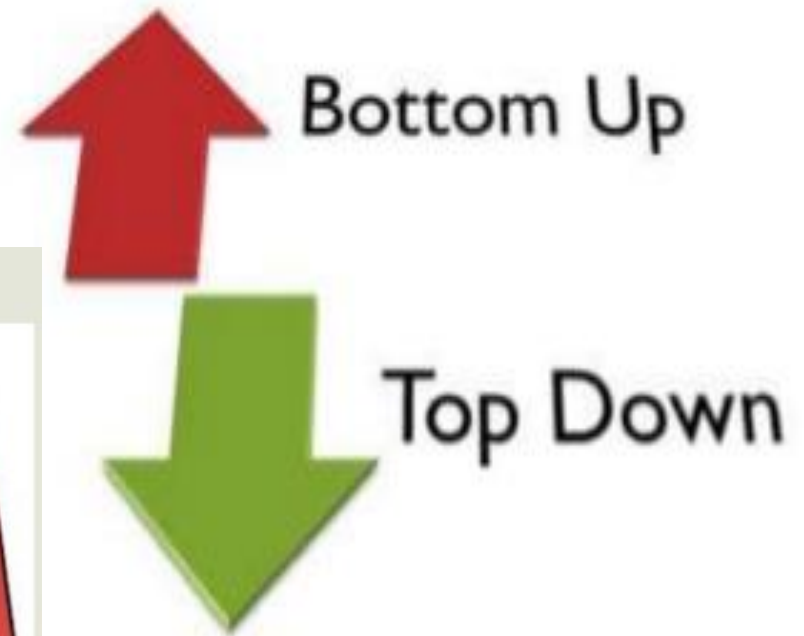
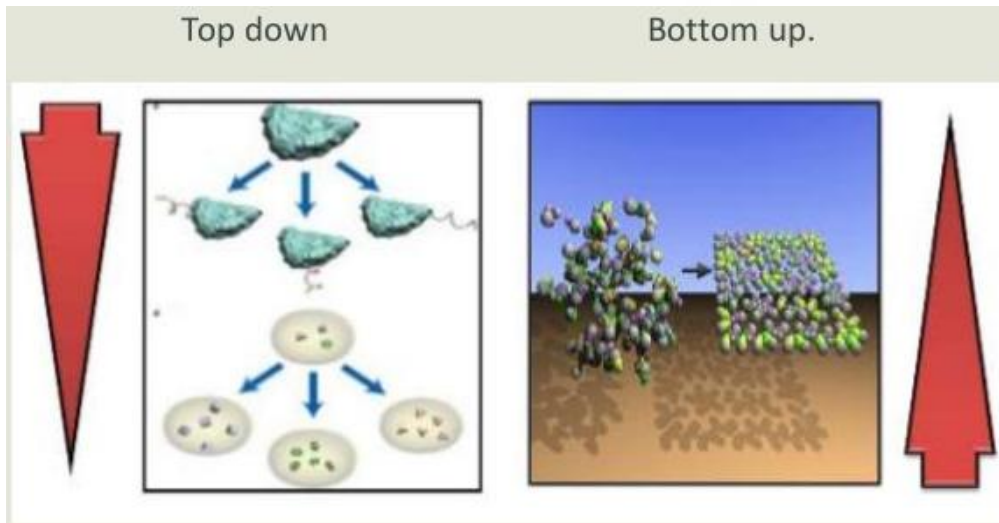


**THERE'S PLENTY
OF
ROOM AT THE
BOTTOM**

Fabrication of Nanomaterials

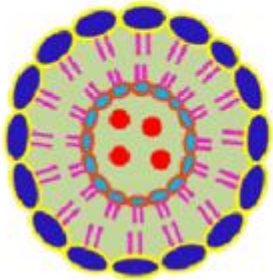
* 2 approaches

- bottom up approach
- top down approach

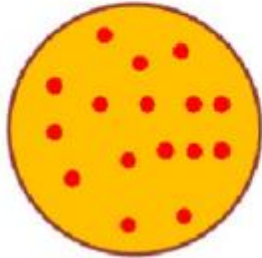


Nanoparticles

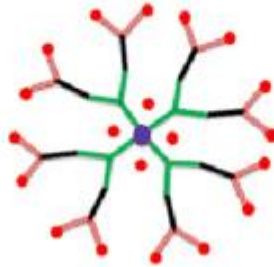
Liposome



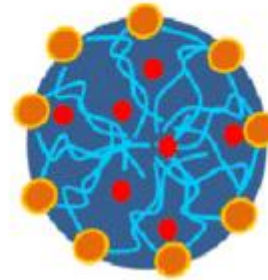
Polymeric nanoparticle



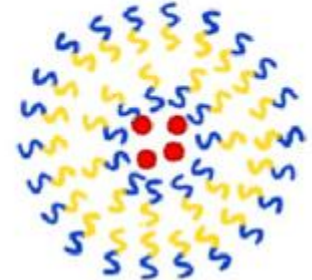
Dendrimer



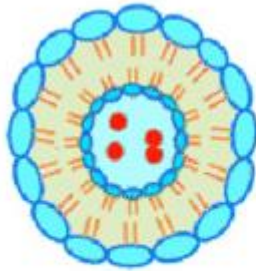
Nanomicelle



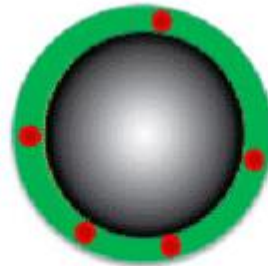
Polymersome



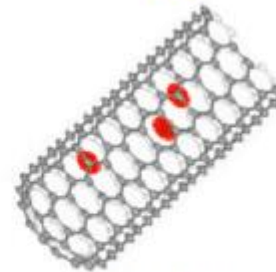
Nanogel



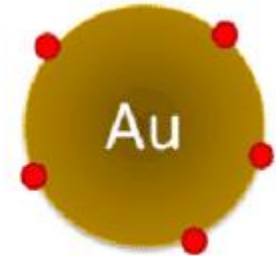
Exosome



Magnetic nanoparticle



Carbon nanotube



Gold nanoparticle

Bionanomaterials

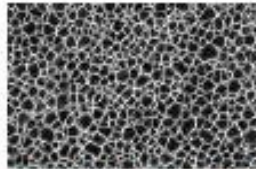
Bionanomaterials

1) Biological materials utilized in nanotechnology

- Proteins, enzymes, DNA, RNA, peptides

2) Synthetic nanomaterials utilized in biomedical applications

- Polymers, porous silicon, carbon nanotubes



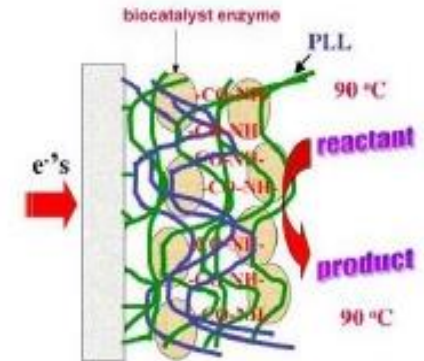
Porous silicon (PSi)



