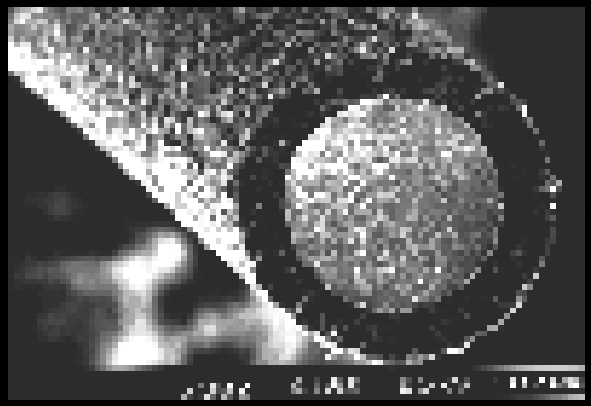
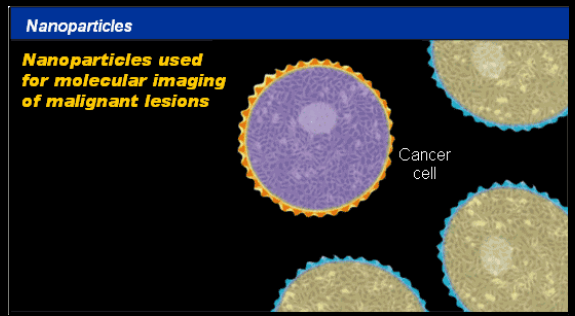
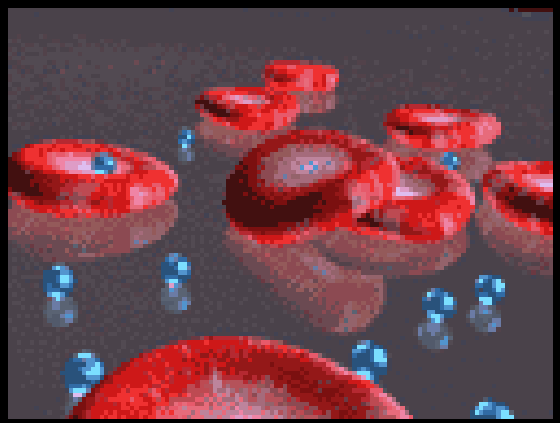






Nanomedicine and Cancer

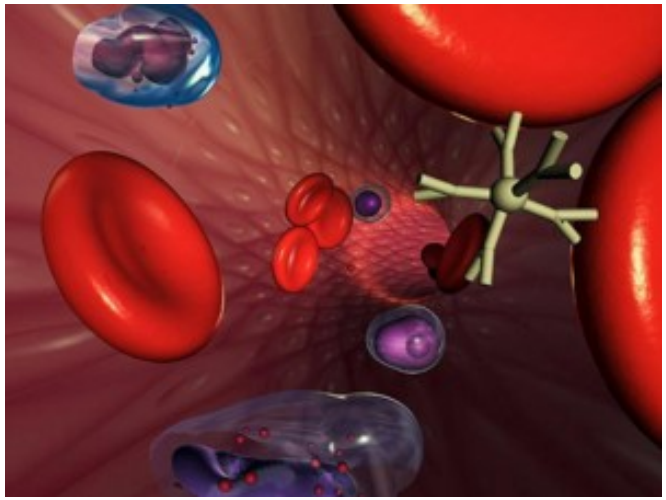
Joseph Abel

Department of Physics, USU

Why Nanomedicine?

- Nanotechnology offers great advancements to medicine
- There is still a lot to be learned about the human body and nanotechnology offers a lot of help.

