NANO(materials, technology, medicine) and Human Health

ADVANCED TRAINING IN UNDERSTANDING THE SAFFETY OF NANOMATERIAL

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University POLITEHNICA of Bucharest, Bucharest, ROMANIA

Nanogentools confidential

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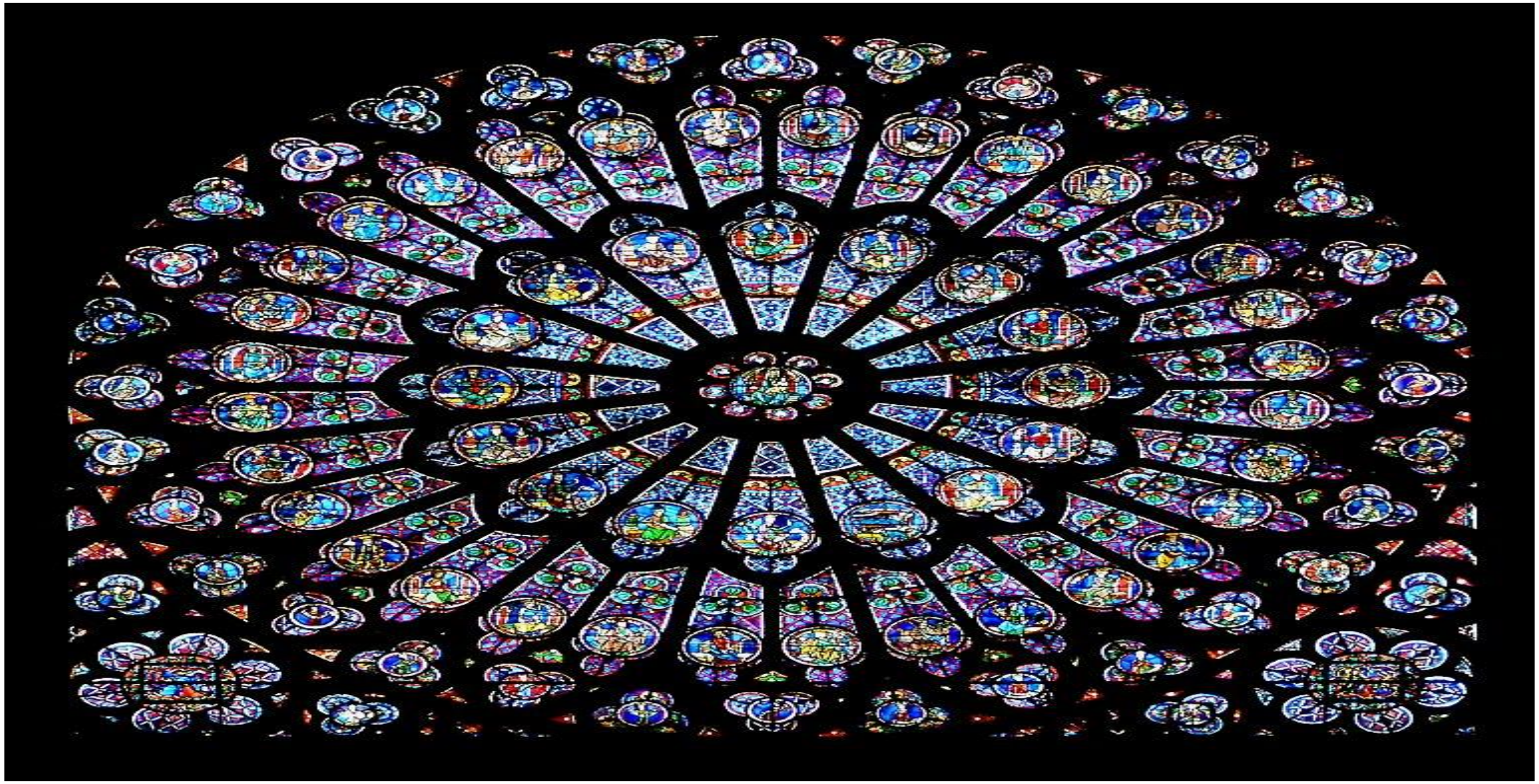
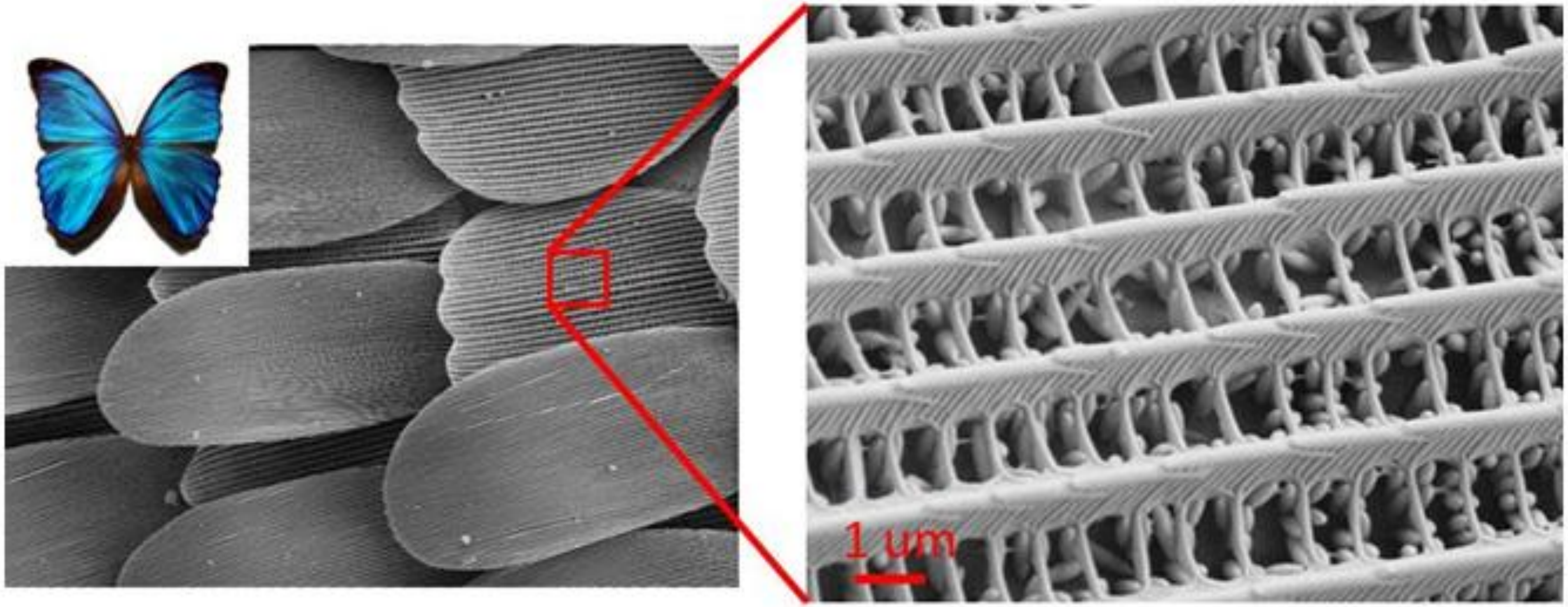
What is NANO?

The Lycurgus Cup, as it is known due to its depiction of a scene involving King Lycurgus of Thrace, is a 1,600-year-old jade green Roman chalice that changes colour depending on the direction of the light upon it.

What is NANO?



What is NANO?



What is NANO?

NANOGENTOOLS

Nano Today (2010) 5, 165–168

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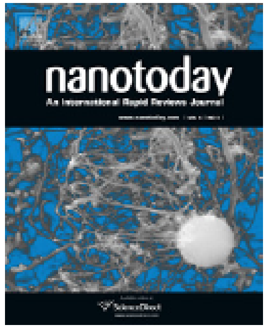
available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/nanotoday



NEWS AND OPINIONS

A complementary definition of nanomaterial

Wolfgang G. Kreyling [a,*], Manuela Semmler-Behnke [a], Qasim Chaudhry [b]

What is NANO?

- ''**Engineered nanomaterial**'' means any intentionally produced material that has one or more dimensions of the order of 100nm or less or is composed of discrete functional parts, either internally or at the surface, many of which have one or more dimensions of the order of 100nm or less, including structures, agglomerates or aggregates, which may have a size above the order of 100nm but retain properties that are characteristic to the nano-scale.

What is NANO?

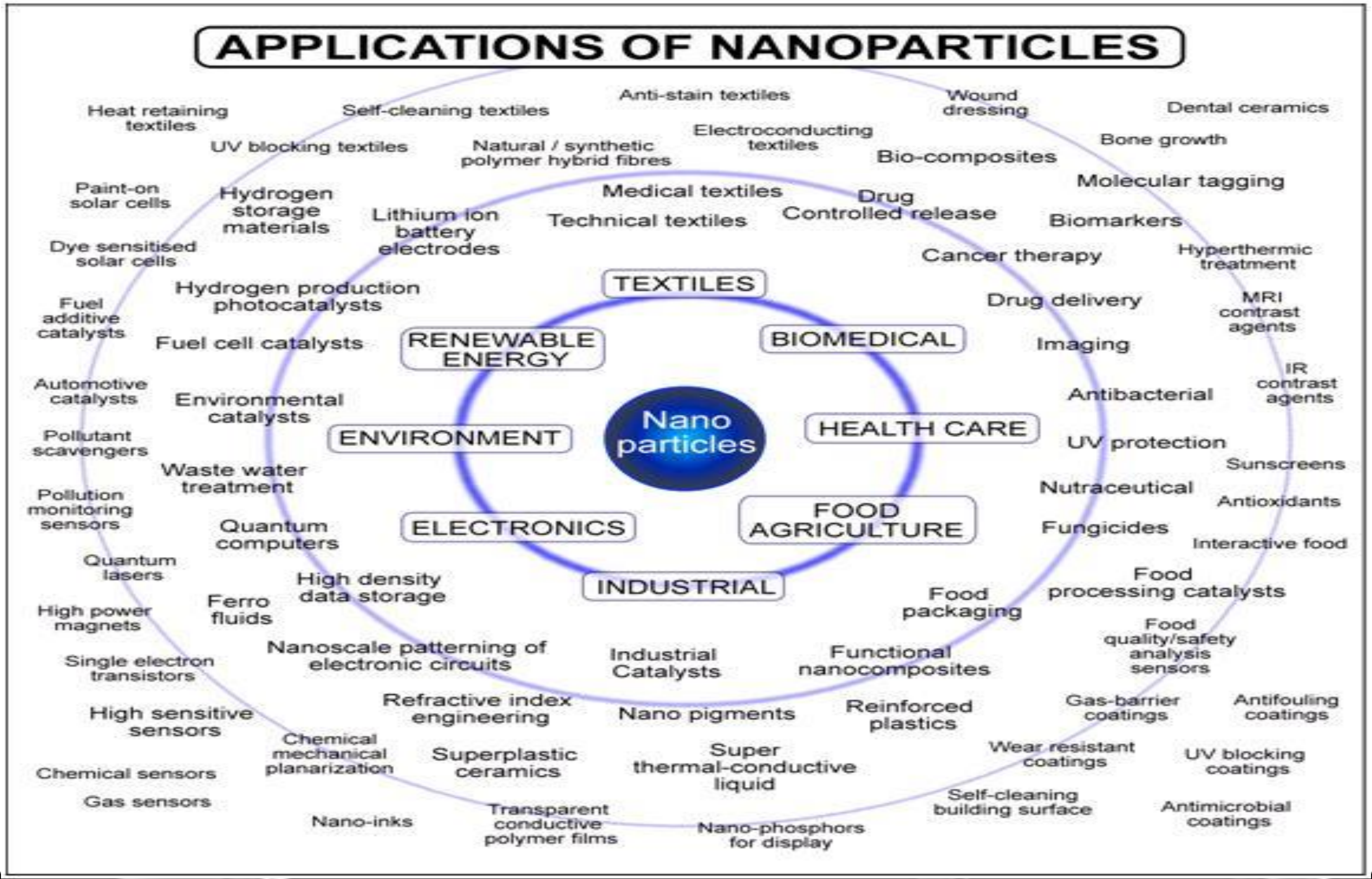
- **Nanotechnology** is the understanding and control of matter at dimensions between approximately 1 and 100 nm, where unique phenomena enable novel applications. . . .
- Dimensions between approximately 1 and 100nm are known as the nano-scale.
- Unusual physical, chemical, and biological properties can emerge in materials at the nano-scale.
- These properties may differ in important ways from the properties of bulk materials and single atoms or molecules.