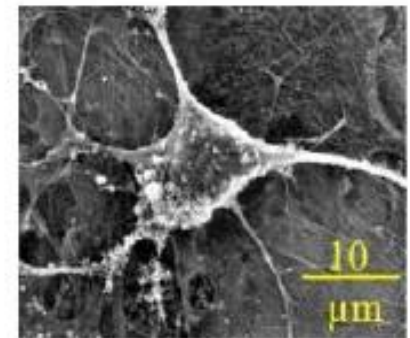
Human cell on PSi



Enzymes are used as oxidation catalysts

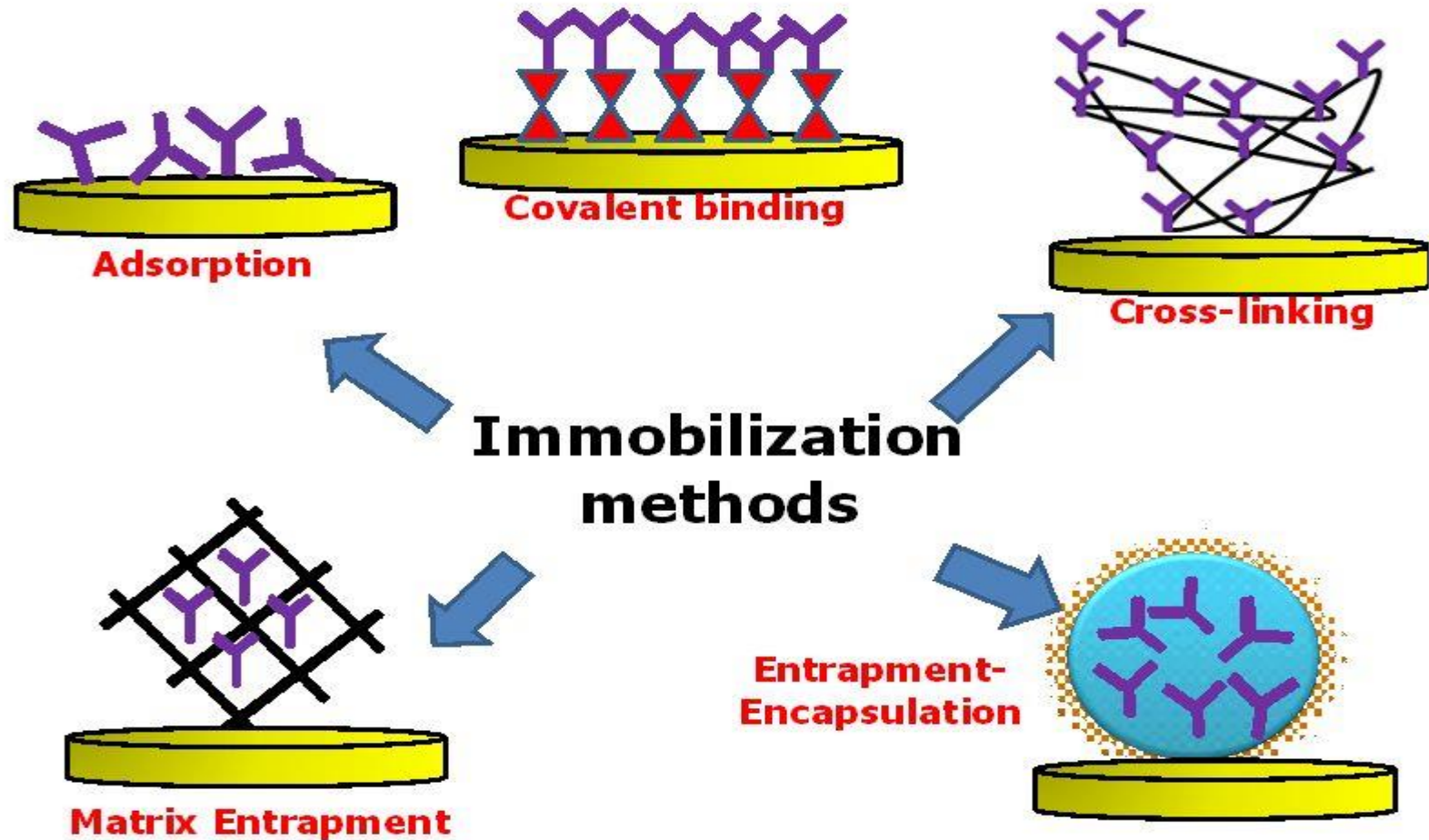


Cross-linked enzymes used as catalyst – Univ. of Connecticut, Storr, 2007

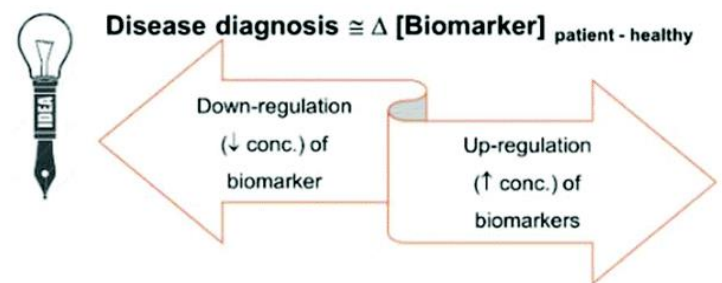
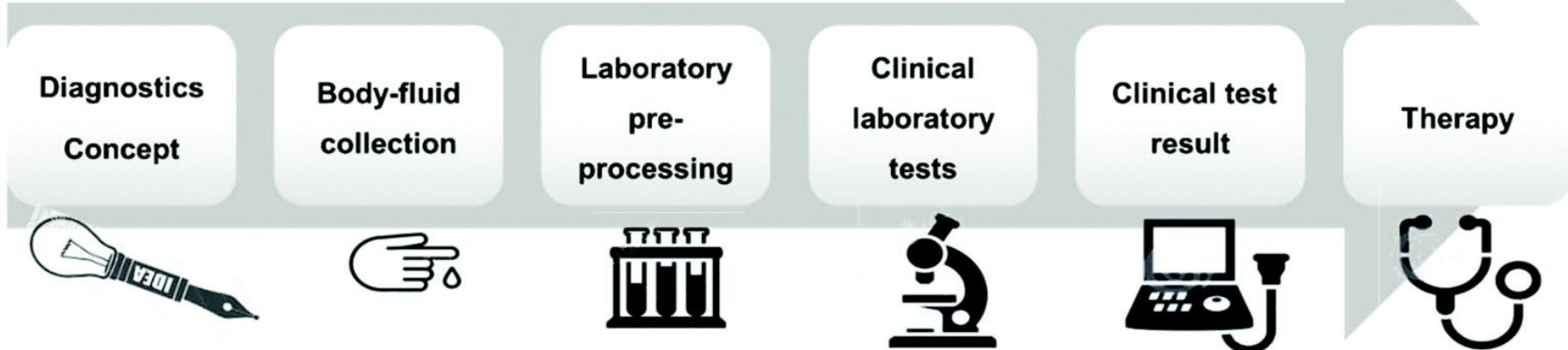


Bone cell on porous silicon – Univ. of Rochester, 2007

Immobilization Protocol



Applications



Selection of specific biomarkers for the disease

Collection of Body-fluid containing selected biomarker



RESEARCH FOCUS OF MEDICAL DEVICE DIAGNOSTICS

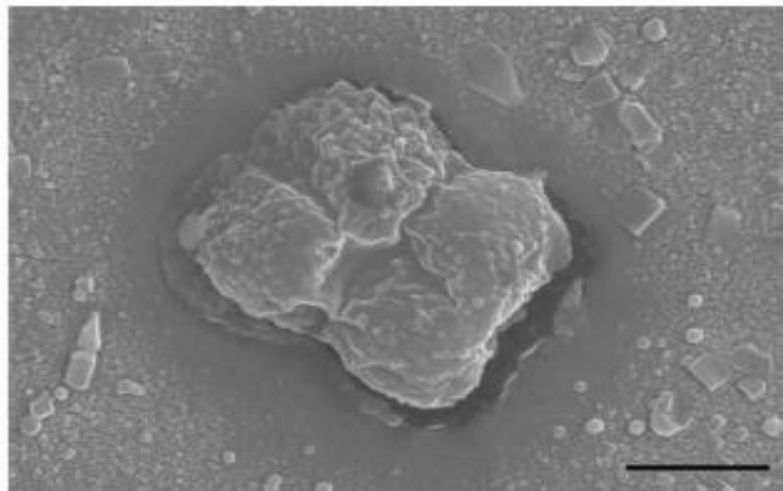
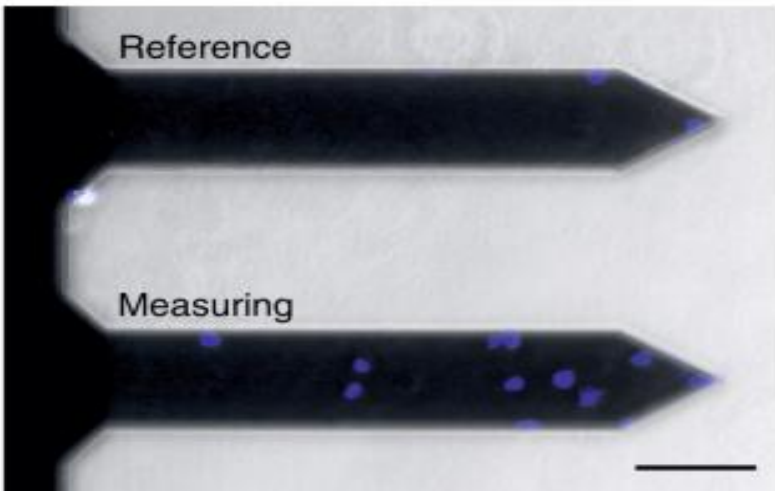
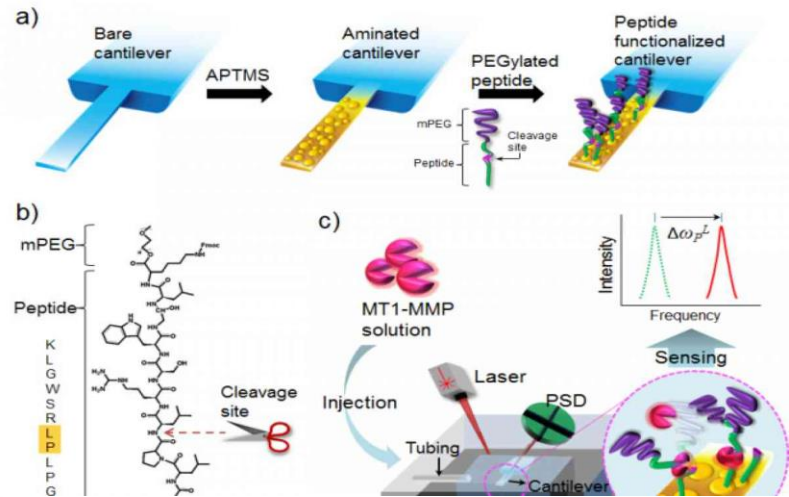
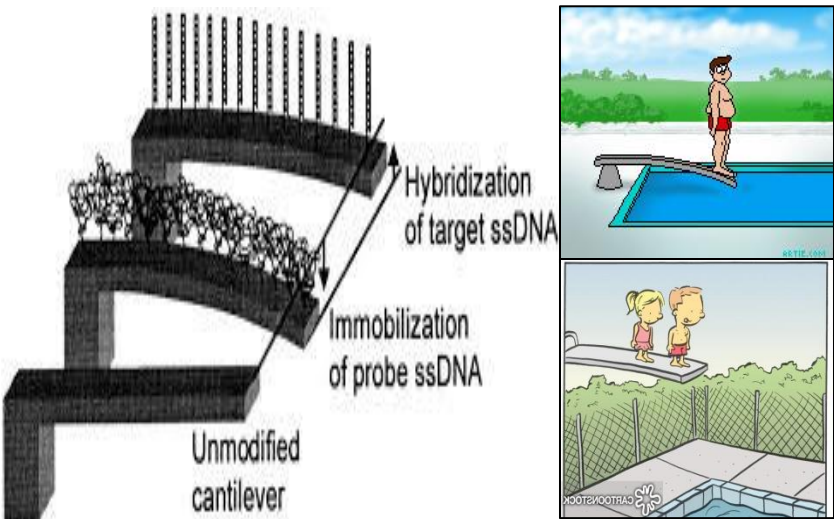
Minimal procedural steps

+

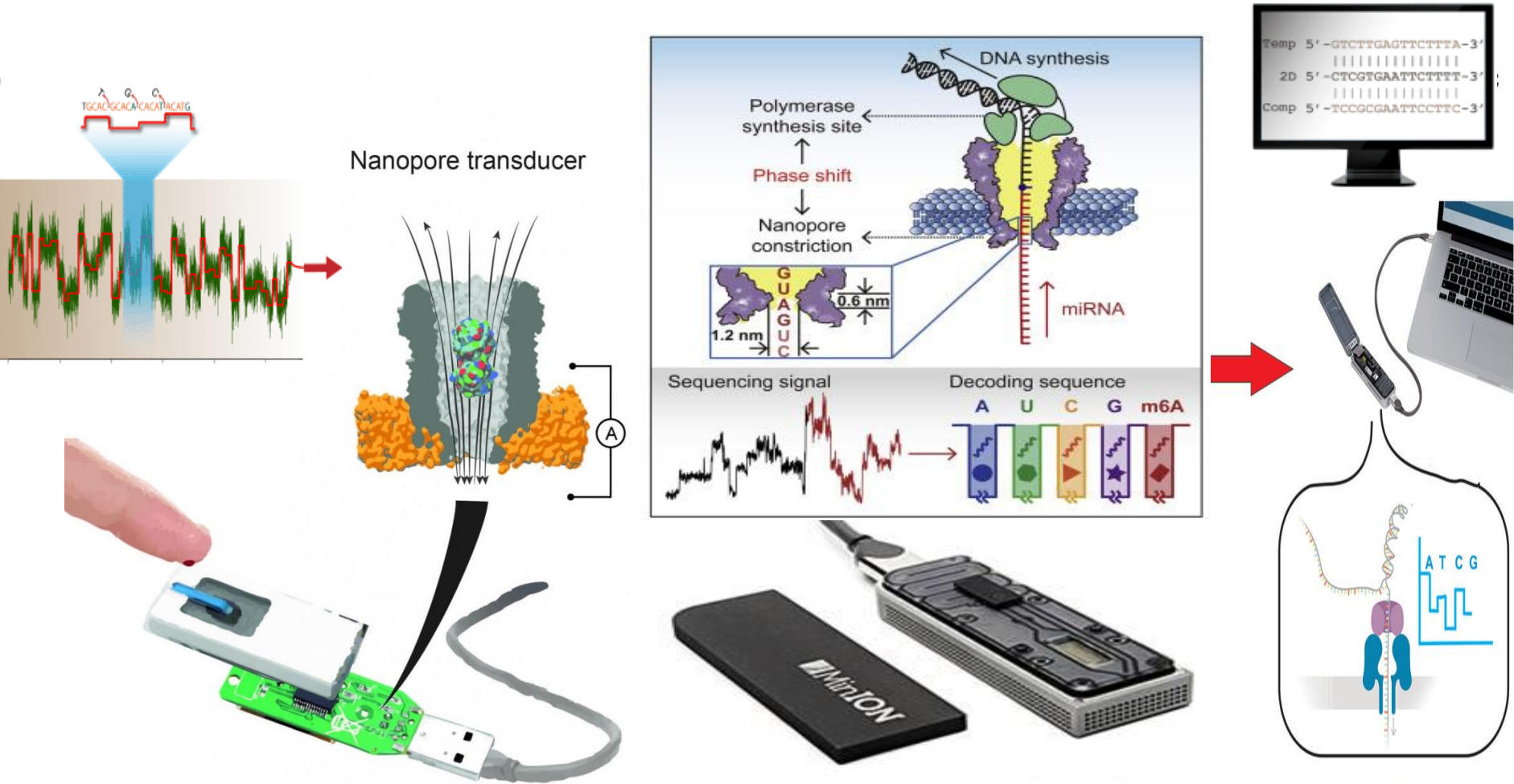
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Direct Fast Quantification of disease biomarkers → Disease Diagnostics