Virus Seeking Probes

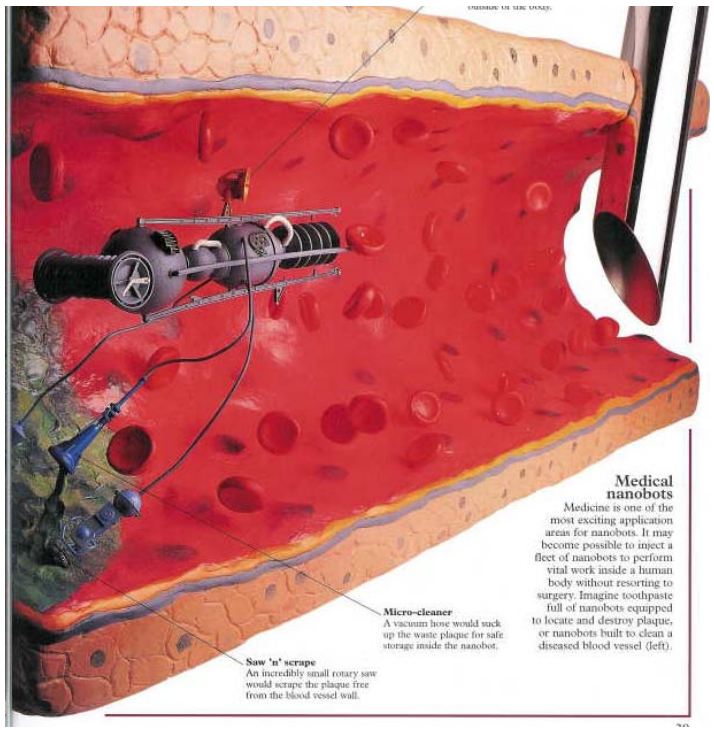


Source: http://science.nasa.gov/headlines/y2002/15jan_nano.htm

Nano-Robots Replacing Neurons

Source: http://www.e-spaces.com/Portfolio/trans/blood/index.html

Artery Cleaner



Source: http://foresight.org/Nanomedicine/Gallery/index.html

Nano-Technology applied to Cancer

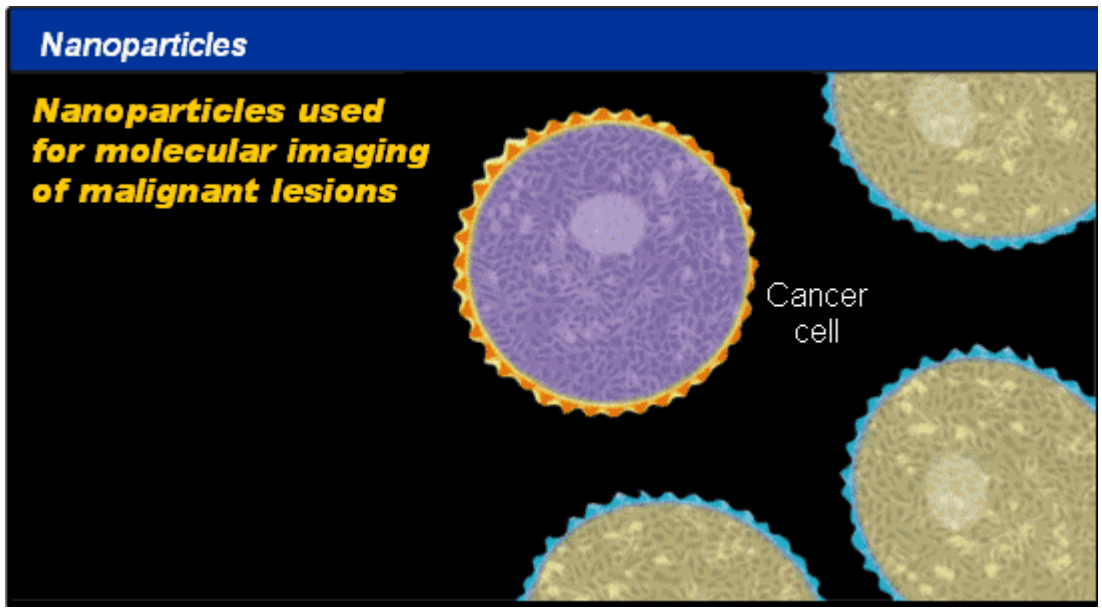
Advantages of Nanoscale devices in Medicine

- Devices smaller than 50 nm can easily enter most cells
- Devices smaller than 20 nm can transit out of blood vessels
- Devices are capable of holding thousands of small molecules
    - Contrast Agents
    - Drugs

Major Areas of Development of Nanomedicine

- Prevention and control
- Early detection
- Imaging diagnostics
- Multifunctional Therapeutics

Nanoparticles

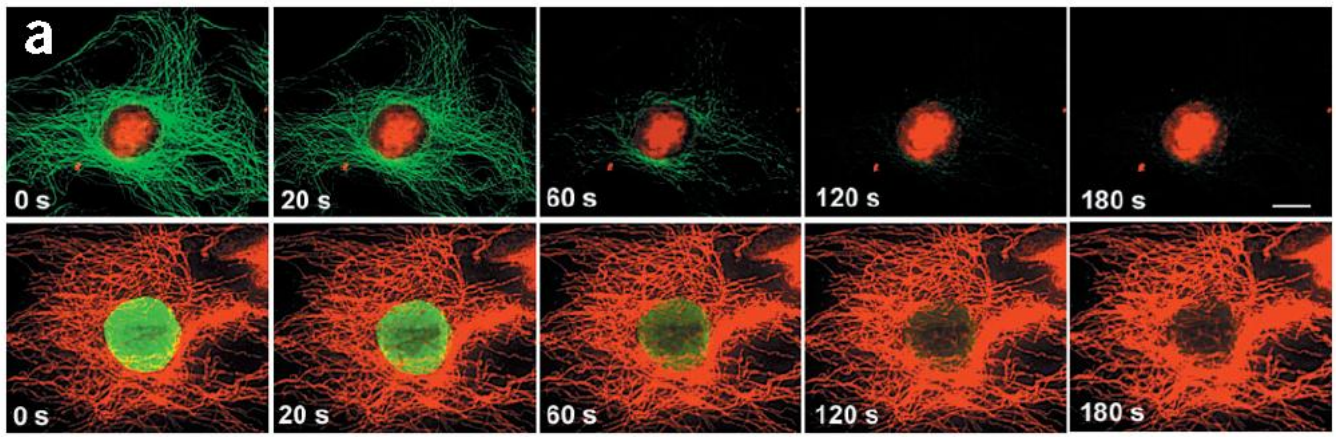


Reference: Ed Neuwelt, Oregon Health Sciences University

Nanoparticle Contrast Agents Under Development

Quantum Dots

- unique optical and electronic properties such as:
  - size and composition
  - tunable fluorescence emission from visible to infrared wavelengths
  - large absorption coefficients across a wide spectral
  - range and very high levels of brightness and photo stability
- colloidal quantum dots are the size of a typical protein