What is NANO?

NANOGENTOOLS

- **Engineered nanomaterial** (ENM) is any material that is deliberately created such that it is composed of discrete functional and structural parts, either internally or at the surface, many of which will have one or more dimensions of the order or 100nm or less.

What is NANO?



APPLICATIONS OF NANOPARTICLES
Nano particles
TEXTILES
RENEWABLE ENERGY
BIOMEDICAL
ENVIRONMENT
HEALTH CARE
ELECTRONICS
FOOD AGRICULTURE
INDUSTRIAL
Heat retaining textiles
Self-cleaning textiles
Anti-stain textiles
Wound dressing
Dental ceramics
UV blocking textiles
Natural / synthetic polymer hybrid fibres
Electroconducting textiles
Bio-composites
Bone growth
Paint-on solar cells
Hydrogen storage materials
Lithium Ion battery electrodes
Medical textiles
Technical textiles
Drug Controlled release
Molecular tagging
Biomarkers
Dye sensitised solar cells
Cancer therapy
Hyperthermic treatment
Hydrogen production photocatalysts
Drug delivery
MRI contrast agents
Fuel additive catalysts
Fuel cell catalysts
Imaging
Automotive catalysts
Environmental catalysts
Antibacterial
IR contrast agents
Pollutant scavengers
UV protection
Waste water treatment
Sunscreens
Pollution monitoring sensors
Nutraceutical
Antioxidants
Quantum computers
Fungicides
Interactive food
Quantum lasers
High density data storage
Food packaging
Food processing catalysts
High power magnets
Ferro fluids
Food quality/safety analysis sensors
Single electron transistors
Nanoscale patterning of electronic circuits
Industrial Catalysts
Functional nanocomposites
High sensitive sensors
Refractive index engineering
Nano pigments
Reinforced plastics
Gas-barrier coatings
Antifouling coatings
Chemical mechanical planarization
Superplastic ceramics
Super thermal-conductive liquid
Wear resistant coatings
UV blocking coatings
Chemical sensors
Self-cleaning building surface
Gas sensors
Nano-inks
Transparent conductive polymer films
Nano-phosphors for display
Antimicrobial coatings

What is NANO?


THE
STONE
AGE
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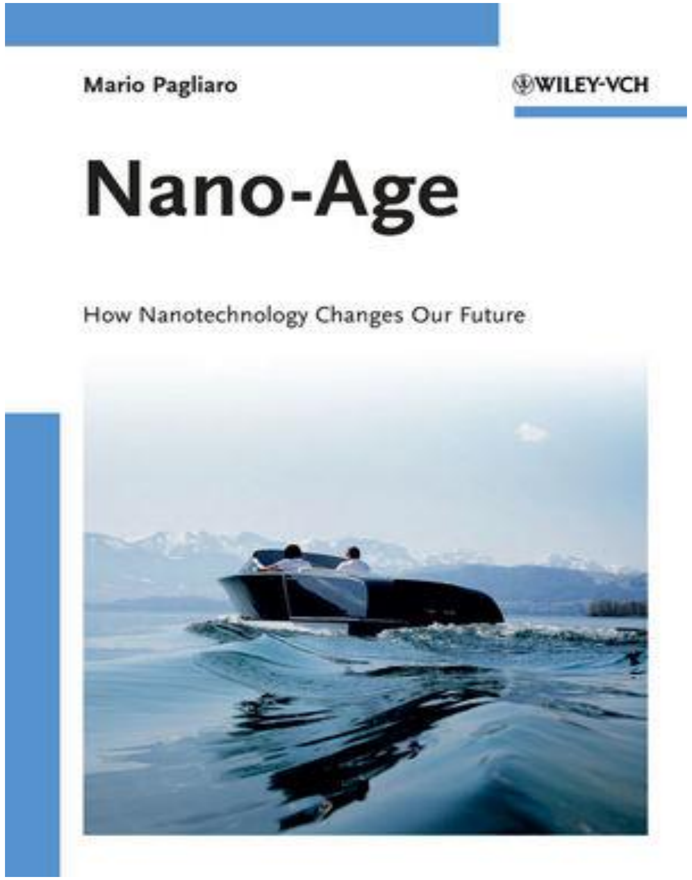
Mario Pagliaro
WILEY-VCH
Nano-Age
How Nanotechnology Changes Our Future

What is NANO?


Nanotechnology
nanoscale
materials
new
Nanomaterials
molecular
study
many
devices
developing
nanotech
cells
debate
various
used
applications
potential
atomic
matter
nanoparticles
technology
dimensions
scale
solar
concerns
whether
Nanomedicine
size
see
science
made
physics
based
sometimes
conventional
structures
introduction
nanorods
generation
implications
well
display
develop
controlling
electronics
medical
commercial
much
economics
future
traditional
special
combats
includes
colloid
Progress
within
nanometers
regulation
products
least
impact
global
one
directly
among
approaches
vast
biological
advocacy
lighting
hand
including
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Development
speculation
self-assembly
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bulk
rise
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also
properties
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effects
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carbon
present
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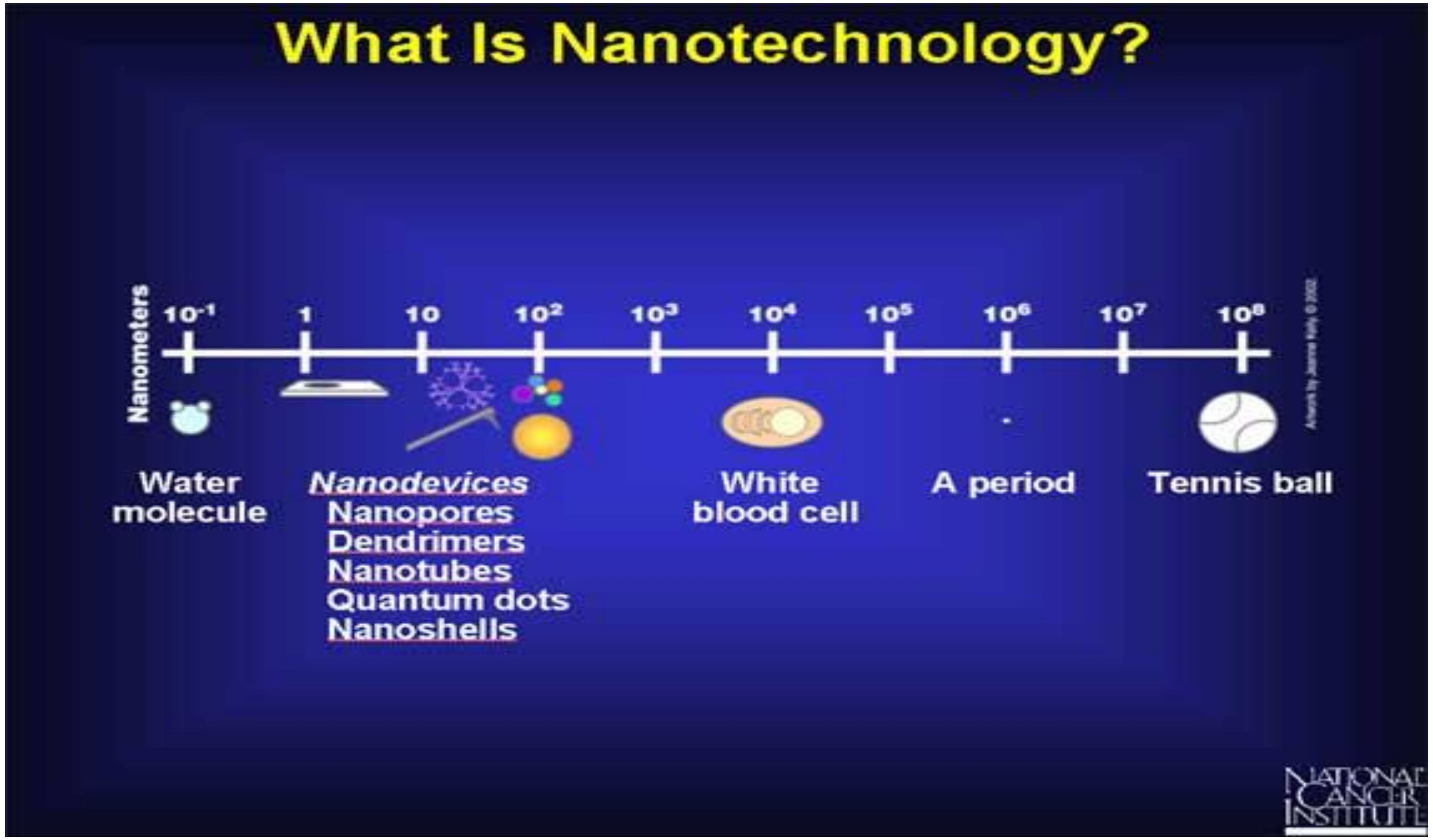
Generally
device
environmental
dimension
dots
Interface
diverse
incorporating
semiconductor
flavor
doomsday
completely
production
using
warranted
useful
quantum
smaller
investigating
energy
shortened
given
governments
silicon
involves
subfields
ranging
may
range
extensions
medicine
nanotubes
scenarios
create
groups
toxicity
control
123RF

What is NANOTECHNOLOGY?

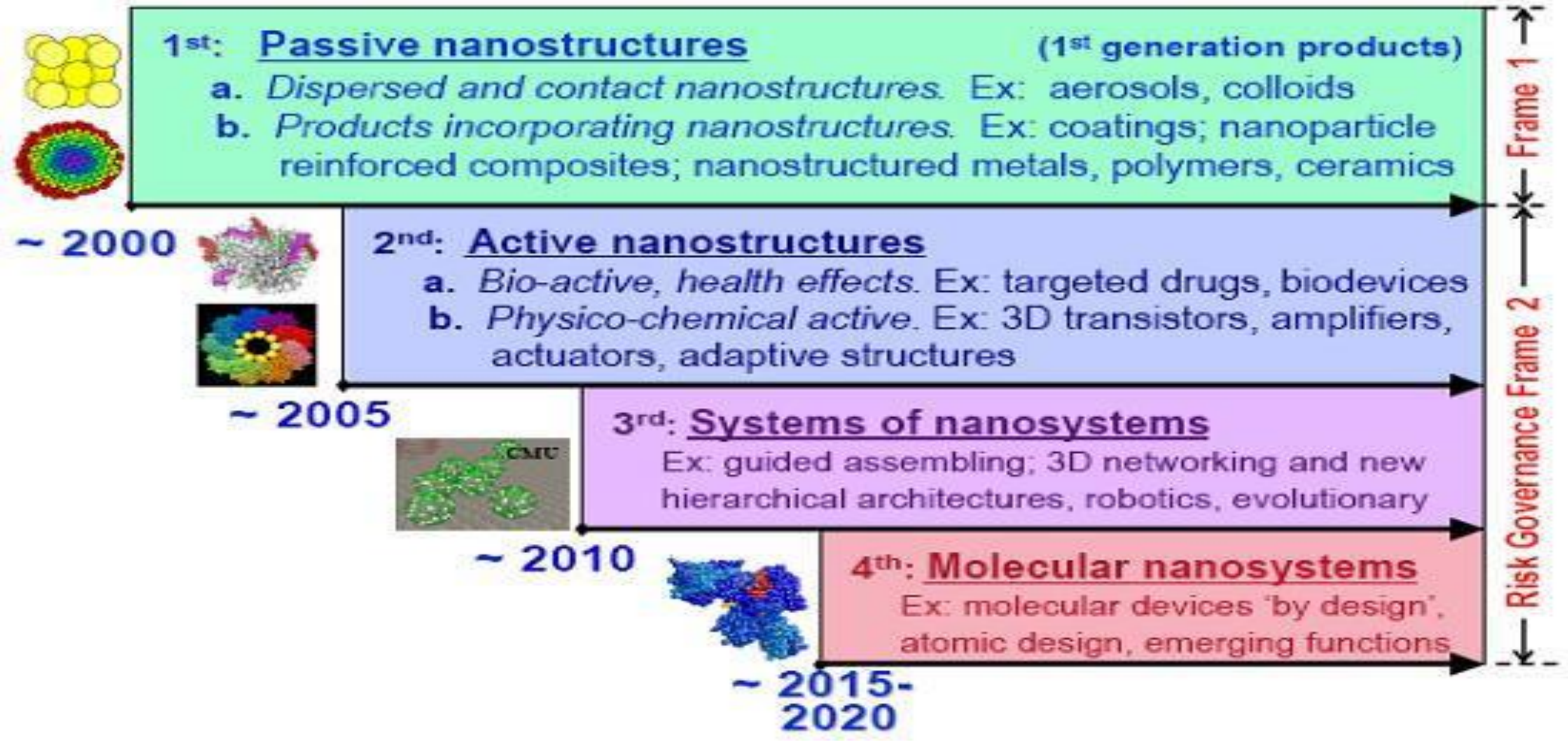
Nanotechnology is

the understanding and control of matter at dimensions between approximately 1 and 100 nm, where unique phenomena enable novel applications. . . .