Nanocantilevers

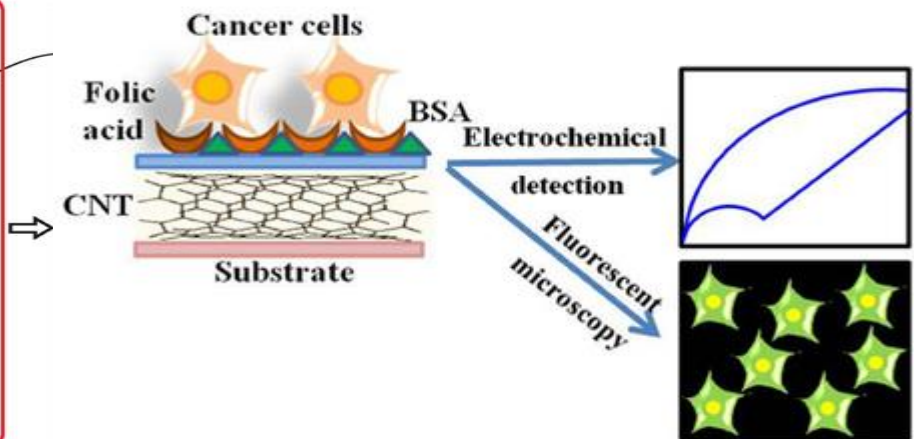
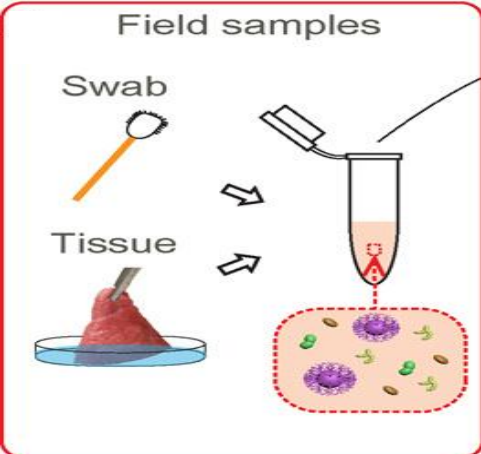
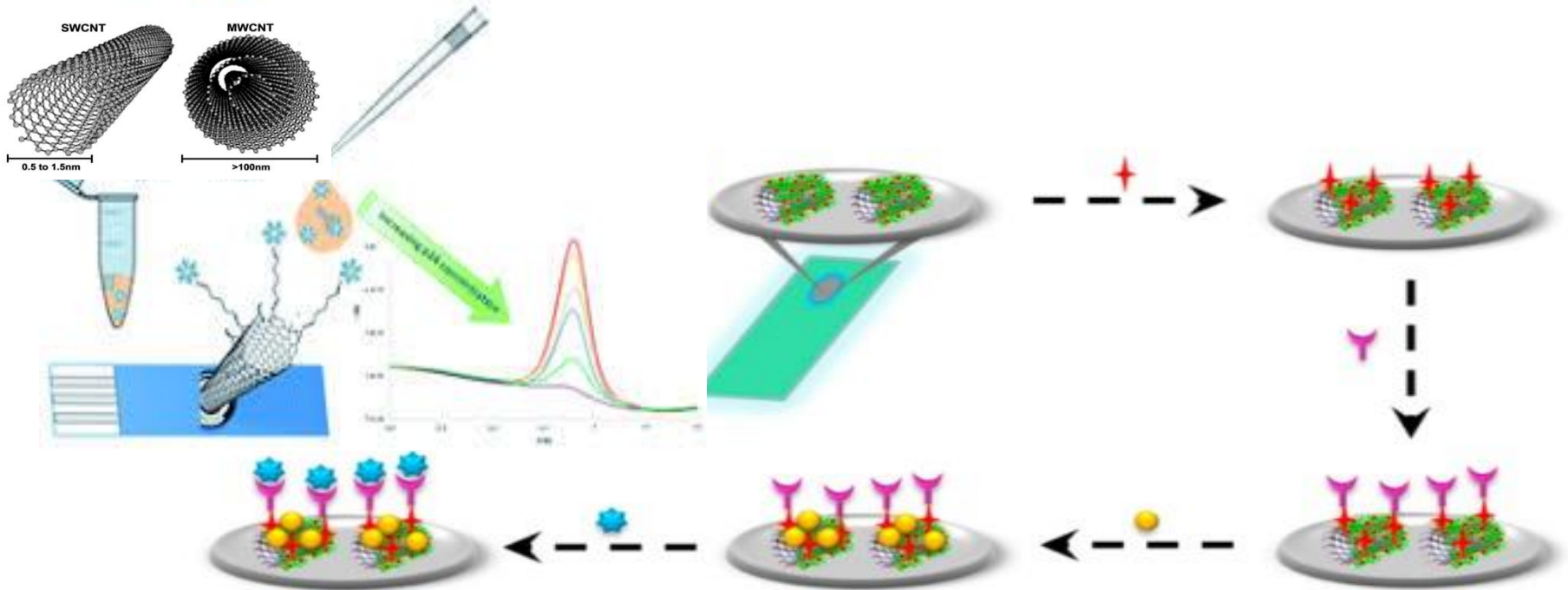


Nanopores

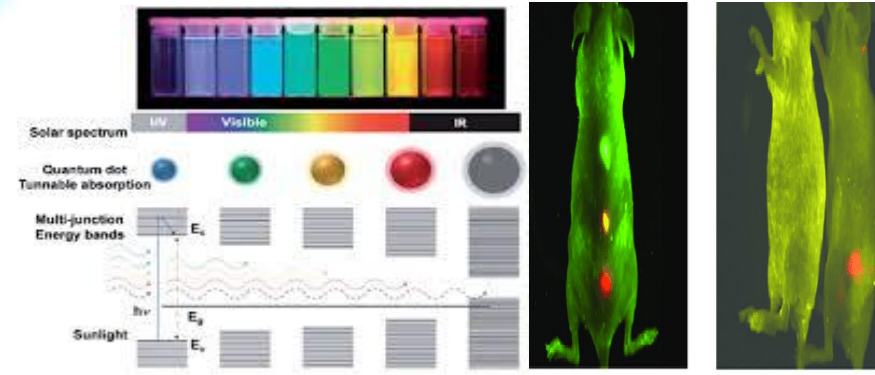
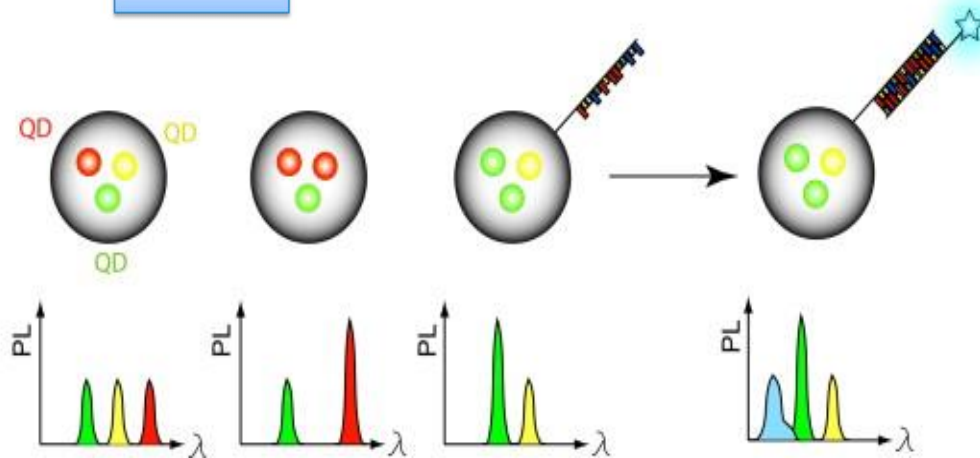
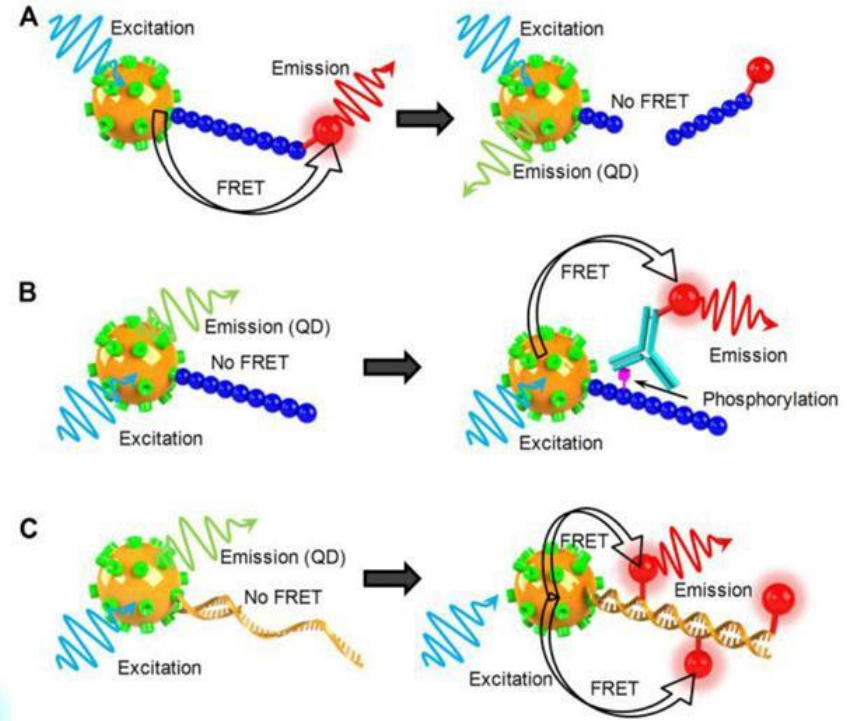
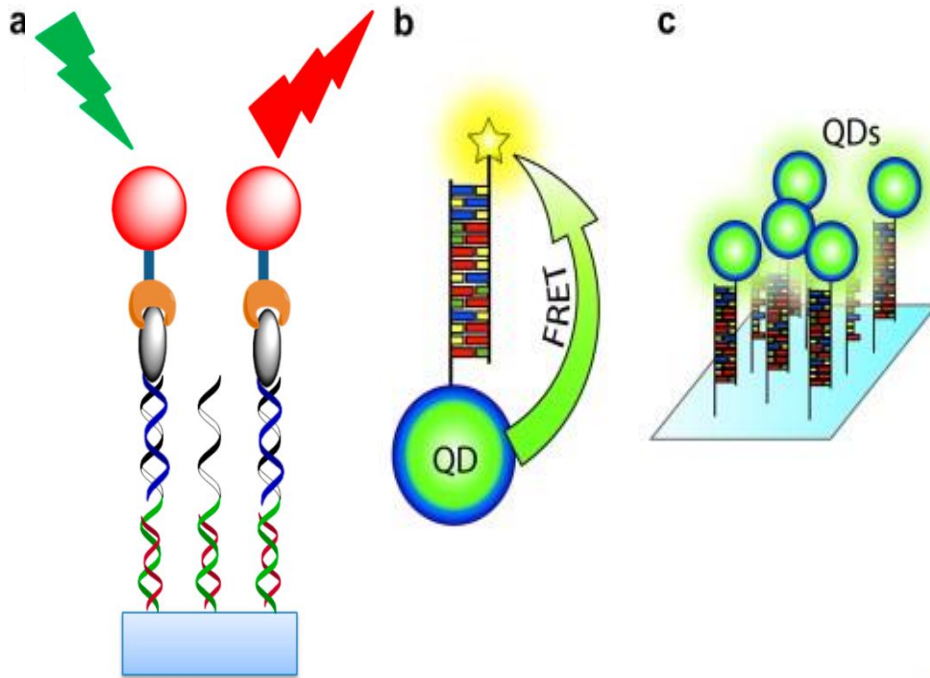