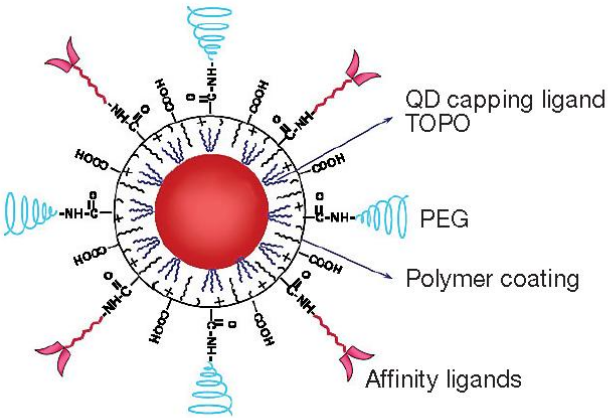


Taken From: The use of nanocrystals in biological detecion, Paul Alivisatos

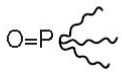
In *vivo* Cancer Targeting and Imaging with Quantum Dots

A summary of the report published by Xiaohu Gao, Richard M Levenson, Leland W K Chung & Shumming Nie

Probe Design



QD capping ligand: TOPO

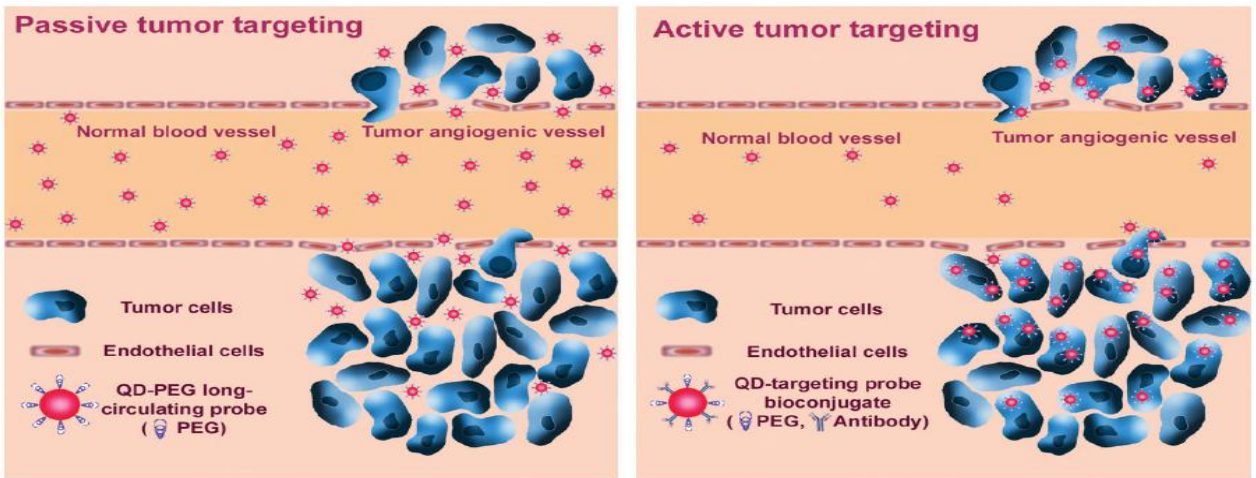


PEG: poly (ethylene glycol)