The (US-)National Nanotechnology Initiative Strategic Plan December 2007
www.nano.gov/NNI Strategic Plan 2007.pdf

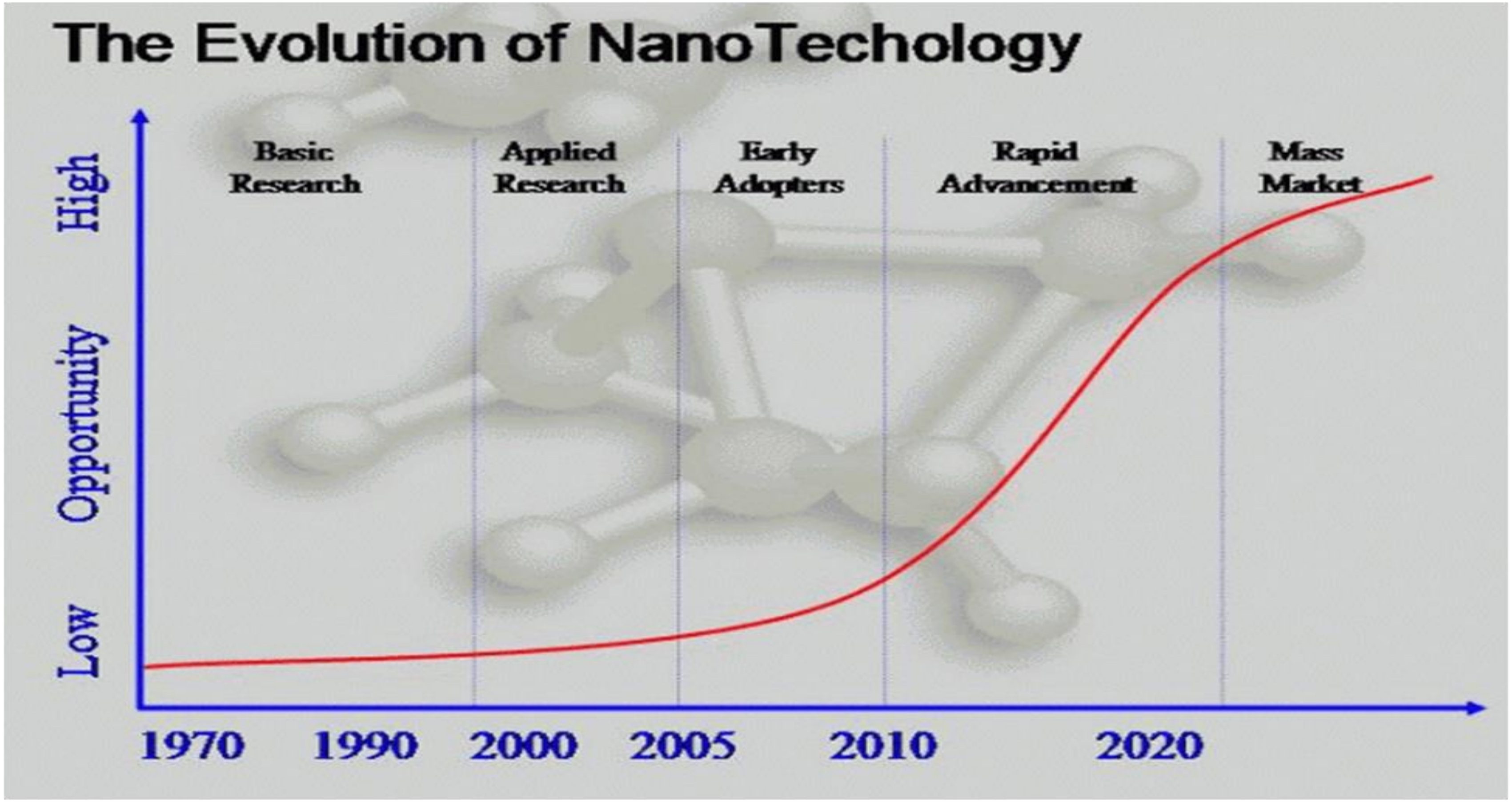


What is NANOTECHNOLOGY?

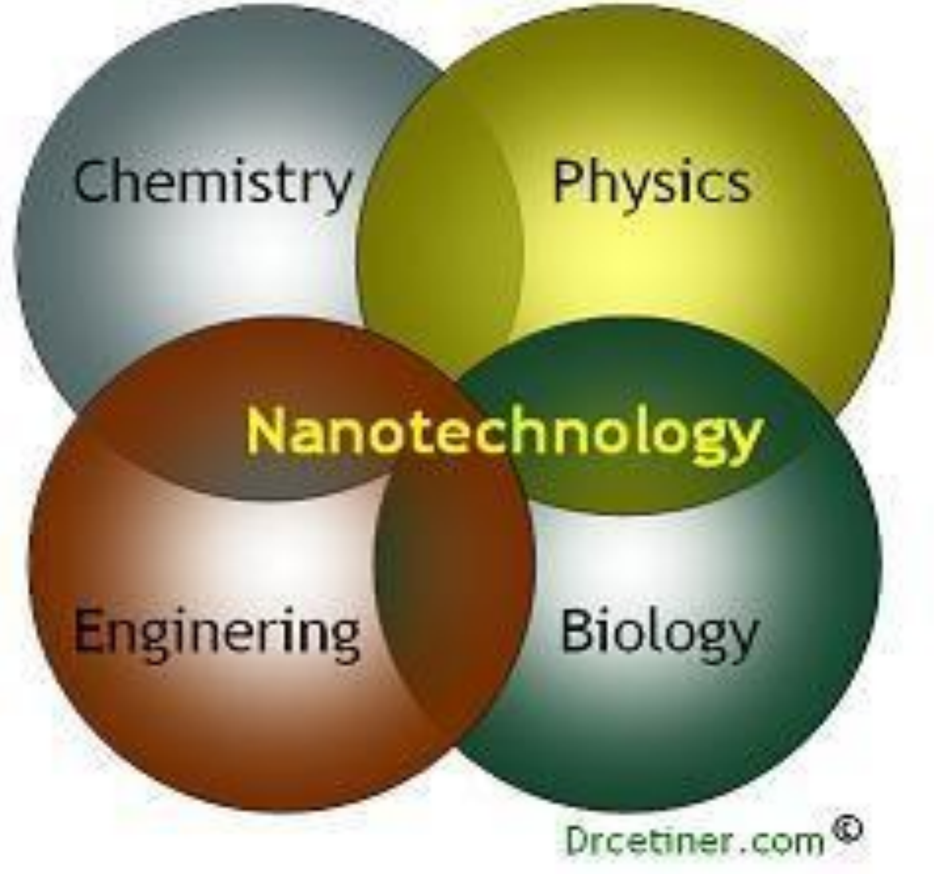


What is NANOTECHNOLOGY?

NANOGENTOOLS



What is NANOTECHNOLOGY?



What is NANOTECHNOLOGY?

[redacted]

What is NANOTECHNOLOGY?

NANOGENTOOLS

Nanotechnology has several application on many fields such as :

- Medicine
- Electronics
- Energy production
- water processing ………

Nanomedicine

- **Nanotechnology applied medically**
- **New breakthroughs in medicine:**
  - Advanced biomedical research tools
  - Labels to experiments
  - Study of DNA and its component genes
  - Diagnostic tests
  - In bone implants etc…

Drug Delivery Methods

- Systems that deliver drugs to specific sites
- Sample Methods:
  - Smart Drugs
  - Nanocomposite hydrogel systems
  - Magnetic Nanoparticles

Drug Delivery Methods

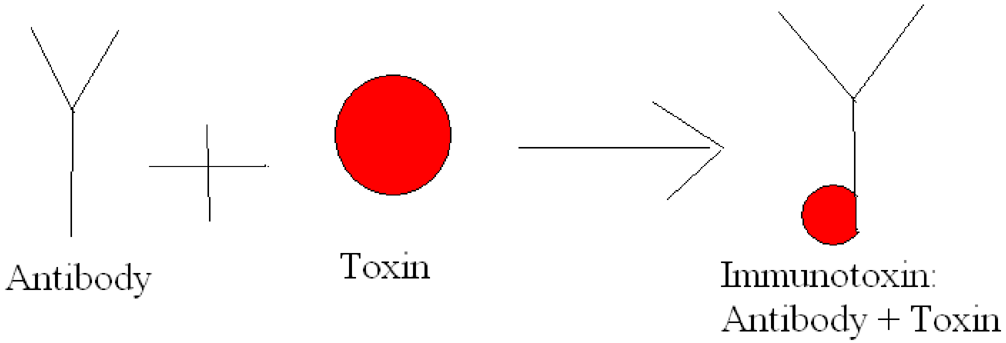
NANOGENTOOLS

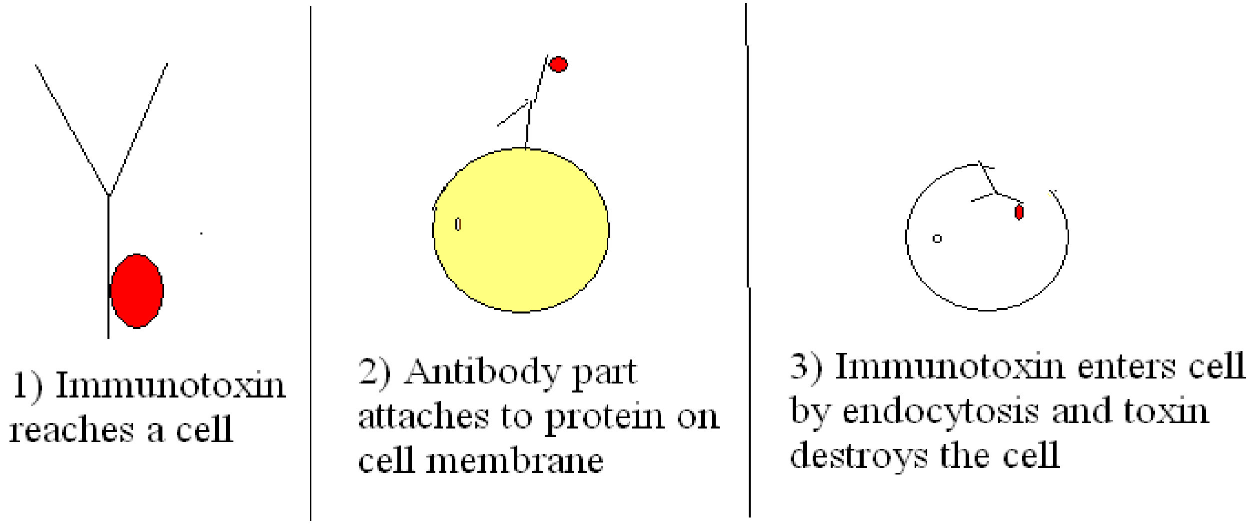
- Smart drugs

-Attack specific antigens

-Immunotoxins that are protein in nature

-Consist of an antibody part and toxic part





Drug Delivery Methods

- Nanocomposite hydrogel systems

  -Thermo therapeutic process

  -Releases drugs that are encapsulated on heating

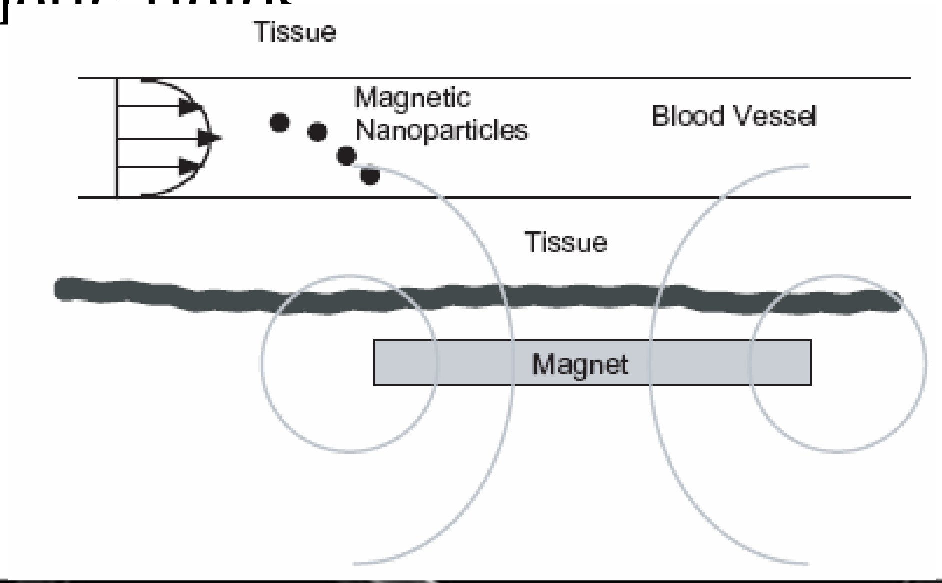
  -Gold nanoshells/nanoparticles can be used