Nanopore Sequencing

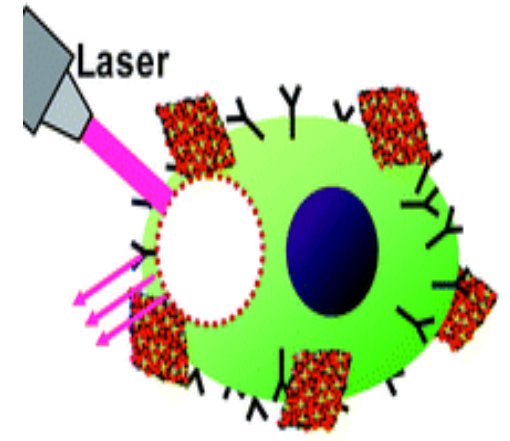
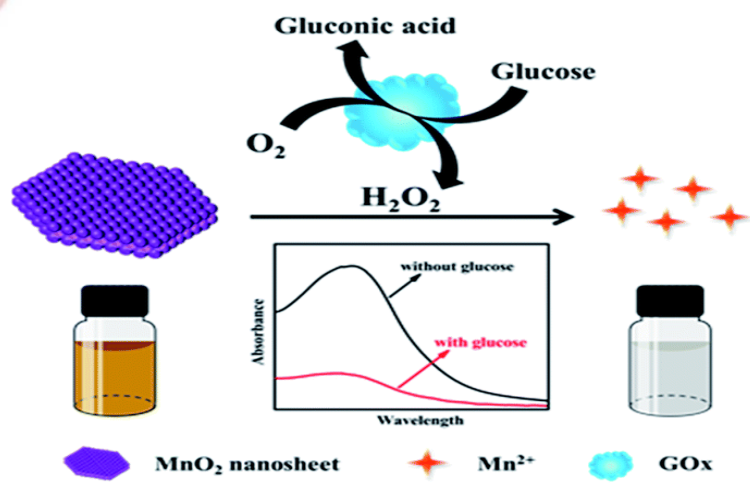
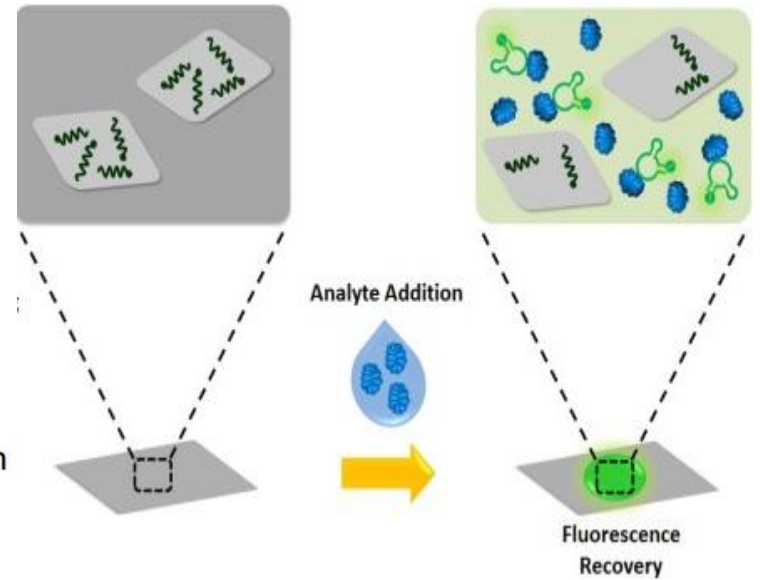
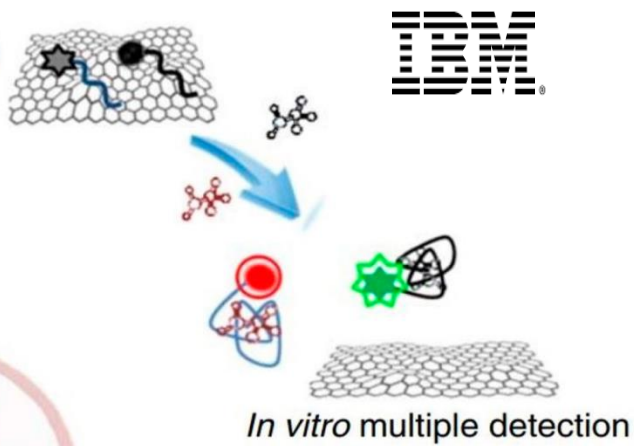
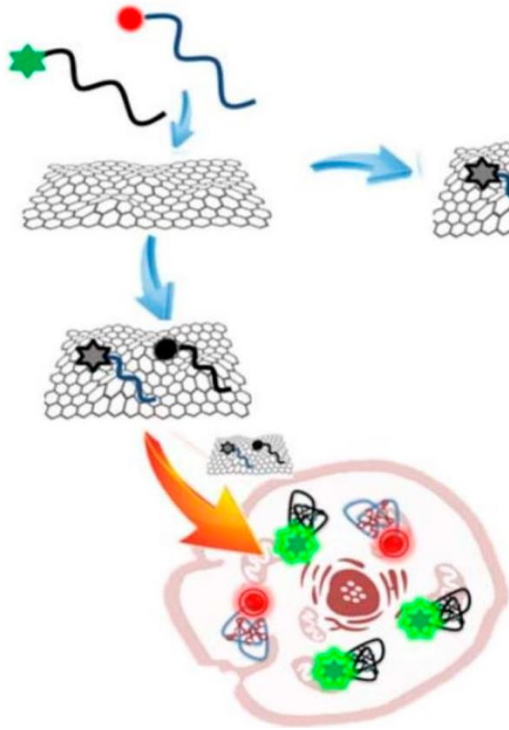
Carbon Nano Tubes



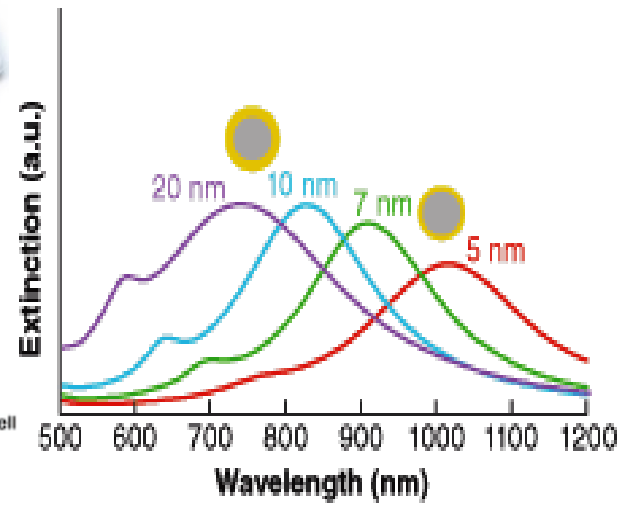
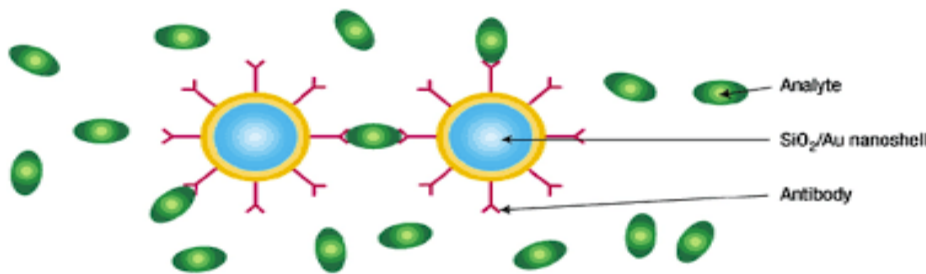
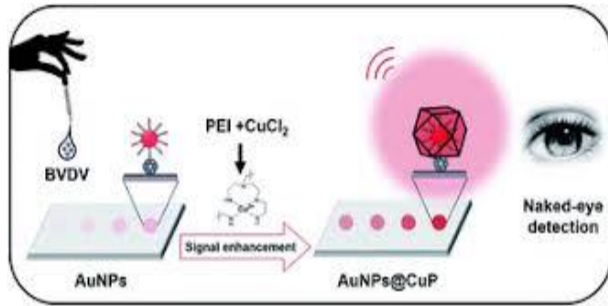
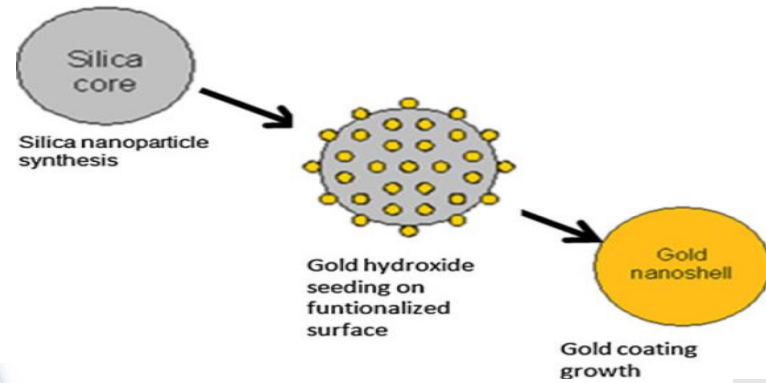
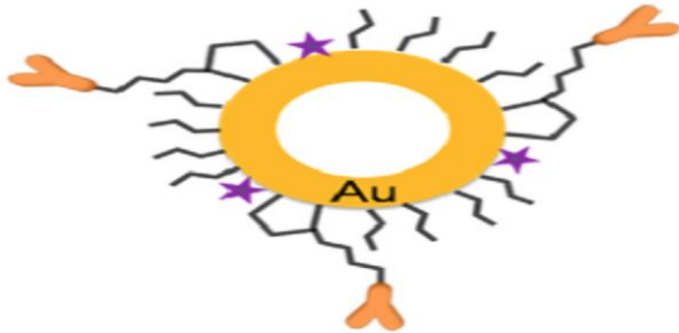
Quantum NanoDots