$+CH_2\text{-}CH_2\text{-}O+_n$ MW = 5,000

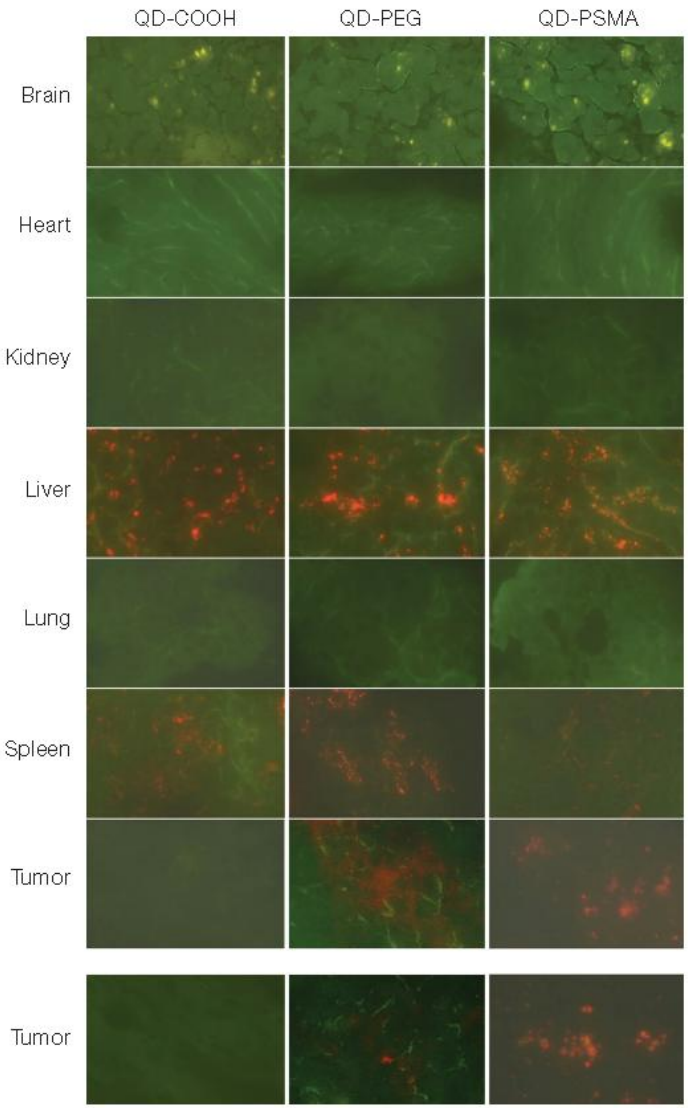
Affinity ligands: antibody, peptide, small-molecule drug, inhibitors