  -Ideal wavelengths of light are infra red i.e 800-1200nm

Drug Delivery Methods

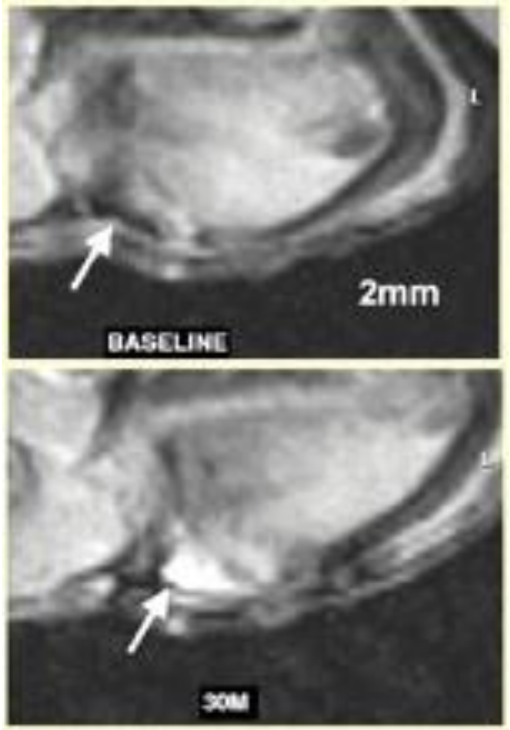
- Magnetic Nanoparticles

  -Drugs are bound to magnetic nanoparticles
  -Carry drugs to malignant sites with magnetic fields
  -Release the drugs by enzymatic activity



Disease Detection

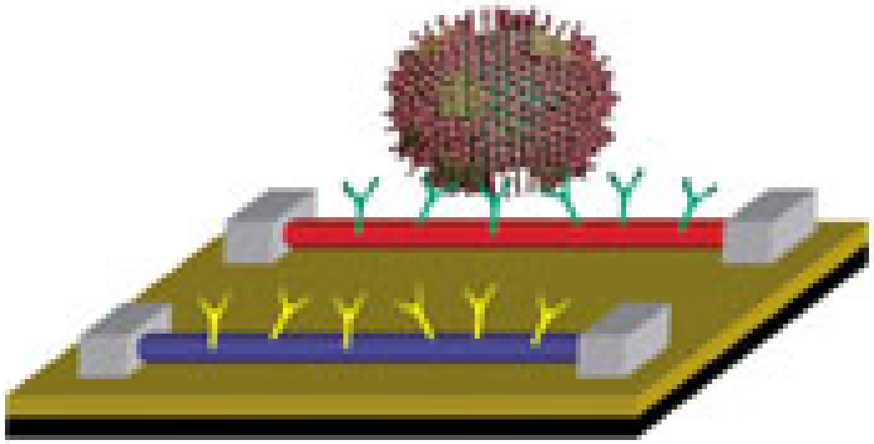
- Cancer/Virus Detection
  - Carbon Nanotubes
  - Gold nanoparticles & Nanodots
  - Nanowires
- Gene Detection
  - Silicon nanowires



Picture taken from
http://mednews.wustl.edu/tips/page/normal/5036.html

Cancer/Virus Detection

- Carbon Nanotubes:
  - Covered with monoclonal antibodies
  - Antibodies for growth factor receptor commonly found in cancer cells
  - Current increases measured
- Silicon Nanowires
  - Similar in use to nanotubes
  - Antibodies attached to wire
  - Current changes measured
  - Can be applied to cancer cells and viruses



Taken from http://www.news.harvard.edu/gazette/2004/10.07/01-nanovirus.html

Cancer/Virus Detection

NANOGENTOOLS

- Gold Nanoparticles & Nanodots

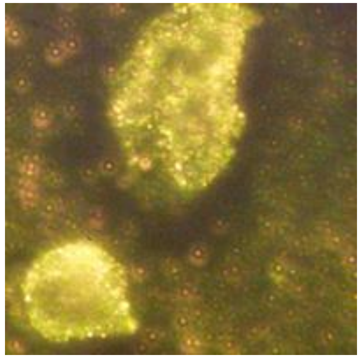
  -Similar application

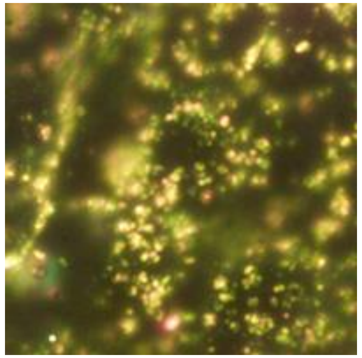
  -Antibodies attached to nanoparticles

  -Nanoparticle antibodies bind to cancer cells

  -Colors reflected when light hits particles

  -Shapes and sizes affect color





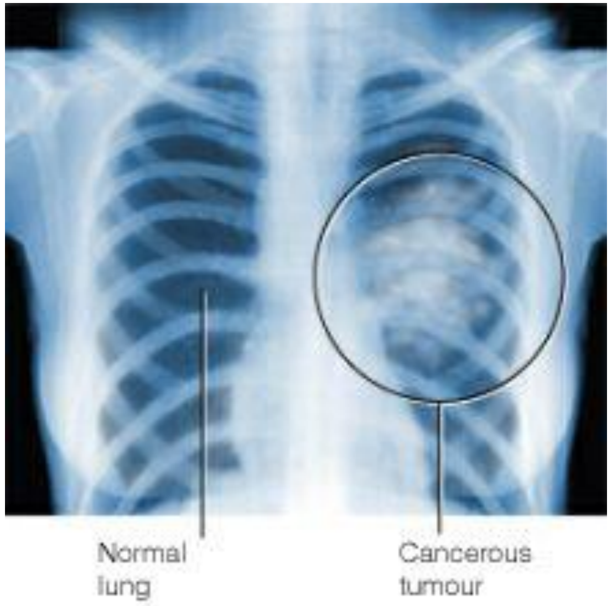
Taken from http://www.gatech.edu/news-room/release.php?id=561

Gene Detection

- Silicon nanowire:
  - Can detect specific genes
  - Nucleic acids attached to nanowires
  - Specific sequences can be created
  - Sensor capable of differentiating mutated and nonmutated genes
  - PCR not needed -> detection time lowered

Imaging Techniques

- Conventional Techniques:
  - X-ray, MRI, Fluoroscopy
  - CAT scan
- Limitations
  - Limited detail
  - Difficult to track movement



Taken from: http://www.besttreatments.co.uk/btuk
/images/lung_cancer_xray.jpg

Imaging Applications

- Molecular Tracking:

  -Use Quantum Dots as labels

  - Dots attached to molecules before injection

  -Fluoroscopy used to track movement

  - Colors from dots seen and imaged

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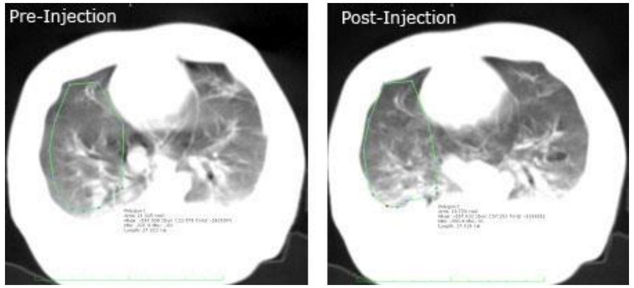
Imaging Applications

- Tracking blood flow:
  - Tag proteins of cells with gold nanoparticles
  - View process of angiogenesis
    - Important for cancer detection and imaging
- Cancer Imaging:
  - Injection of gold nanoparticles
  - Localization around tumors
  - CT scan shows cancerous regions



Taken from http://www.rsna.org/Publications/rsnanews/oct05/nanoparticles.cfm

POTENTIAL APPLICATION OF NANOPARTICLES IN MEDICINE: Cancer Diagnosis and Therapy

OUTLINE

- SECTION I
- Nanomedicine overview
- SECTION II
- Nanotechnology potential in medicine
- SECTION III
- Promising works
- SECTION IV
- Assessment

SECTION I

Nanomedicine Review

Nanomedicine

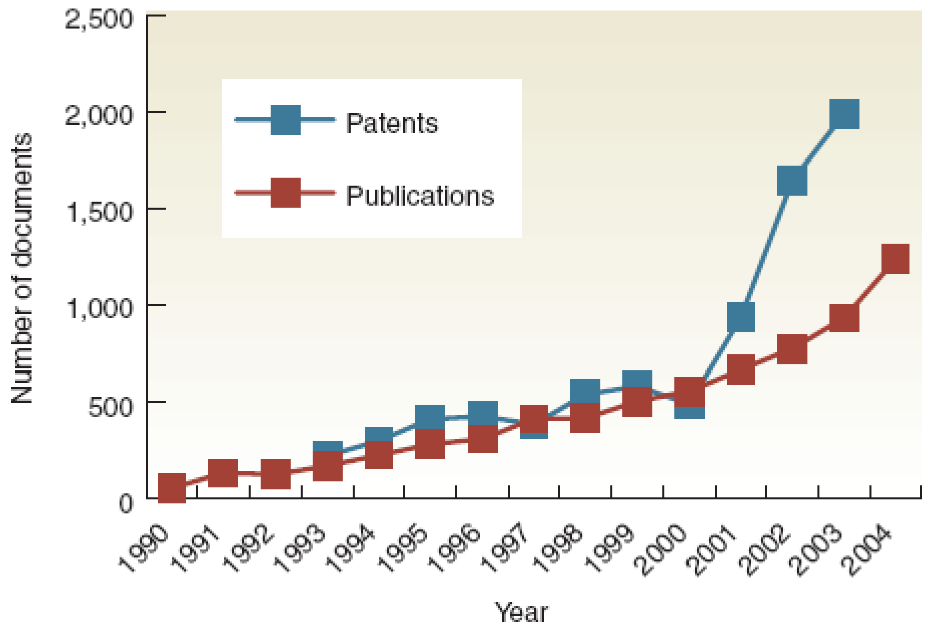
NANOGENTOOLS

- Premise:
- Nanometer-sized particles have optical, magnetic, chemical and structural properties that set them apart from bulk solids, with potential applications in medicine.
- Potential applications