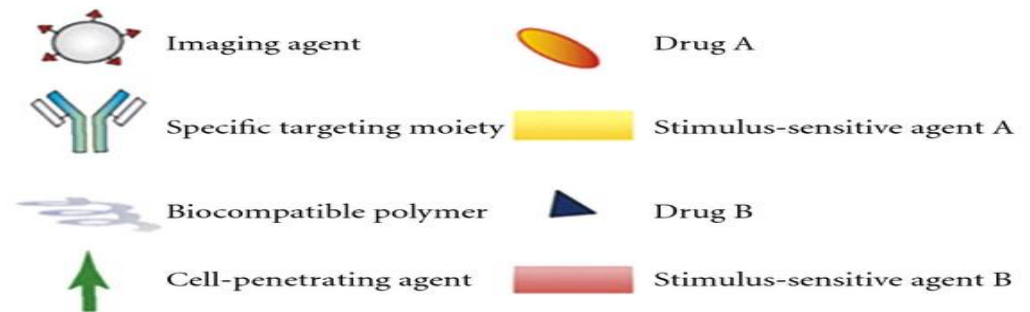
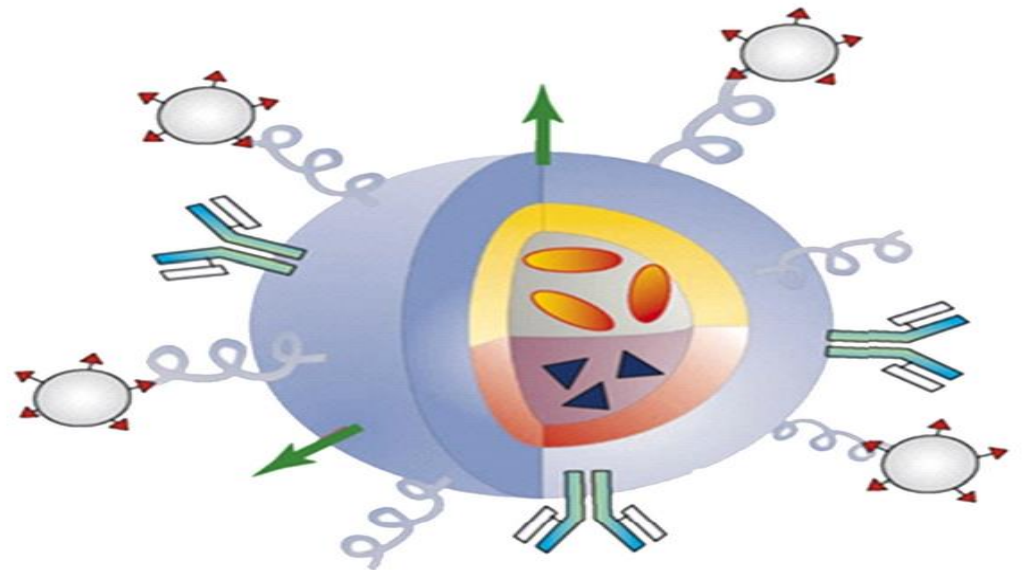
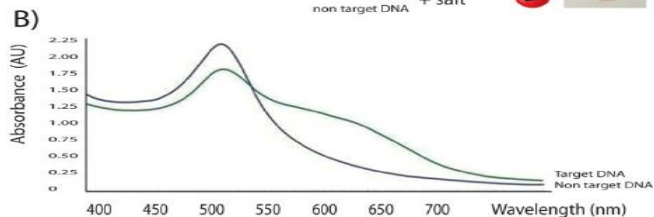
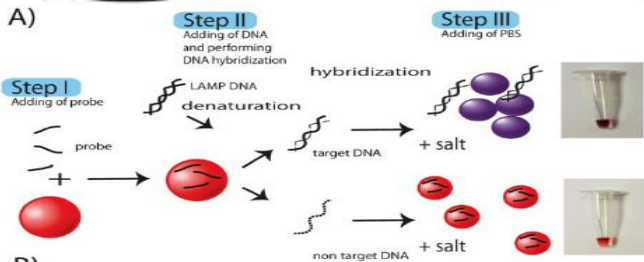
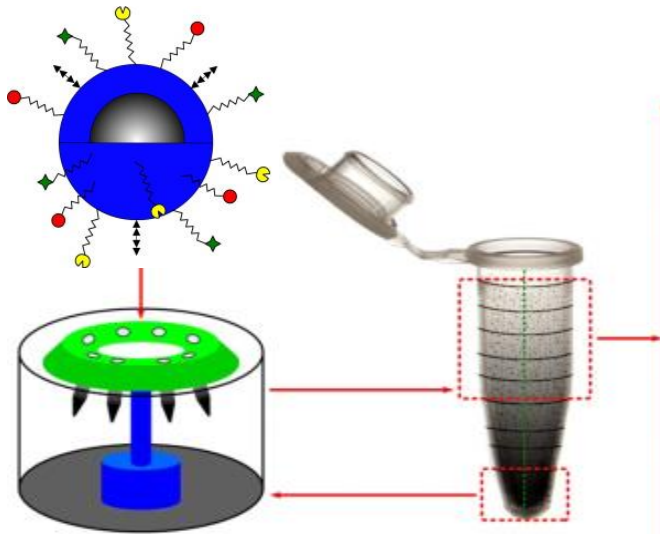
Nanosheets



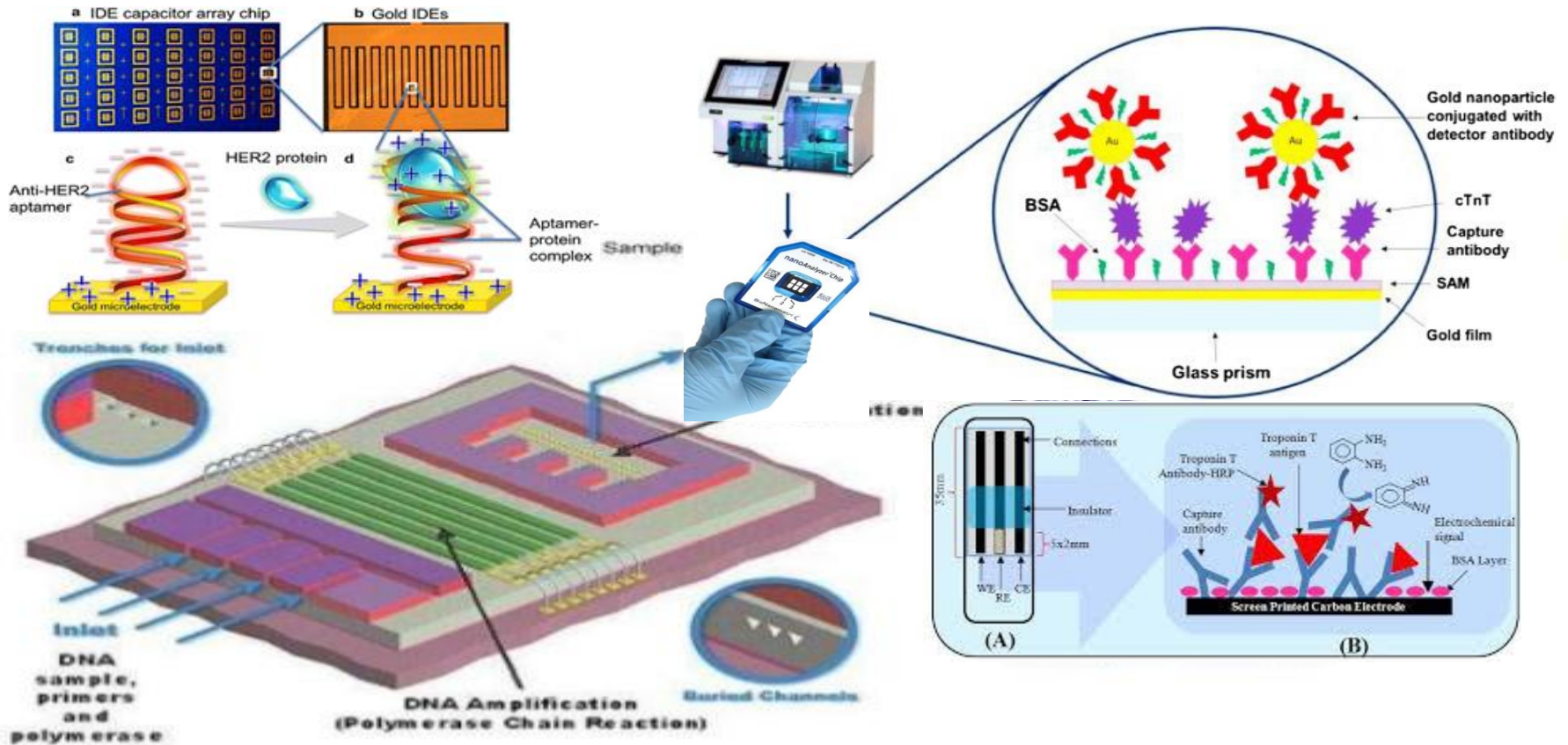
Nanoshells



Magnetic Nanoparticles



Bio-NanoChip



Dendrimers

Void spaces

Entrapment of guest molecules

Targeting groups

- Cationic, anionic, neutral, and hydrophobic
- Biocompatible
- Biomarkers

Generation (G)

G3

G2

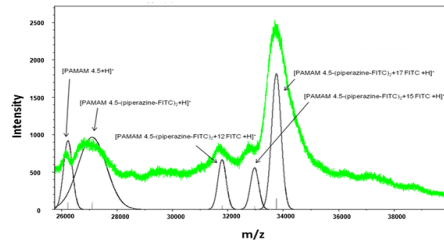
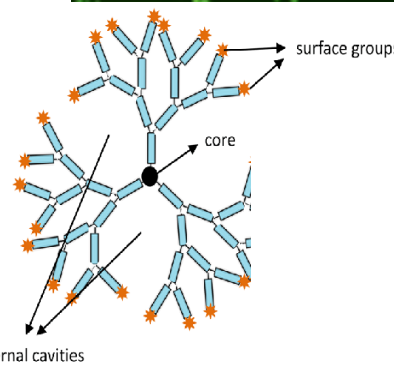
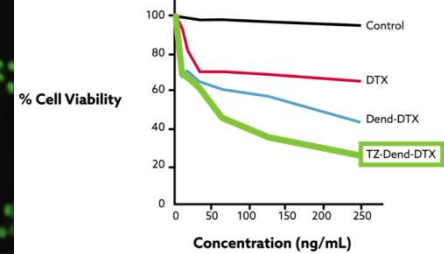
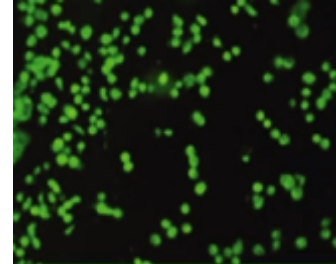
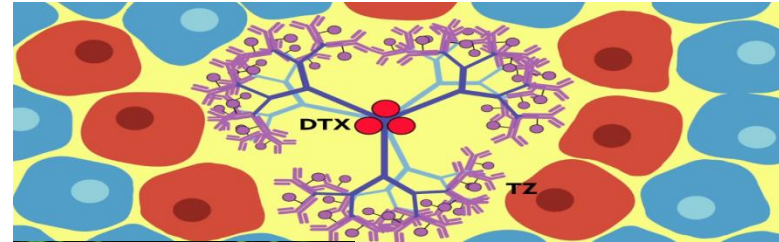
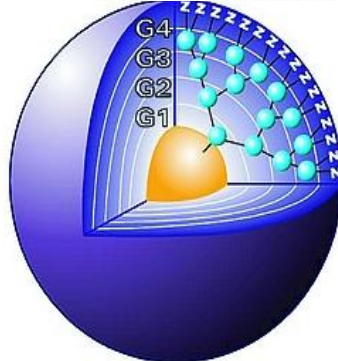
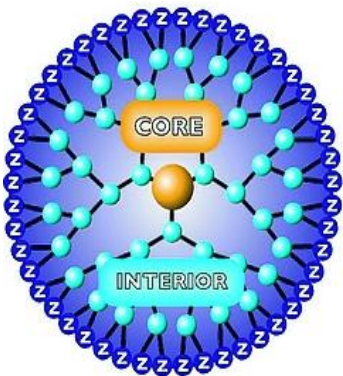
G1

Core

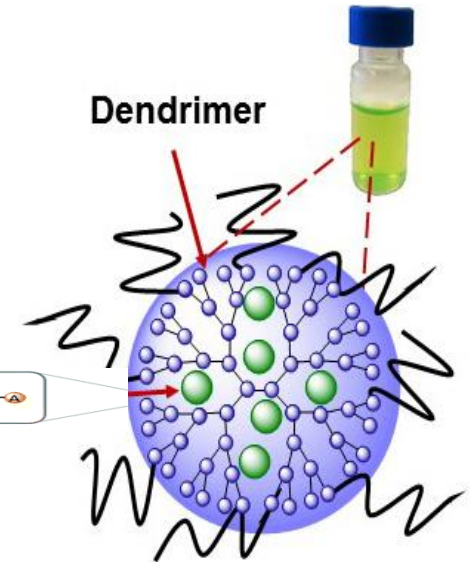
- Small molecules
- Nanoparticles
- Polymers
- Biocompatible