Tumor Targeting

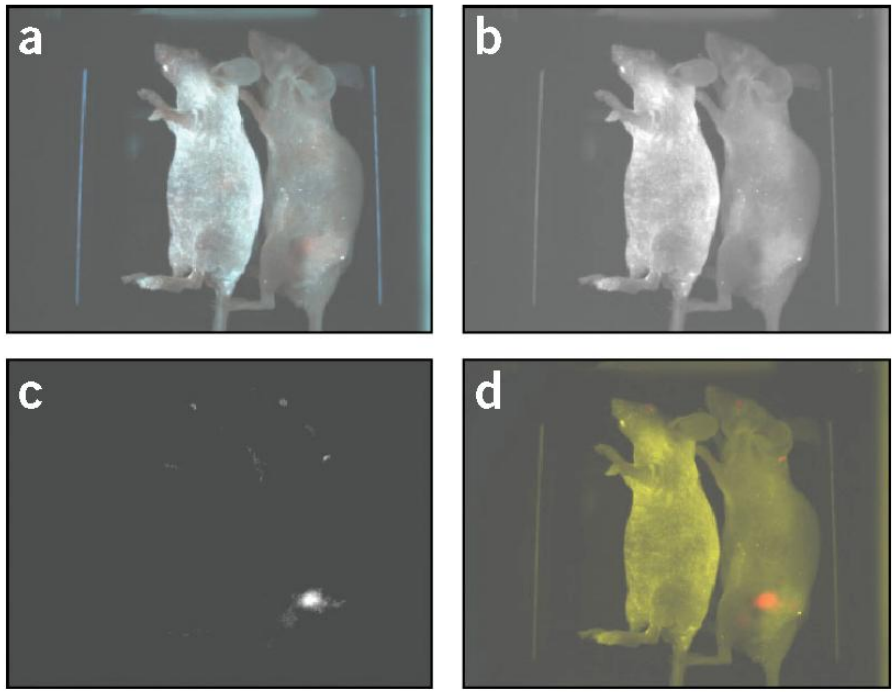


Behavior of Quantum Dots in Animals

Histological Examination of QD Uptake

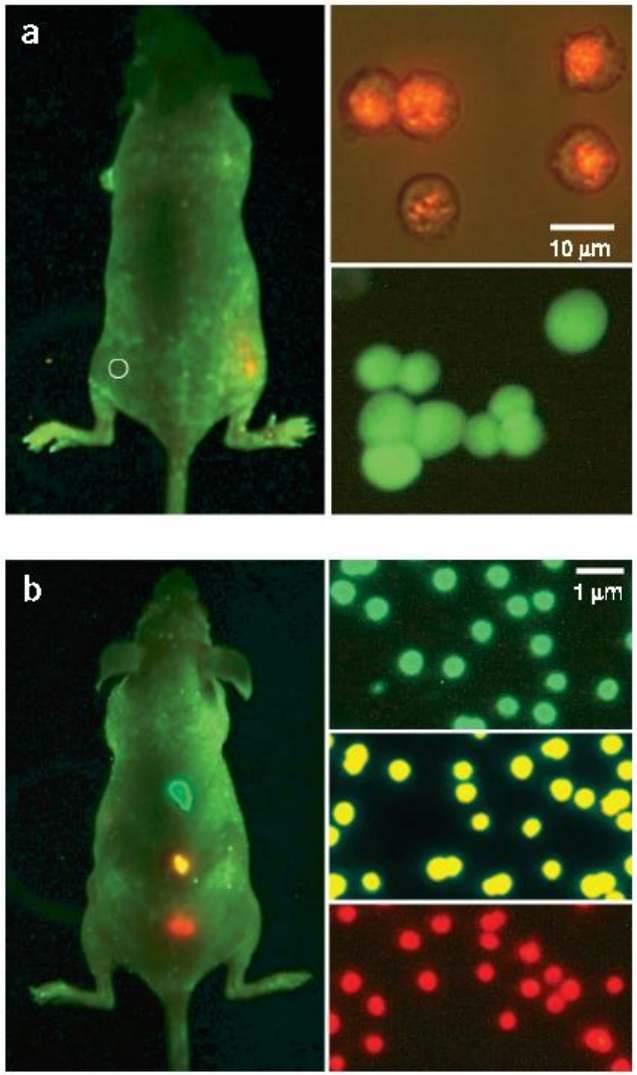


Quantum Dots in Live Mouse



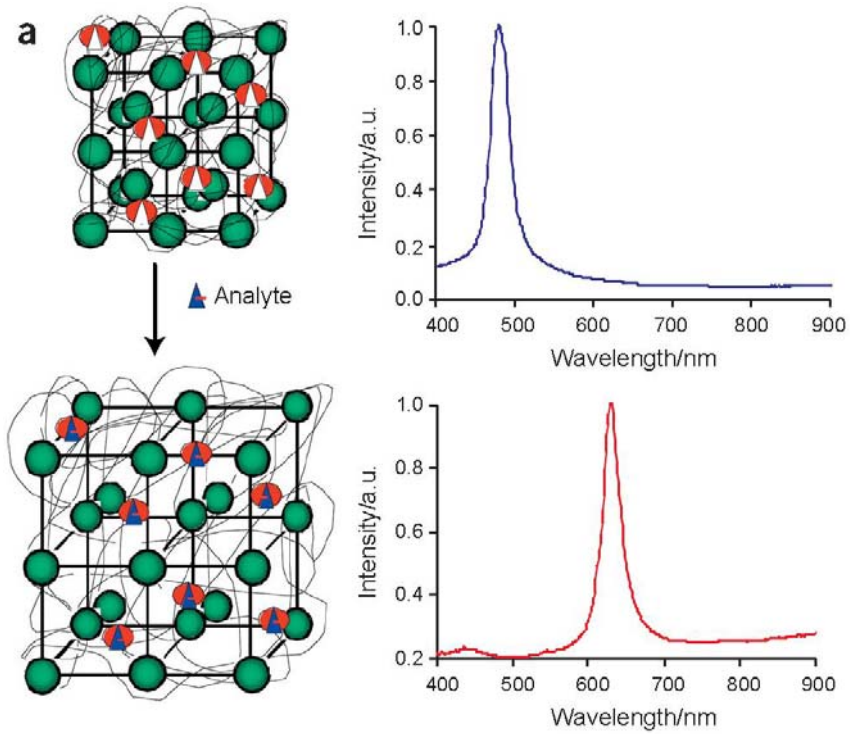
Behavior of Quantum Dots in Animals

Quantum Dots vs Organic Dyes



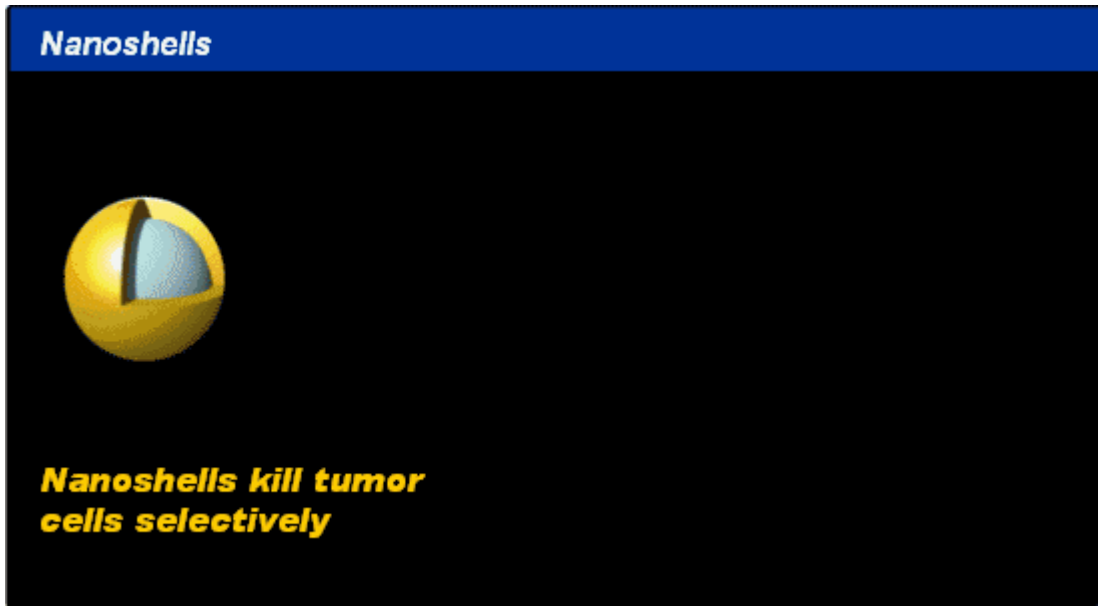
Nanoparticle Contrast Agents Under Development