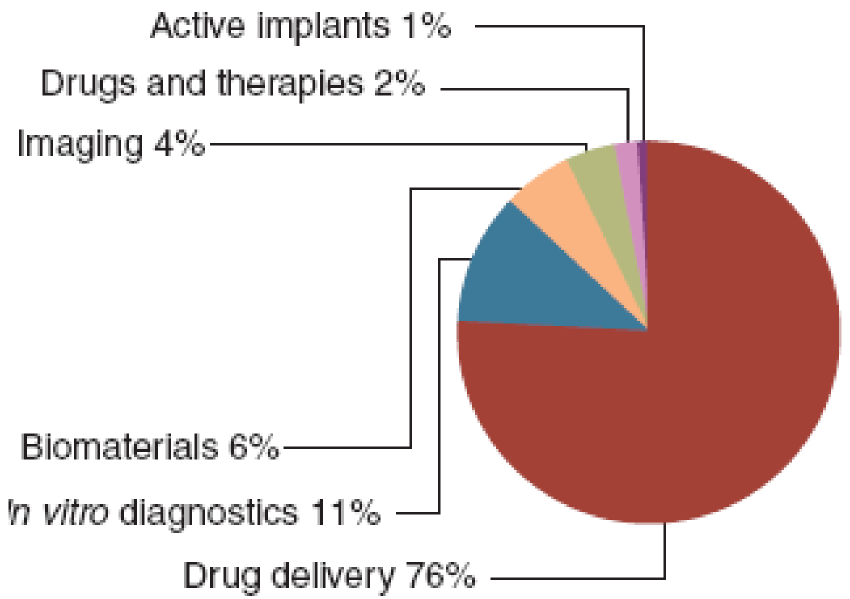
DRUG DELIVERY	**MEDICAL IMAGING**
DIAGNOSIS & SENSING	**THERAPY**

Interesting facts about nanomedicine

A. Interest in the area has grown exponentially



B. Drug delivery is the most productive area



Interesting facts about nanomedicine

C. Drug delivery is the most established technology in the nanomedicine market

Table 1 Commercial efforts in nanomedicine[a]

			Product pipeline		
Healthcare sector	Number of products	Sales ($ billions)	Total	Advanced stages[b]	Companies
Drug delivery	23	5.4	98	9	113
Biomaterials	9	0.07	9	6	32
In vivo imaging	3	0.02	8	2	13
In vitro diagnostics	2	0.78	30	4	35
Active implants	1	0.65	5	1	7
Drugs & therapy	0	0	7	1	7
Total	38	6.8	157	23	207

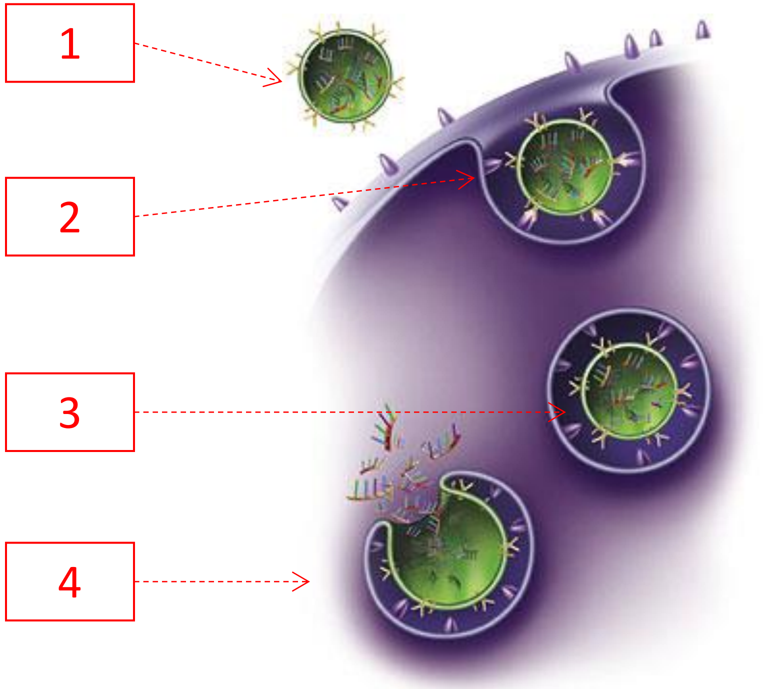
[a]Sales numbers of nanomedicines are estimates for the year 2004. [b]Drugs where the product is in clinical phase 2/3 or 3 and for all other products where market introduction is expected within two years.

Nature Biotechnology 2006, Vol. 4, pp.1212-1217

Drug Delivery

NANOGENTOOLS

A. Because of their small sizes, nanoparticles are taken by cells where large particles would be excluded or cleared from the body



Source: Comprehensive Cancer Center Ohio University

1) A nanoparticle carries the pharmaceutical agent inside its core, while its shell is functionalized with a 'binding' agent

2) Through the 'binding' agent, the '<u>targeted</u>' nanoparticle recognizes the target cell. The functionalized nanoparticle shell interacts with the cell membrane

3) The nanoparticle is ingested inside the cell, and interacts with the biomolecules inside the cell

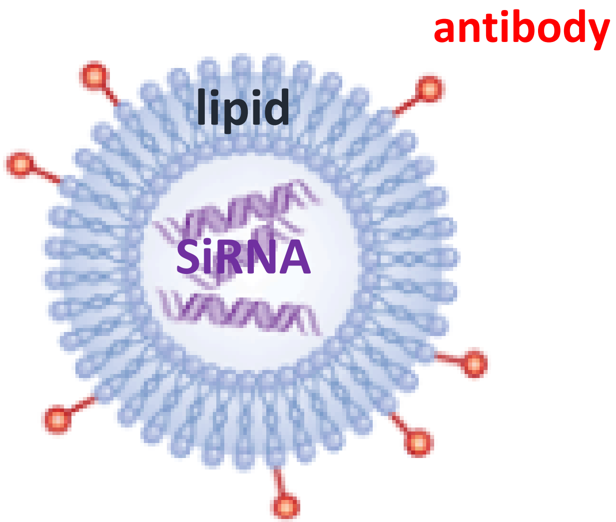
4) The nanoparticle particles breaks, and the pharmaceutical agent is released

A Drug Delivery Nanoparticle

NANOGENTOOLS

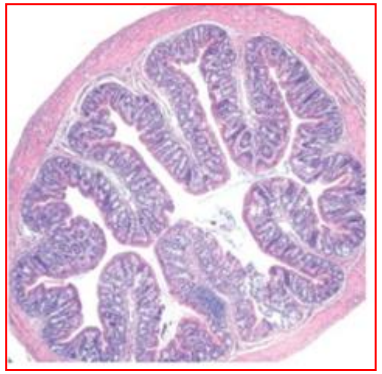
A. Nanoparticles for drug delivery can be metal-, polymer-, or lipid-based. Below (left) an example of the latter, containing SiRNA encapsulated, and functionalized with an specific antibody. SiRNA can control often lethal inflammatory body responses, as shown in the microscopic images below (right)

B.

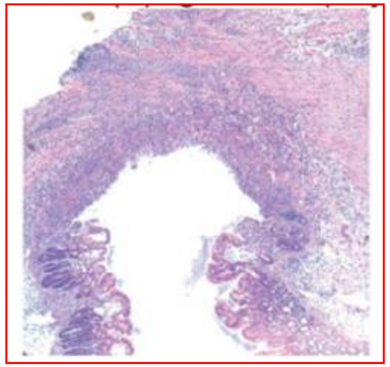


Science 2008, Vol. 316, pp 627-630

C.



Healthy tissue



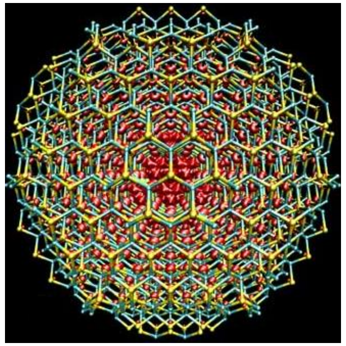
Sick tissue treated with non-targeted nanoparticles

Sick tissue treated with targeted nanoparticles

Medical Imaging

A. Optical properties of nanoparticles depend greatly on its structure. Particularly, the color (wavelength) emitted by a quantum dot (a semiconductor nanoparticle) depends on its diameter.

B.



CdSe nanoparticle (QD) structure

Source: Laurence Livermore Laboratories

Solutions of CdSe QD's of different diameter

Source: Department of immunology, University of Toronto

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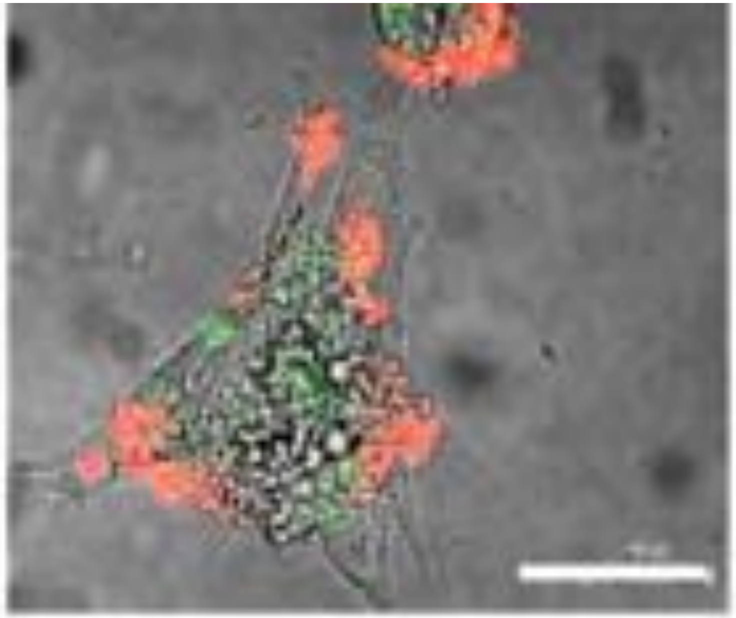
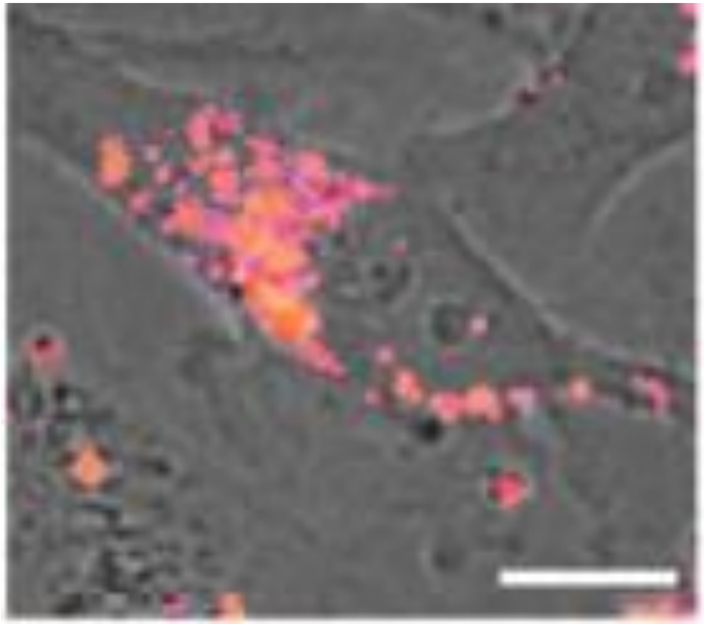
Medical Imaging

C. The quantum dots (QD) can be injected to a subject,   and then be detected by exciting them to emit light



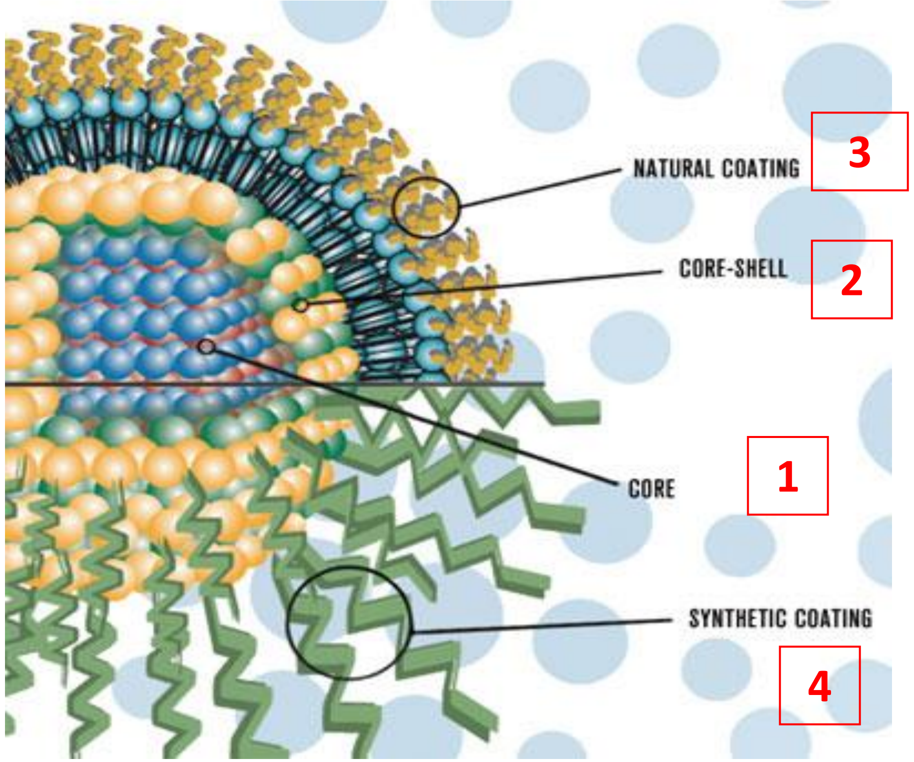


Imaging of QD's targeted on cellular structures

Nano Letters 2008., Vol. 8, pp3887-3892

A Quantum Dot Nanoparticle

A. The quantum dot itself (the semiconductor nanoparticle) is toxic. Therefore some typical modifications has to be made for it to become biocompatible.