Interior branching

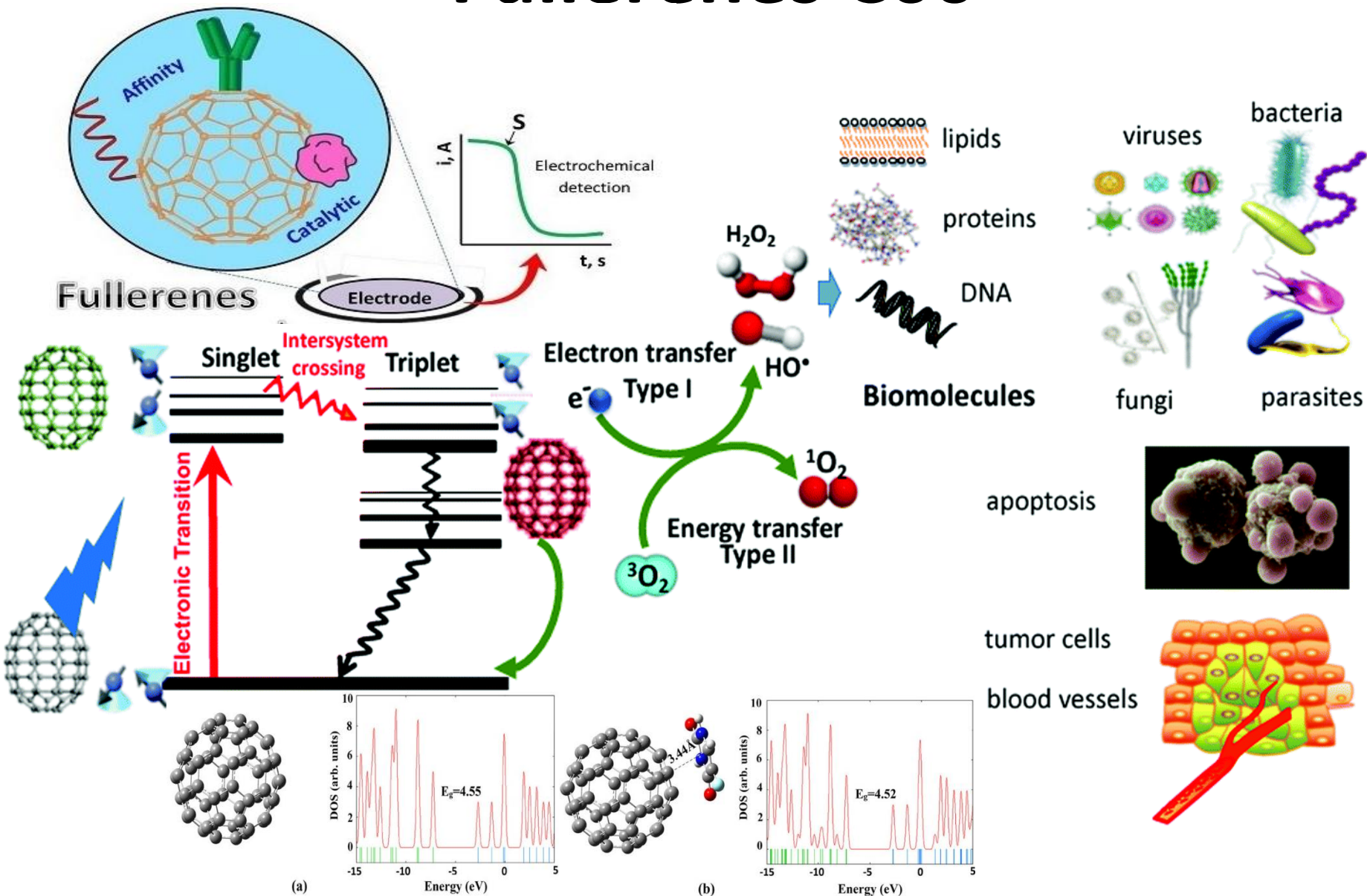
- Covalent structure
- Connect core to surface group



Dendrimer



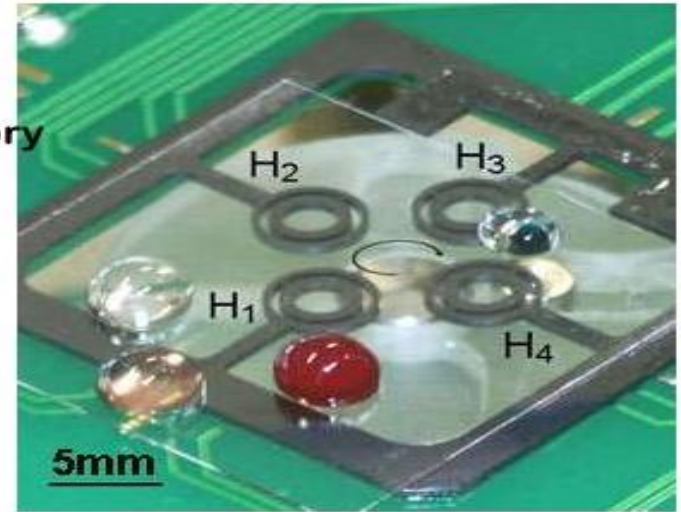
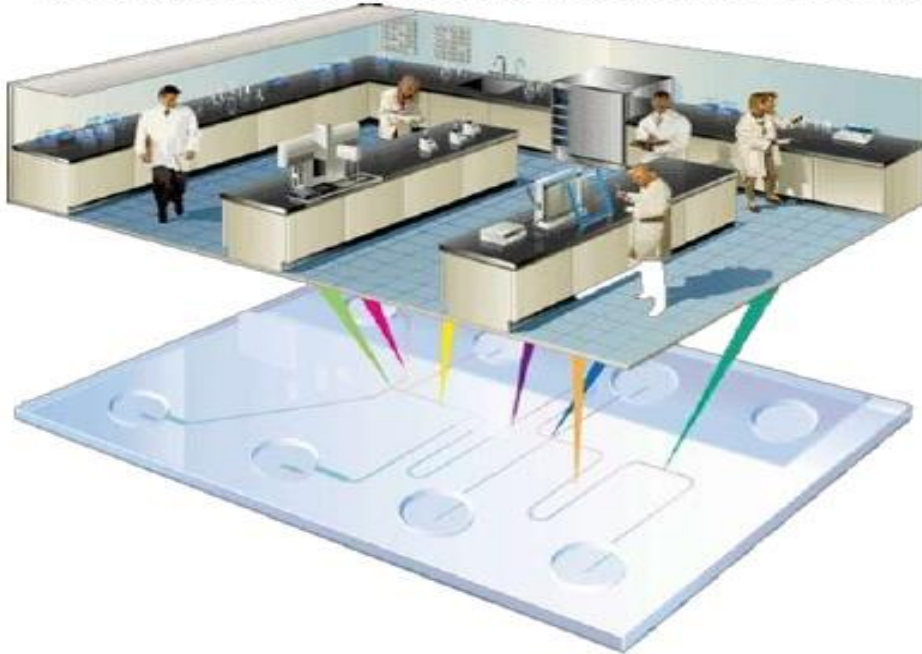
Fullerenes C60



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



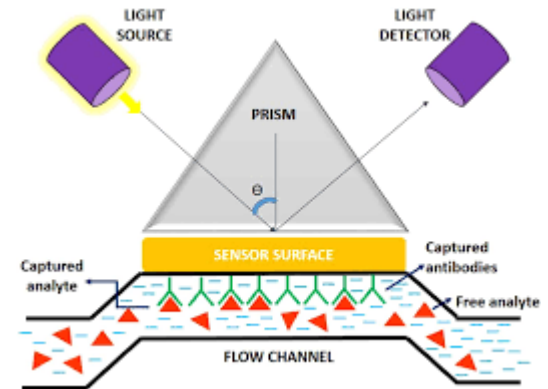
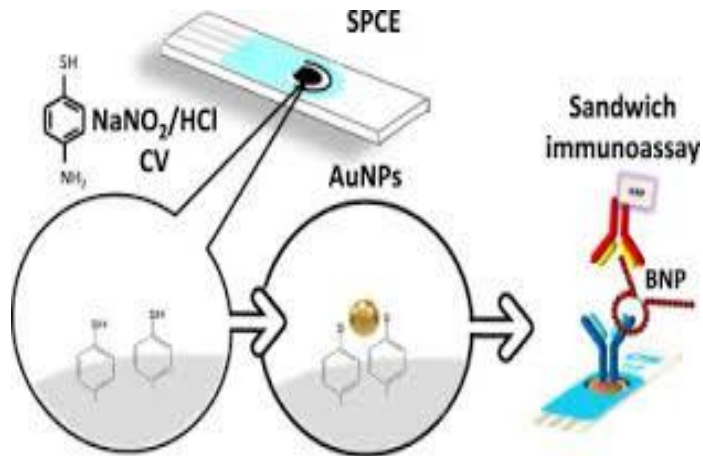
Fabrication of Gene chip

Potential applications:

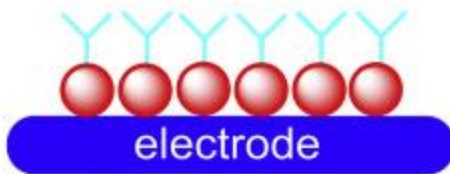
- (1) Lab-on-a-chip applications
- (2) Early cancer detection
- (3) Infectious disease detection
- (4) Environmental monitoring
- (5) Pathogen detection



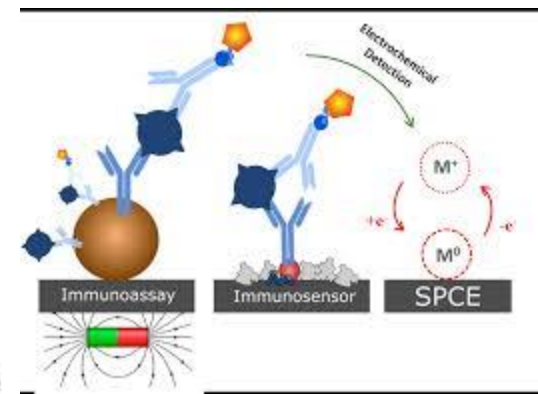
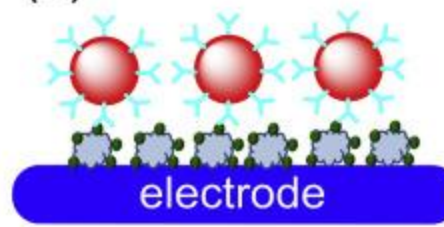
Real Time Immune Sensor



(A)




(B)



 nanomaterial

 anti-aflatoxin

 aflatoxin conjugate

LSPR/TIRE bio-sensing platform for detection of low molecular weight toxins

Publisher: IEEE

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PDF

Ali Al-Rubaye ; Alexei Nabok ; Hisham Abu-Ali ; Andras Szekacs ; Ester Takacs [All Authors](#)

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LSPR/TIRE bio-sensing platform for detection of low molecular weight toxins

Ali Al-Rubaye, Alexei Nabok, Hisham Abu-Ali
 Materials and Engineering Research Institute, Sheffield Hallam University, UK
 Andras Szekacs, Ester Takacs
 Agro-Environmental Research Institute, NARIC, Budapest, Hungary

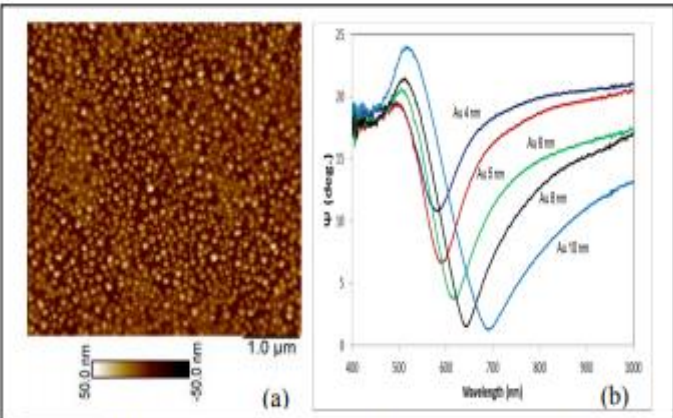


Fig.1. (a) AFM image of 5nm thick film after annealing at 550°C; (b) ellipsometry Ψ spectra of nano-structured Au films of different thickness.