Photonic Crystals



Taken From: The use of nanocrystals in biological detecion, Paul Alivisatos

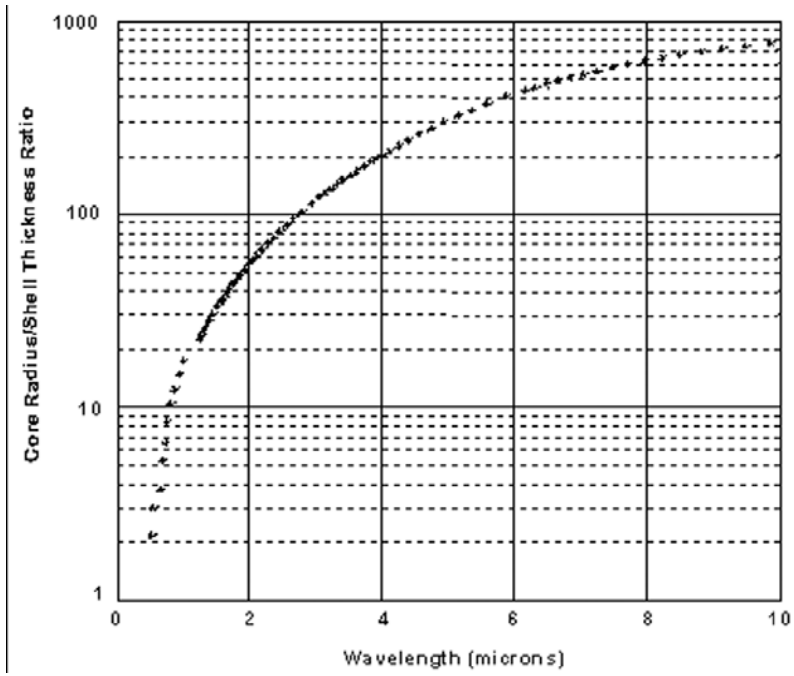
Nanoshells



Reference: Jennifer West, Rice University

Properties of Gold Nanoshells

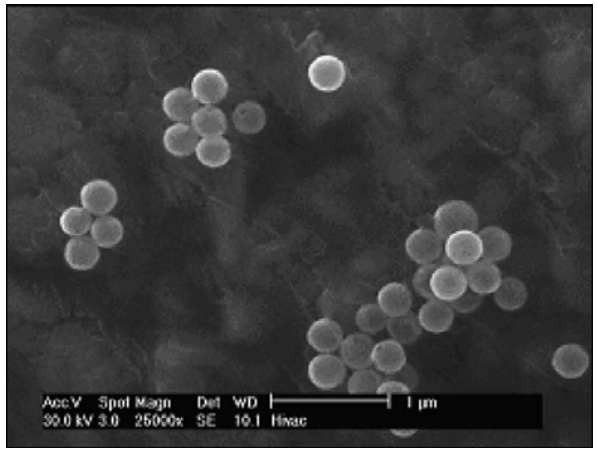
- “Tunability” of the optical resonance

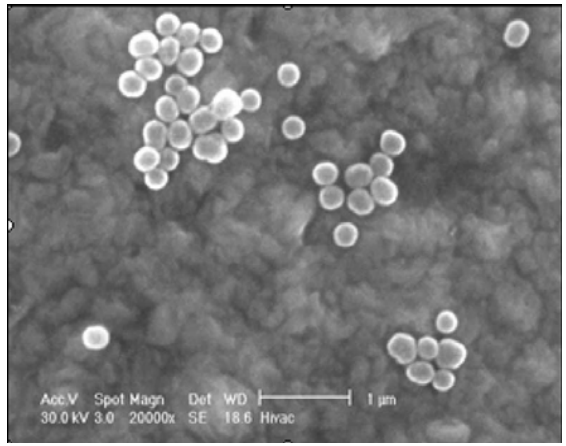


Nanoshell-Enabled Photonics-Based Imaging and Therapy of Cancer, Christopher Loo, B.S.1, Alex Lin, B.S.1, Leon Hirsch, B.S.1,Min-Ho Lee, M.S.1,Jennifer Barton, Ph.D.2,Naomi Halas, Ph.D.3,JenniferWest, Ph.D.1,Rebekah Drezek, Ph.D.1