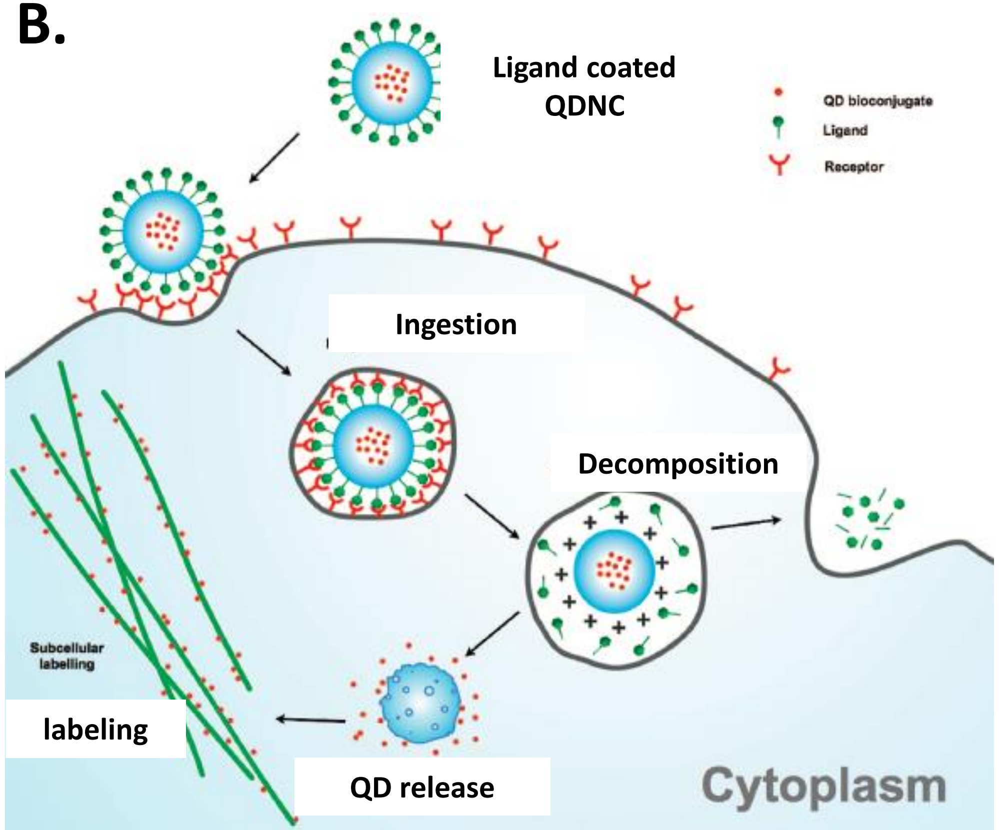
1) **The core consist of the semiconductor material that emits lights**
2) **The shell consist of an insulator material that protects the light emitting properties of the QD in the upcoming functionalization**
3) **The shell is functionalized with a biocompatible material such as PEG or a lipid layer**
4) **Additional functionalization can be done with several purposes (e.g. embed a drug for drug delivery, or assemble an antibody to become the QD target-specific**

Source: The scientist (2005), Vol. 19, p. 35

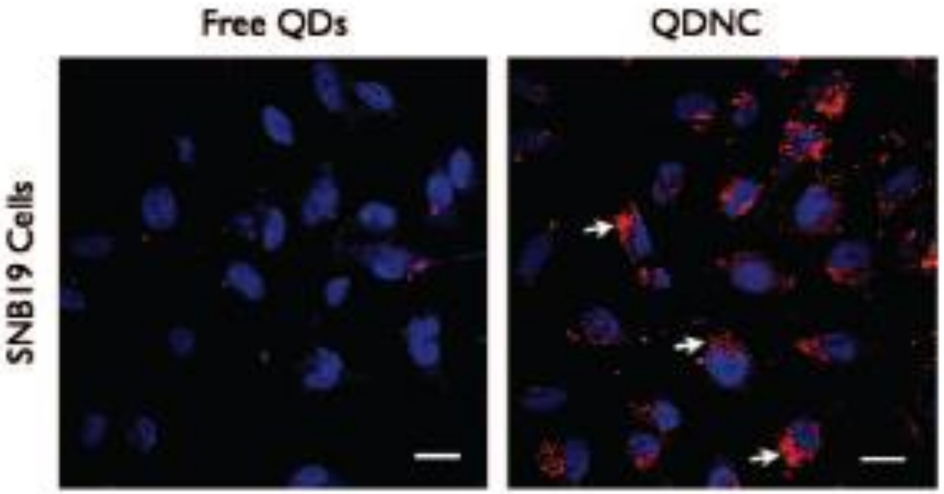
Targeting QD's for intracellular imaging

A. Using a drug-delivery-like mechanism, a targeted lipid-based nanoparticle (TNP) encapsulating QD's specifically 'attacks' a cell having the receptors that pair with its ligand coating. Upon ingestion and destruction of the TNP, the QD's are set free and accumulate on intracellular structures

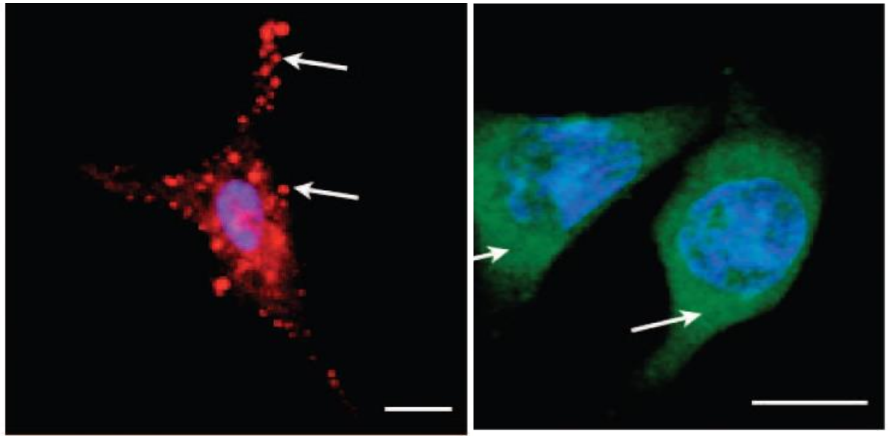
B.



Targeting QD's for intracellular imaging



C. *QD (red)intracellular uptake is enhanced when using the QDNC instead of the free QD's*



D. *Imaging of nucleus (blue) and cytoplasm (other) after 30 min (left) and 3 hours after uptake*

Nano Letters 2008., Vol. 8, pp3887-3892

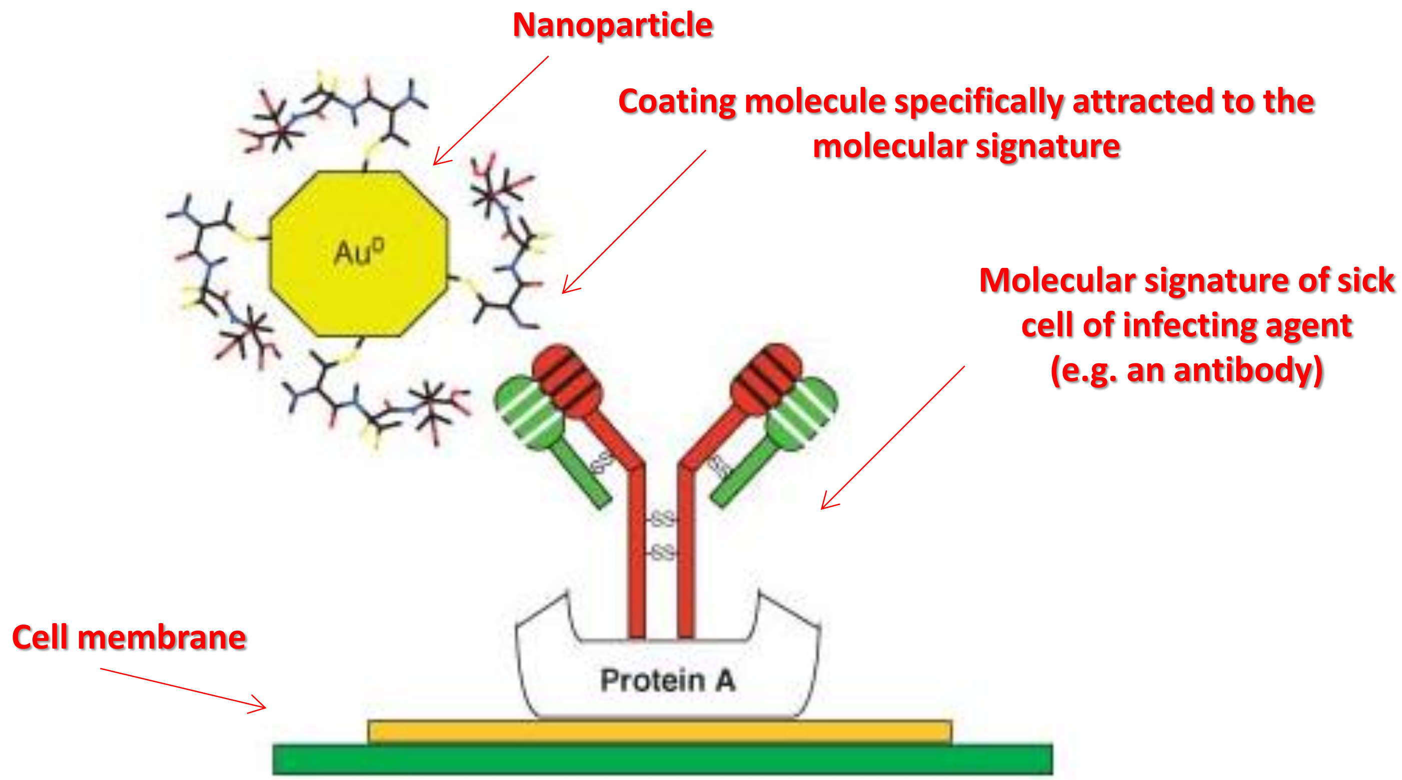
Diagnosis and Sensing

A. Diseases can be diagnosed through the (simultaneous) detection of a (set of) biomolecule(s) characteristic to a specific disease type and stage (biomarker).

Diagnosis and Sensing

B. Each cell type has unique molecular signatures that differentiate healthy and sick tissues. Similarly, an infection can be diagnosed by detecting the distinctive molecular signature of the infecting agent

C. A nanoparticle can be functionalized in such a way that specifically targets a biomarker. Thus, the detection of the nanoparticle is linked to the detection of the biomarker, and to the diagnosis of a disease



Huffman, Nanomedicine and Nanobiotechnology, Vol. 1, 1, 2009

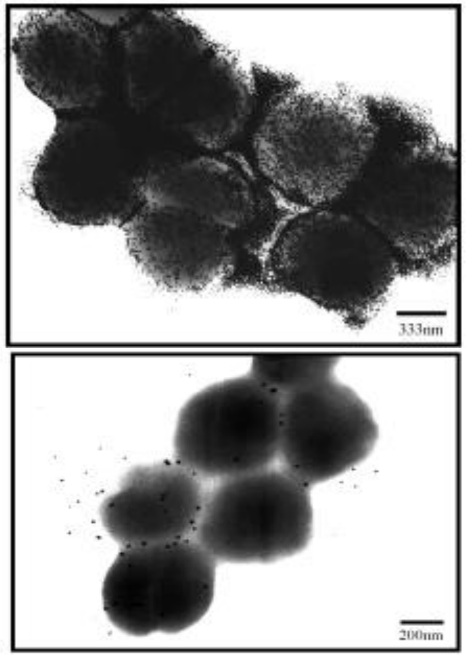
Nanoparticles in action

A. Modifying a ferromagnetic nanoparticle with human immunoglobulin G (IgC), which specifically binds the protein A in the cellular wall of *staphylococcus*, the bacteria can be detected through a MRI test

B.