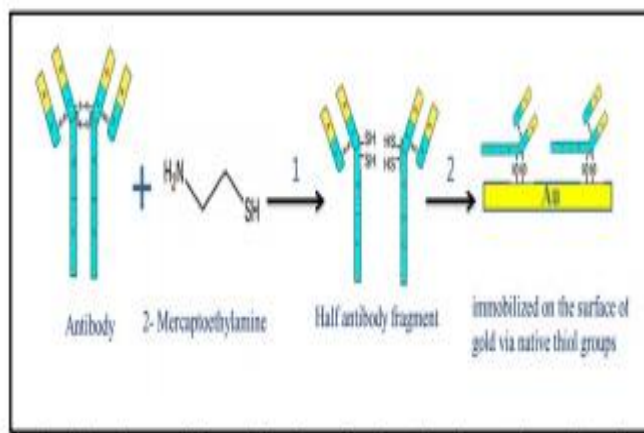


Fig. 3. The scheme of immobilization of split antibodies on the gold surface.

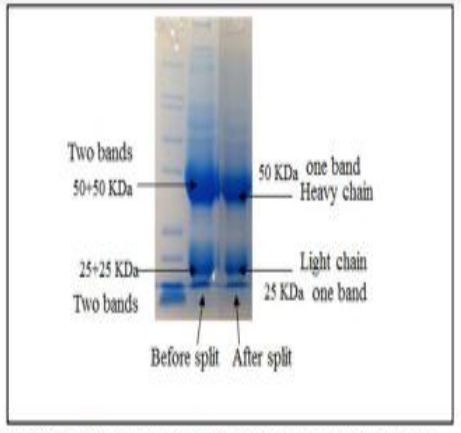


Fig. 4. SDS - PAGE electrophoresis of antibodies before and after splitting



Highly sensitive label-free in vitro detection of aflatoxin B1 in an aptamer assay using optical planar waveguide operating as a polarization interferometer

Ali Al-Jawdah¹ · Alexei Nabok¹ · Hisham Abu-Ali¹ · Gaelle Catanante² · Jean-Louis Marty² · Andras Szekacs³

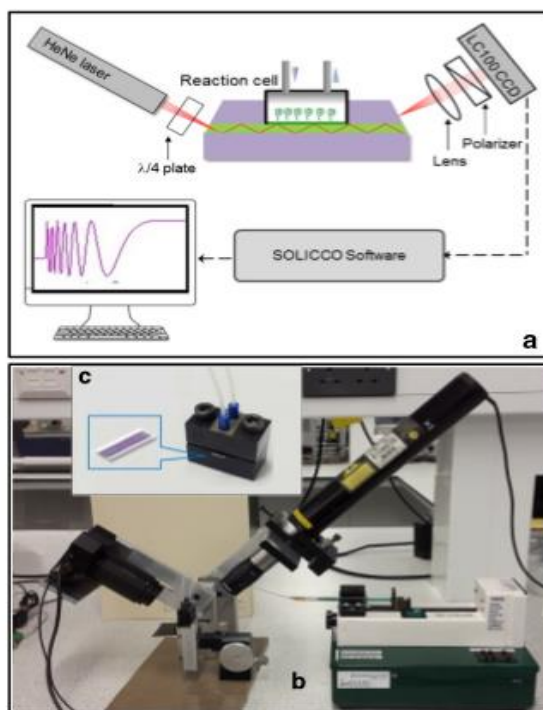


Fig. 1 Schematic diagram (a) and photograph (b) of the PI OPW experimental setup; the reaction cell with inserted OPW (c), the inset shows zoomed-in OPW chip

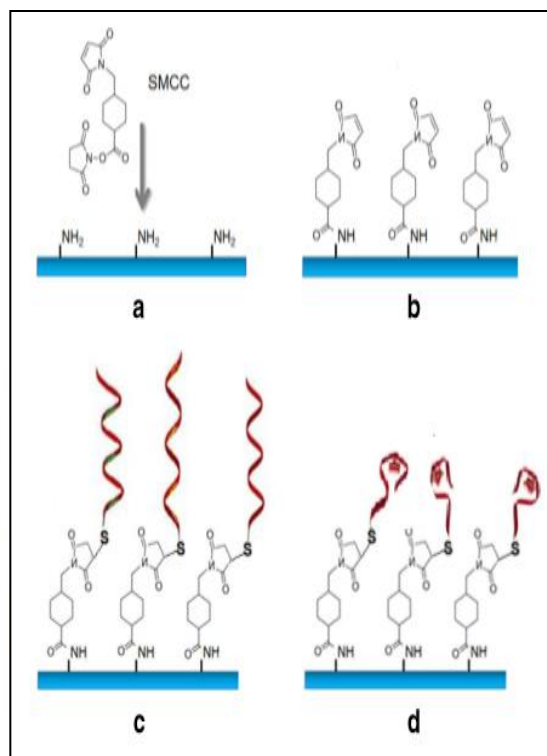


Fig. 3 Aptamer immobilization protocol: amine-functionalized surface of Si₃N₄ (a), SMCCactivated surface (b), aptamers immobilized (c), and aptamer binding target analyte molecules (d)

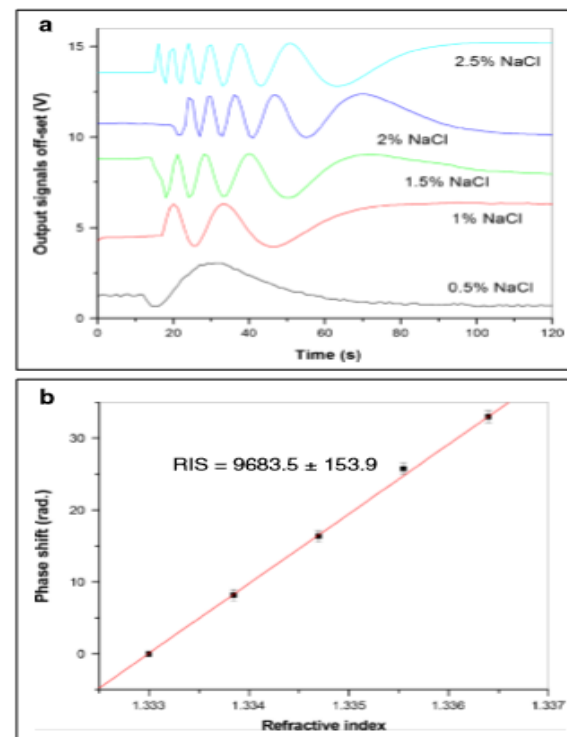
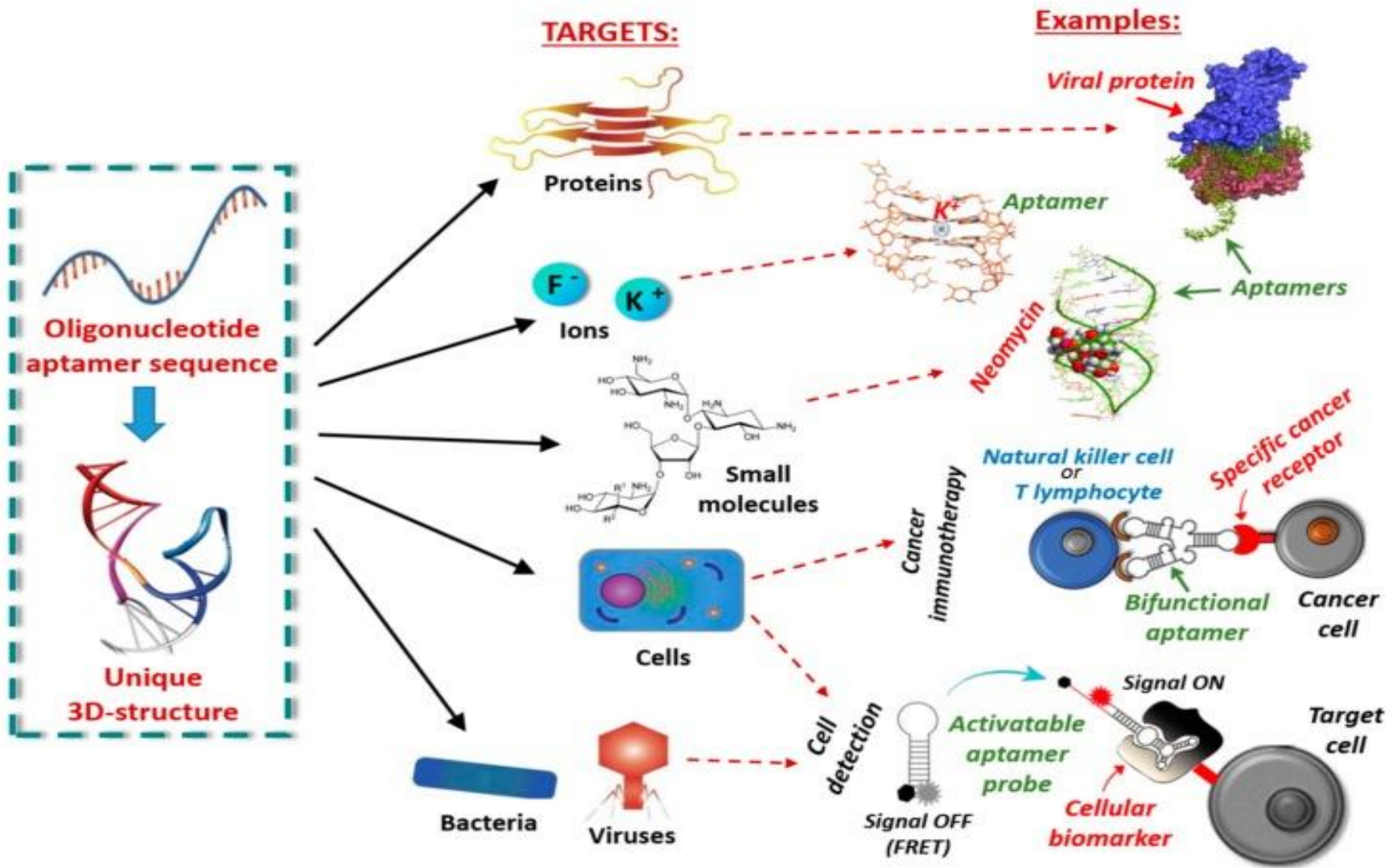


Fig. 2 Evaluation of the refractive index sensitivity (RIS): response signals to refractive index changes by injecting NaCl solutions of different concentrations (a), the dependence of phase shift against refractive index (b)

Aptasensors



Article

Development of Novel and Highly Specific ssDNA-Aptamer-Based Electrochemical Biosensor for Rapid Detection of Mercury (II) and Lead (II) Ions in Water