Images of Nanoshells

Larger diameter nanoshells used for Imaging

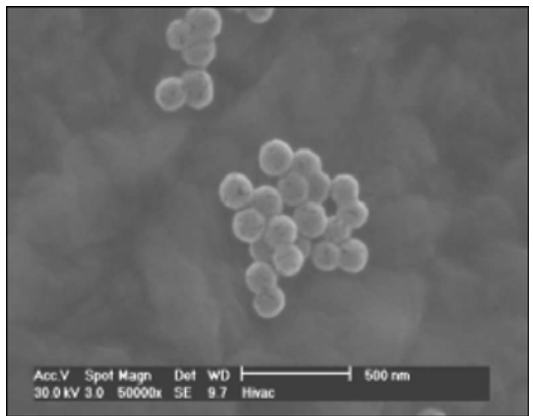




120 nm radius and 35 nm shell thickness

100 nm radius and 20 nm shell thickness

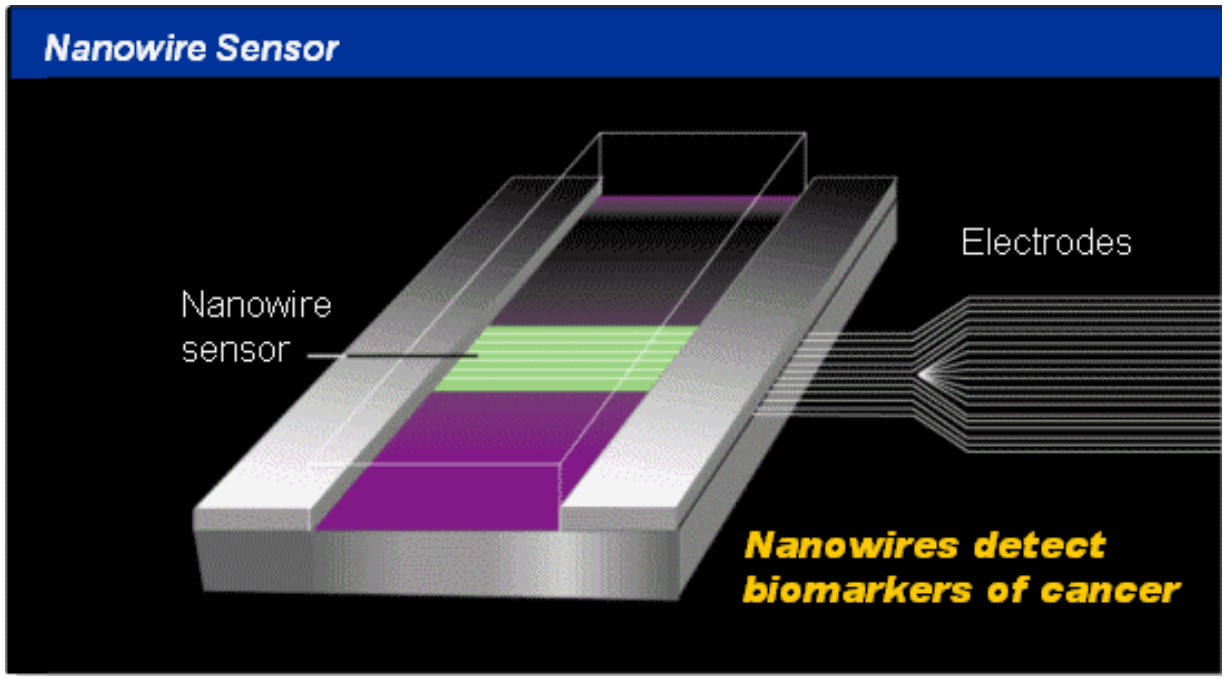
Smaller diameter nanoshells used for photothermal therapy applications



60 nm radius and 10 nm shell

Nanoshell-Enabled Photonics-Based Imaging and Therapy of Cancer, Christopher Loo, B.S.1, Alex Lin, B.S.1, Leon Hirsch, B.S.1,Min-Ho Lee, M.S.1,Jennifer Barton, Ph.D.2,Naomi Halas, Ph.D.3,JenniferWest, Ph.D.1,Rebekah Drezek, Ph.D.1

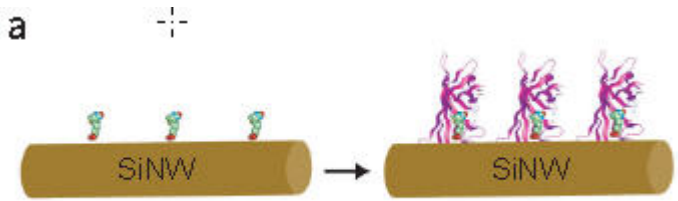
Nanowire Sensor



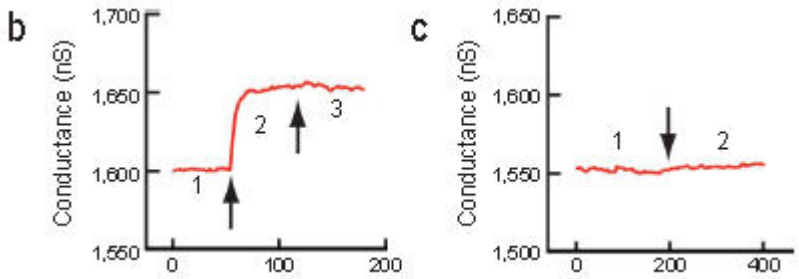
Reference: Jim Heath, California Institute of Technology