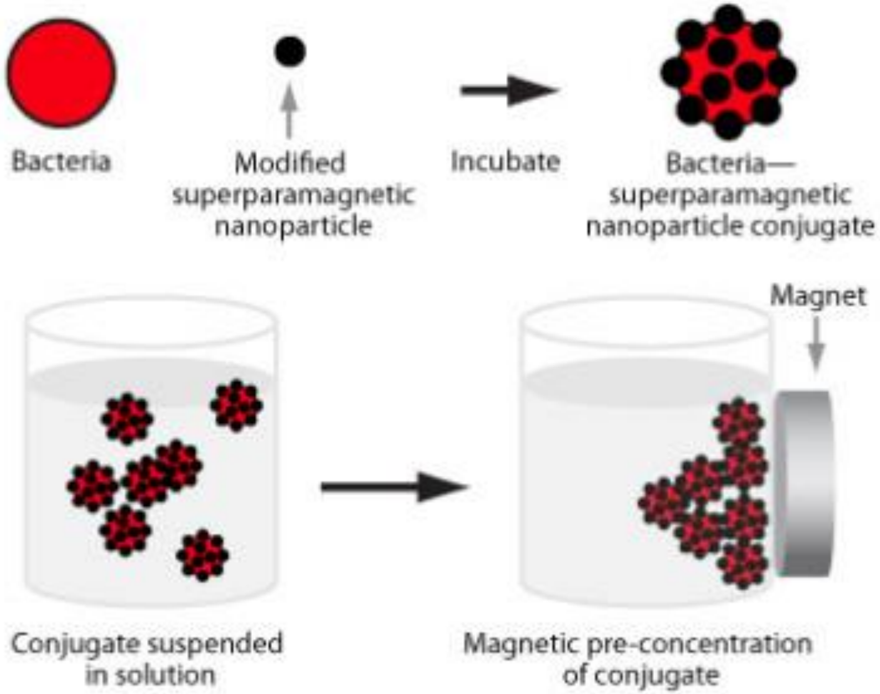
Accumulation of functionalized ferromagnetic nanoparticles on staphylococcus

Negligible accumulation of nanoparticles in absence of functionalization



Analytical Chemistry 2004, Vol. 76, pp.7162-7168

C.



Directed accumulation of dangerous bacteria by conjugation with functionalized magnetic nanoparticles

National Research Council, Canada

Therapy

A. Nanometer-sized particles are particularly responsive to electromagnetic and acoustic excitations through a variety of phenomena (e.g. plasmon resonance) that lead to local extreme conditions (e.g. heating). The nanoparticle is able to tolerate this condition, but no so the biological material nearby

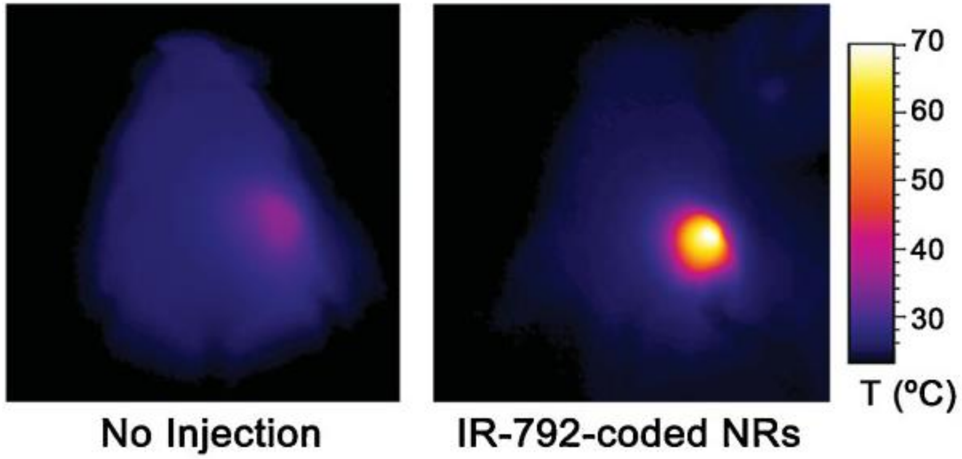
Therapy

B. Intramuscular injections of colloidal gold, a suspension of gold nanoparticles, has been used for decades to alleviate pain linked to rheumatoid arthritis. The mechanism is still unknown

Colloidal gold

Source: John Hopkins Center

C.



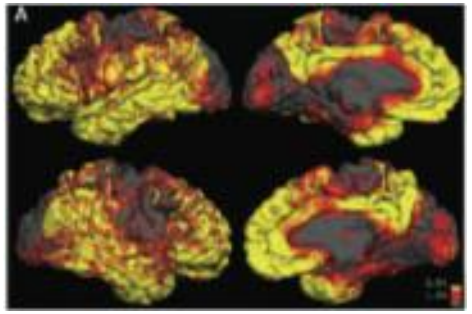
An infrared beam illuminates two mice specimens. The local temperature increases for the mouse that received and injection of gold nanorods.

Adv. Mater. 2009, 21, 3175–3180

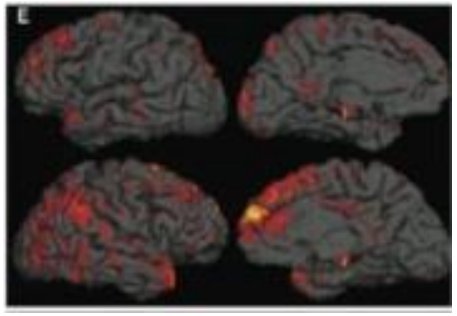
Gold Nanoparticles vs. Alzheimer

A. Alzheimer and other degenerative diseases are caused my the clustering of amyloidal beta (*Aβ*) protein.

B.

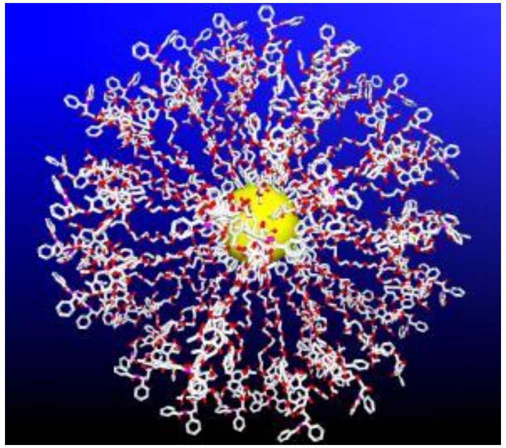


Alzheimer's brain

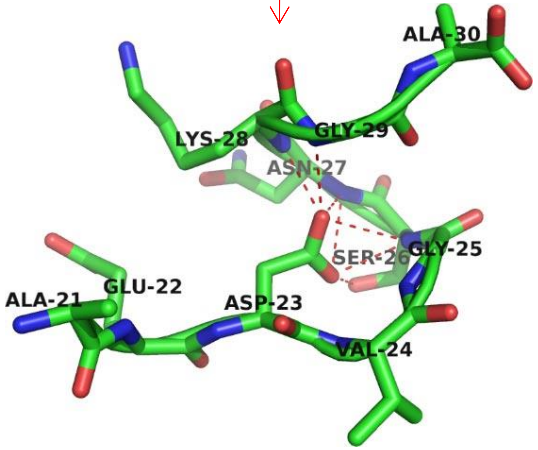


Healthy brain

C.



Functionalized nanoparticle



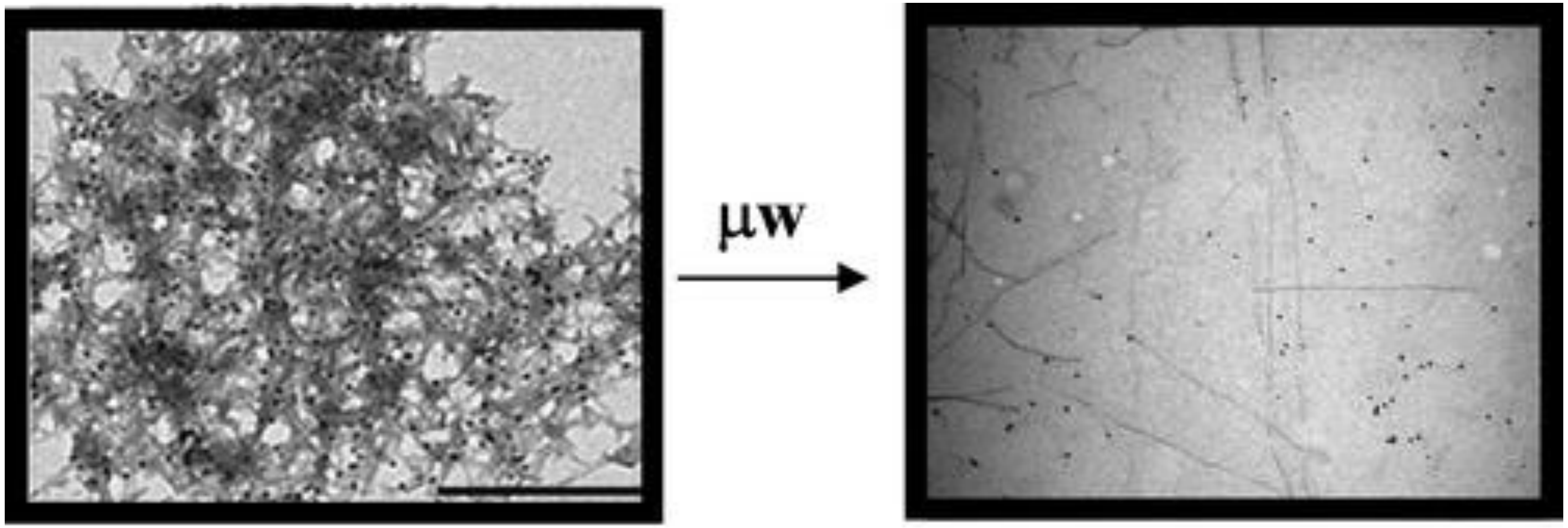
Chemical structure of Aβ-protein

D. Gold nanoparticles can be functionalized to specifically attach to aggregates of this protein (amyloidosis)

Nanogentools confidential

Gold Nanoparticles vs. Alzheimer

A. The functionalized gold nanoparticles selectively attach to the aggregate of amyloidal protein. The microwaves of certain frequency are irradiated on the sample. Resonance with the gold nanoparticles increases the local temperature and destroy the aggregate



Before irradiation *After irradiation*

Nanoletters 2006, Vol. 6, pp.110-115

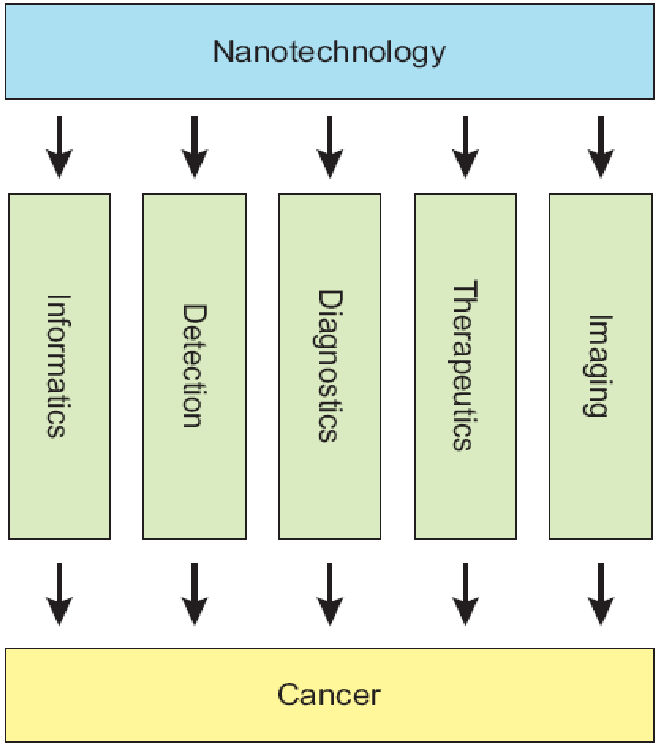
SECTION II

Nanotechnology potential in medicine

Cancer Nanotechnology

A. It is an interdisciplinary area merging science, engineering and medicine with the sole purpose of provide humanity new tools to fight cancer

B.