Q2

Analytical Chemistry

best quartile

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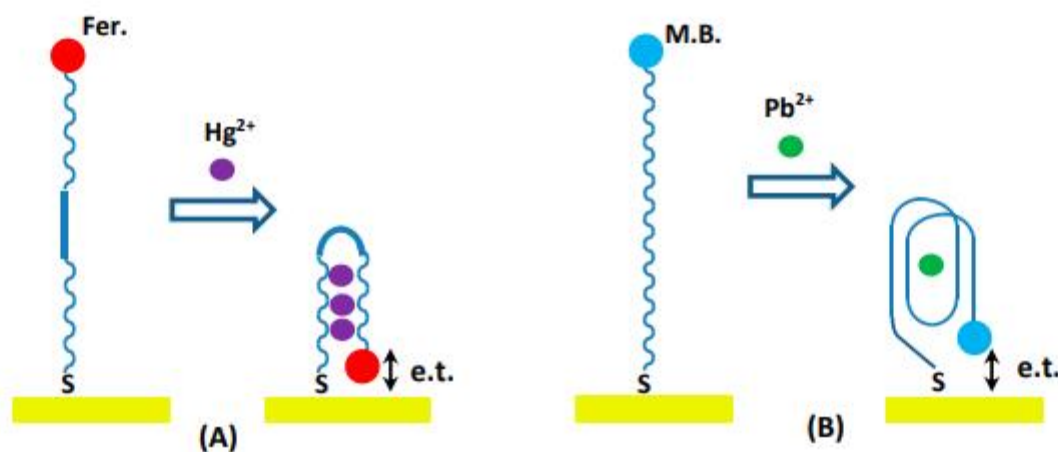



Figure 1. Schematic diagram of electrochemical detection of heavy metal ions Hg²⁺ (A) and Pb²⁺ (B) using redox-labelled aptamers.

Electrochemical Aptasensor for Detection of Dopamine

Hisham Abu-Ali ^{1,3}, Cansu Ozkaya ^{1,2}, Frank Davis ¹ , Nik Walch ¹ and Alexei Nabok ^{1,*}

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8 of 11

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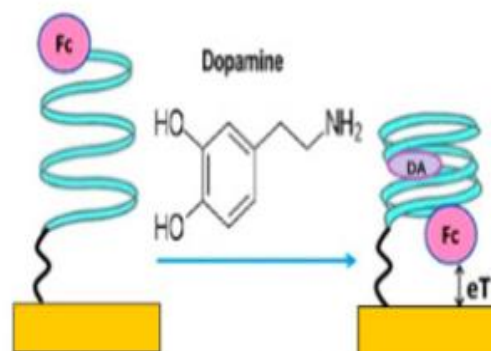


Figure 2. The scheme of electrochemical aptasensing of dopa

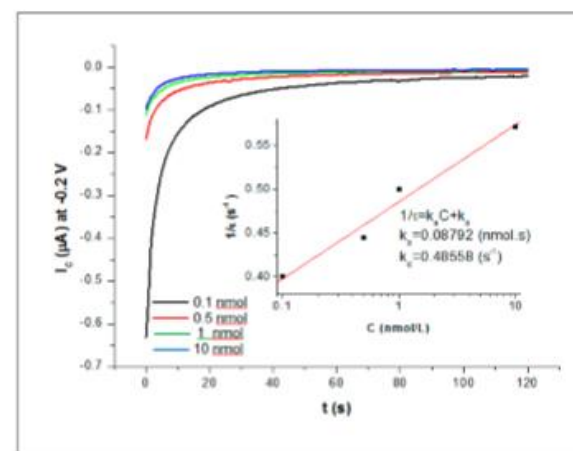
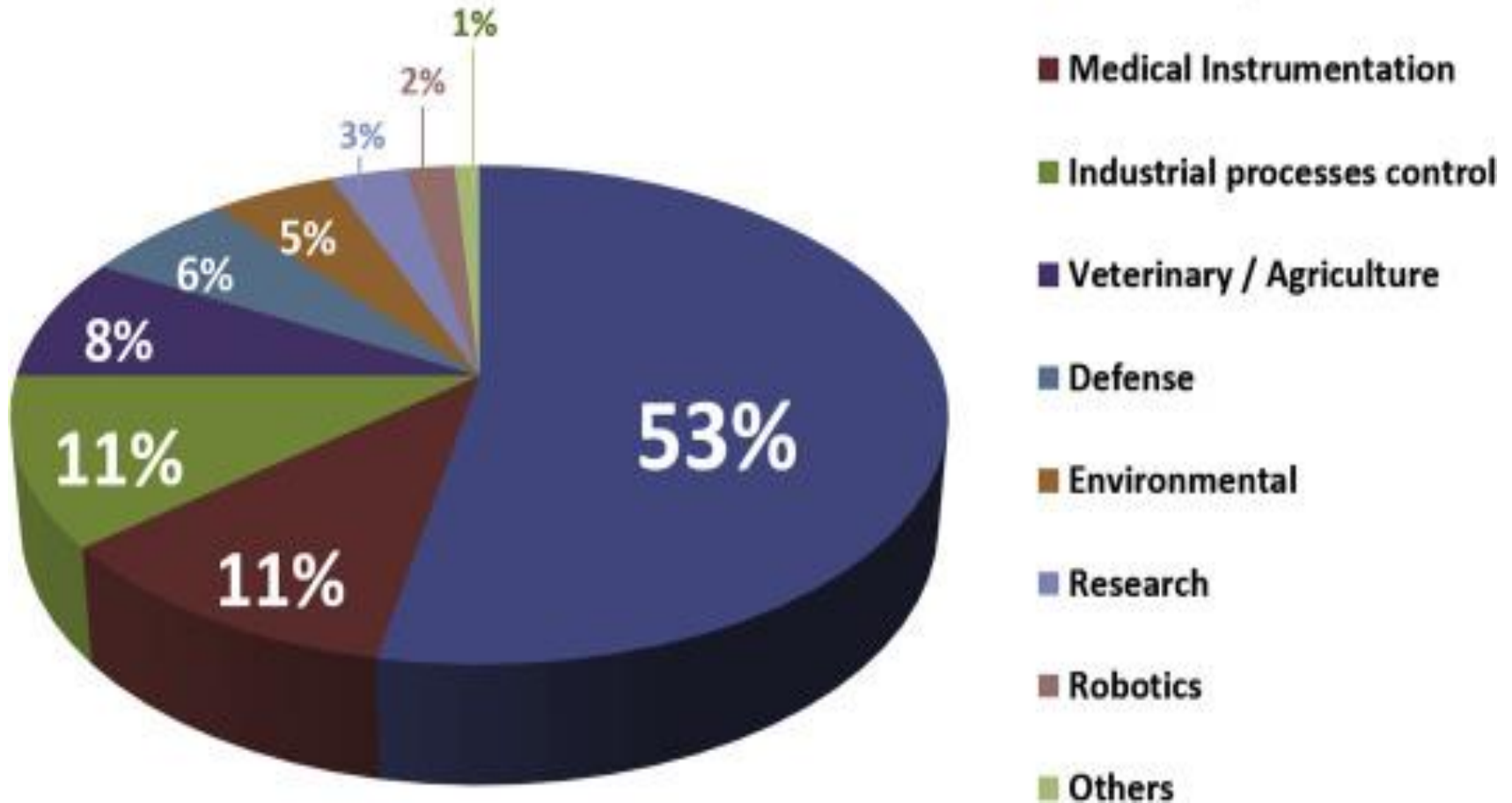
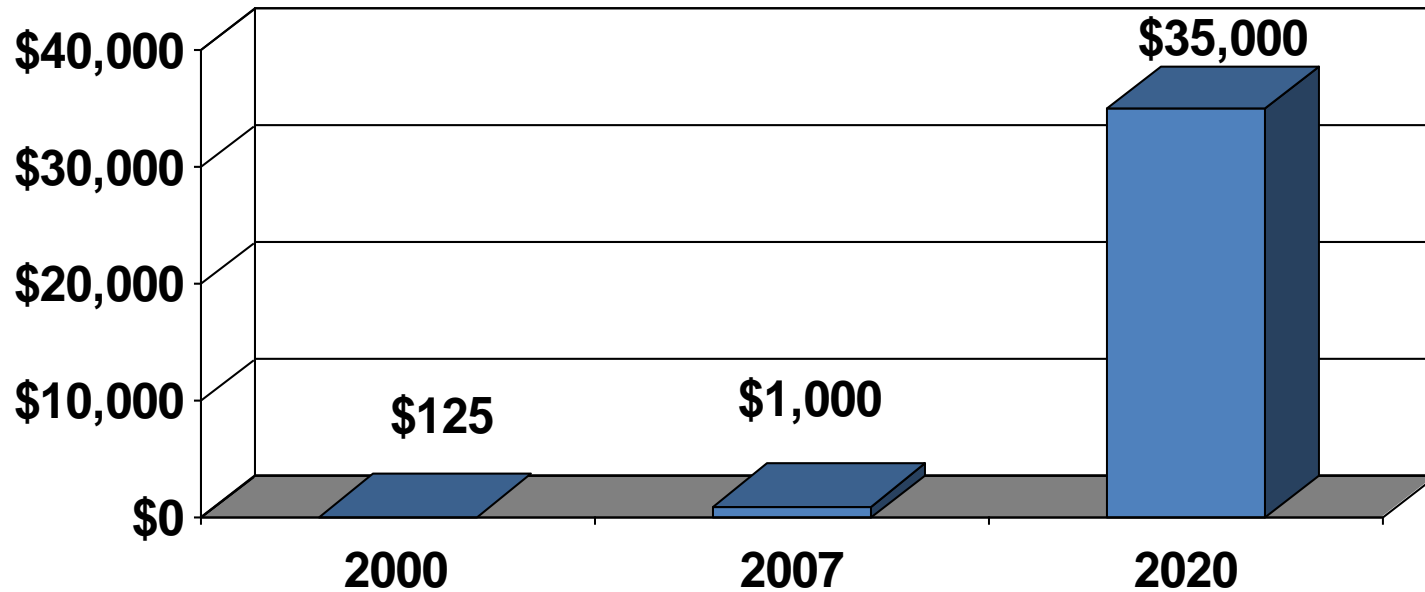


Figure 5. Time dependencies of I_c (at -0.2 V) at different concentrations of dopamine. Inset shows the linear dependence of $1/\tau$ vs., C and the values of k_a and k_d found.

Nanoproducts Marketing



(In Billions)



The US market for nanomaterials started with \$125 million in 2000 and increased to \$1 billion in 2007 and expected to reach \$35 billion by the end of 2020.

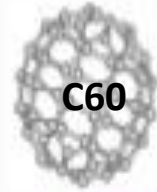
NanoQuiz ???



12,756 Km



22 cm



C60

0.7 nm

10^{16}

$1.27 \times 10^7 \text{ m}$

0.22 m

$0.7 \times 10^{-9} \text{ m}$



10 millions times
smaller

1 billion times
smaller

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http://www.nanoed.org/concepts_apps/AuNanoShells/InDepthIntroPg1.html#InDepthIntro

<http://www.nanomedicinecenter.com/drug-delivery/>

A hand wearing a blue nitrile glove is shown holding a glowing, wireframe cube. The cube is composed of a grid of lines and small, bright white dots at the vertices, giving it a digital or molecular appearance. The background is a soft, out-of-focus gradient of light blue and white, suggesting a clean, clinical or laboratory environment. The lighting is bright, highlighting the texture of the glove and the luminous quality of the cube.

THE END
BIG THANKS FOR
YOUR ATTENTION