Nano-Wires in Biosensing

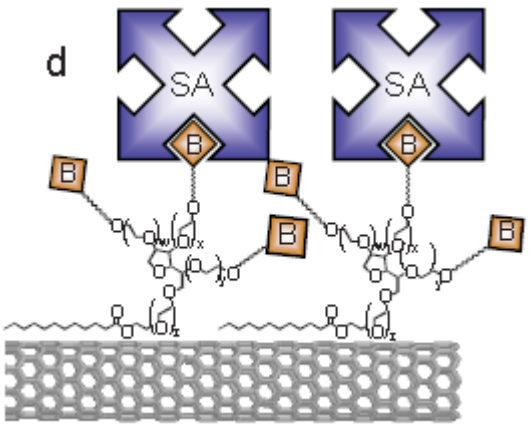
Silicon Nanowire



Conductance Graphs



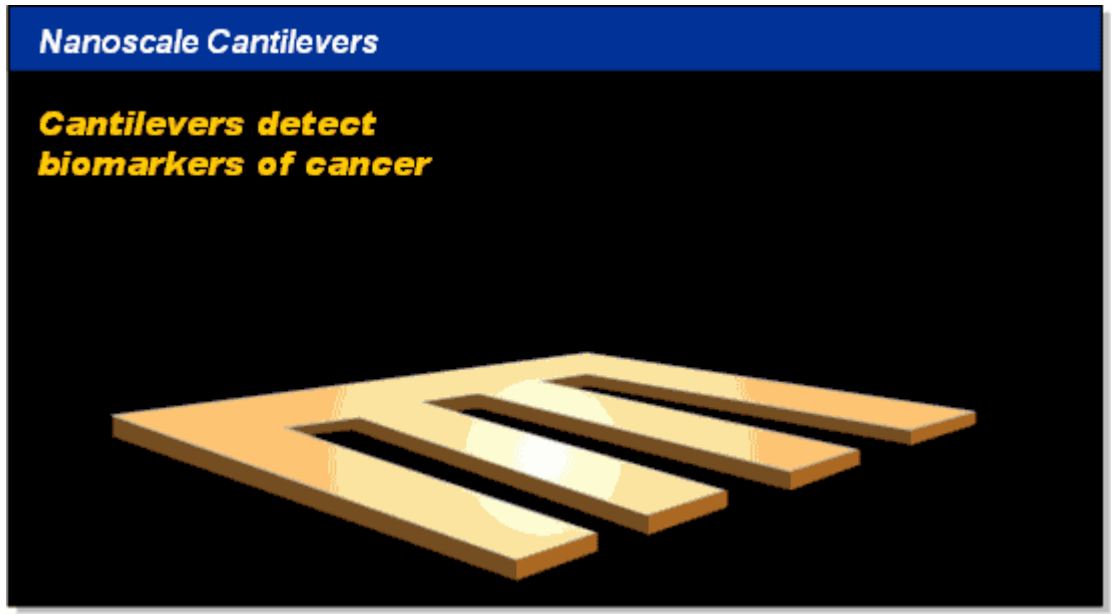
Carbon Nanotube



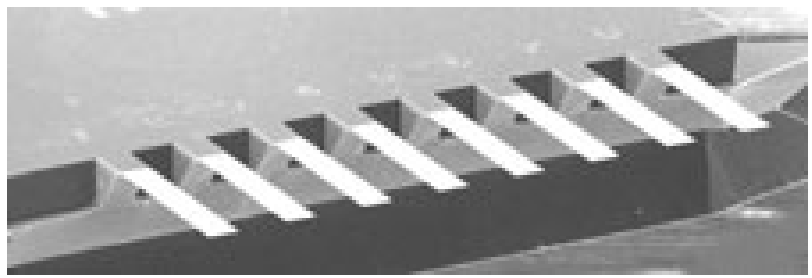
Taken From: The use of nanocrystals in biological detecion, Paul Alivisatos

Nanoscale Cantilevers

Cantilevers can be used as detectors of molecules. In this example specific molecules are attached to the cantilevers. The molecules selected are molecules that will bind to a specific molecule. When that molecule binds to the cantilever it changes the physical properties of the cantilever and that change can be detected.



Reference: Arun Majumdar, University of California at Berkeley



A team at the California Institute of Technology is using tiny cantilevers to probe molecular bonds.

Nanomedicine - Conclusion

- Nanotechnology will radically change the way we diagnose, treat and prevent cancer
- Nanomedicine for cancer has the ability to improve health care dramatically
- Current research is mostly in diagnostic tools, although there are many other application of nanomaterials in medicine…
- There are still lots of advances needed to improve Nanomedicine

60 s