C.

PREMISE

Cancer nanotechnology, as a particular area of nanomedicine, is based upon the same premise that nanoparticles display unique properties potentially useful in medical (oncological) applications.

Nanoparticles in the size range of 5-100nm have enough surface area to be properly functionalized to bind specific targets, with a variety of ulterior purposes

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Cancer Facts

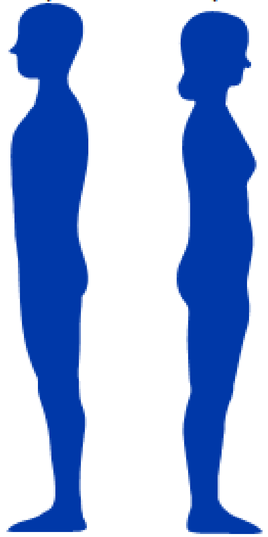
US Mortality, 2006

Rank	Cause of Death	No. of deaths	% of all deaths
1.	Heart Diseases	631,636	26.0
2.	**Cancer**	**559,888**	**23.1**
3.	Cerebrovascular diseases	137,119	5.7
4.	Chronic lower respiratory diseases	124,583	5.1
5.	Accidents (unintentional injuries)	121,599	5.0
6.	Diabetes mellitus	72,449	3.0
7.	Alzheimer disease	72,432	3.0
8.	Influenza & pneumonia	56,326	2.3
9.	Nephritis*	45,344	1.9
10.	Septicemia	34,234	1.4

A. The second main cause of death in the US, and certainly the diseases that lower the life quality of the patient the most

2009 Estimated US Cancer Deaths*

Men 292,540	
Lung & bronchus	30%
Prostate	9%
Colon & rectum	9%
Pancreas	6%
Leukemia	4%
Liver & intrahepatic bile duct	4%
Esophagus	4%
Urinary bladder	3%
Non-Hodgkin lymphoma	3%
Kidney & renal pelvis	3%
All other sites	25%



Women 269,800	
26%	Lung & bronchus
15%	Breast
9%	Colon & rectum
6%	Pancreas
5%	Ovary
4%	Non-Hodgkin lymphoma
3%	Leukemia
3%	Uterine corpus
2%	Liver & intrahepatic bile duct
2%	Brain/ONS
25%	All other sites

B. Lung cancer is the overwhelming lead cause of cancer-related deaths.
BEWARE SMOKERS!!!!

Motivation

NANOGENTOOLS

DIAGNOSIS

A. The only factor that really correlates to the patient survival is early cancer detection

Motivation

NANOGENTOOLS

THERAPY

B. Chemotherapy and radiotherapy kill healthy and sick cells indiscriminately

Motivation

NANOGENTOOLS

IMAGING

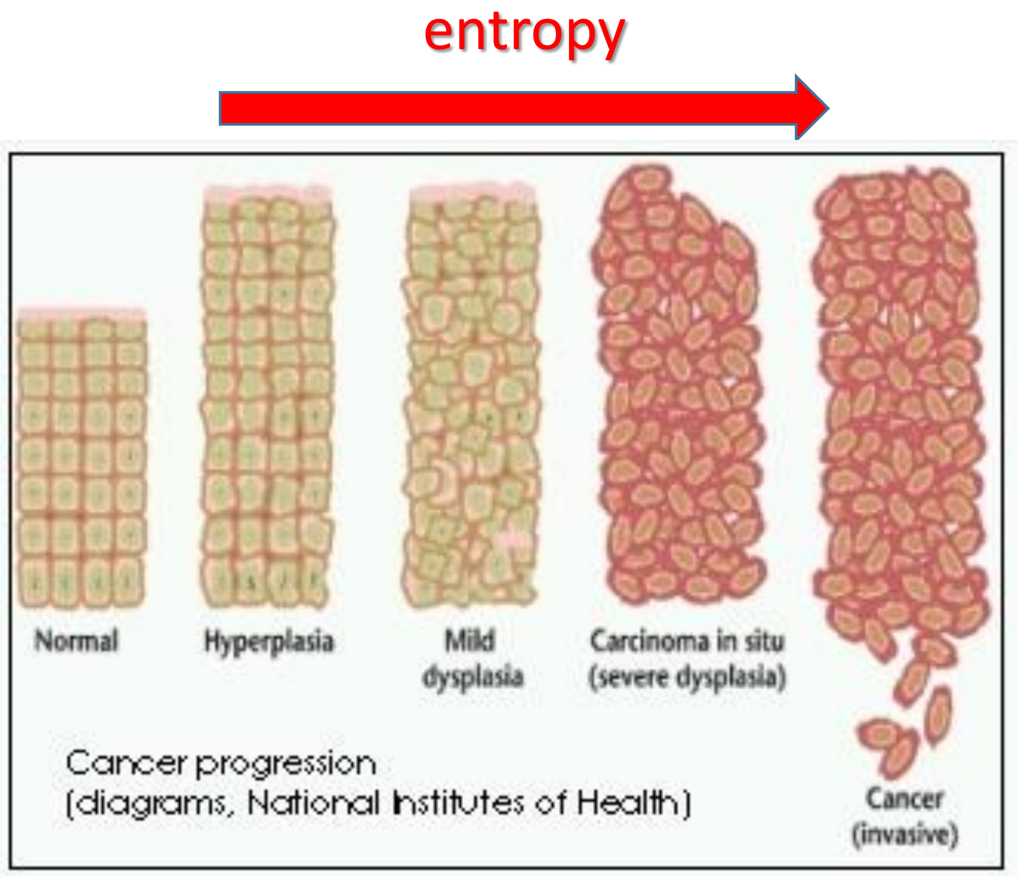
C. Cancer resurgence after surgery occurs due to failure to recognize and remove all cancerous colonies

Cancer: Too complex to handle?

A. If you are an engineer, you can think of cancer as a living organism finally succumbing to entropy. Therefore, cancer is not one disease but million of diseases characterized by the disordered an uncontrolled growth of cells

Cancer: Too complex to handle?

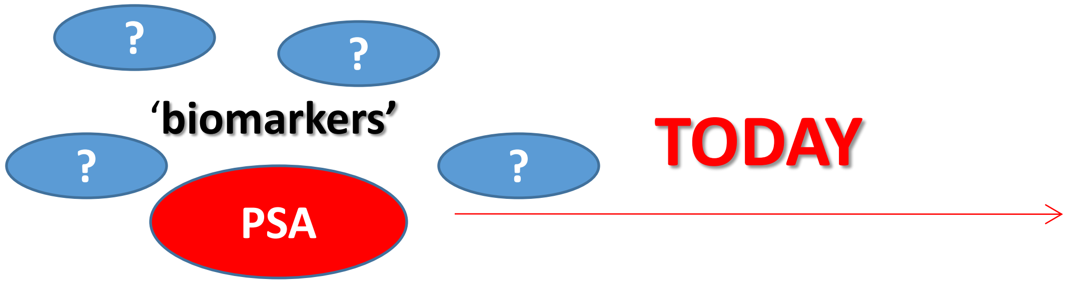
NANOGENTOOLS



C. There are a myriad of metabolic/biological events that can unleash the growth of cancer cells. We must completely understand all the complex biochemistry of cancer to improve both diagnosis and treatment

D. The key is full 'biomarker' characterization of a different types of cancer

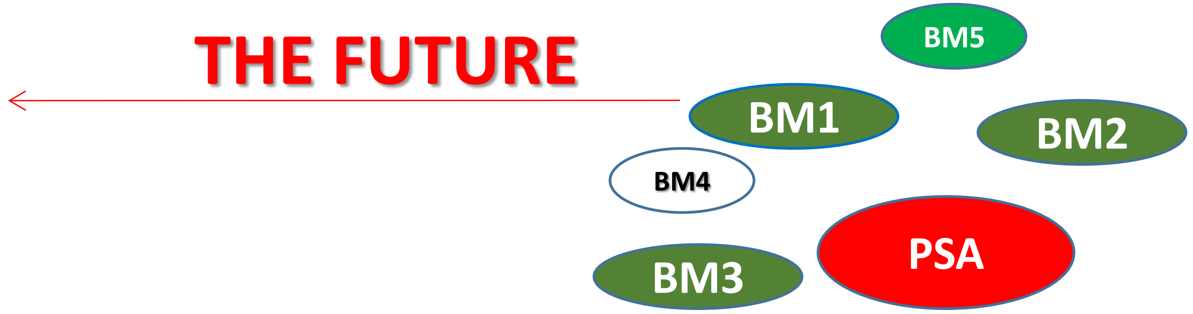
Biomarker Research Status



Hmmm!! I see you have abnormal PSA levels. You might have some problems in your prostate.
We must check for cancer

Biomarker Research Status

Oh!! You have abnormal PSA levels. Also, your levels of BM1, BM2, BM3 are off, and BM4 levels are subnormal. You are starting to develop prostate cancer of the A phenotype. But don't worry your BM5 is fine, so metastasis hasn't occurred yet. Let's start treatment



Nanoprobes: The usual suspects

NANOGENTOOLS

Quantum Dots

Gold Nanoparticles

functionalized to achieve biocompatibility and cell targeting

Nanorods

Nanotubes

Liposomes

Polymeric Nanoparticles

Therapy

NANOGENTOOLS

A. There is a search dual-mode nanoparticle that can detect a tumor (imaging) and destroy it (therapy)

B. There is two action modes for therapeutical nanoparticles

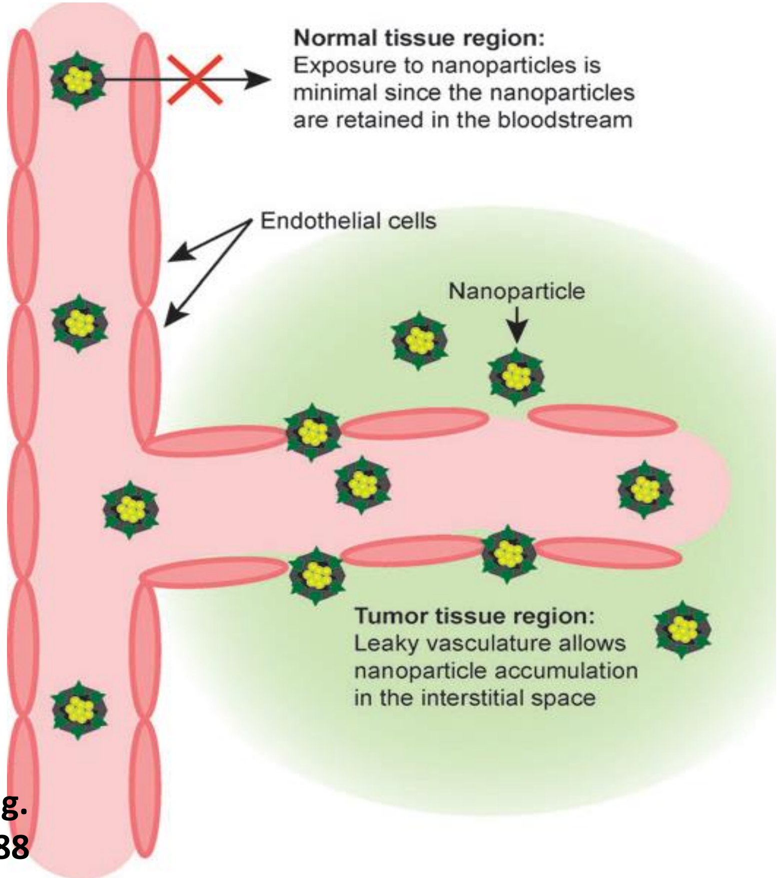
Passive Targeting

Based on retention effect of particle of certain hydrodynamic size in cancerous tissues

Active Targeting

Based on nanoparticle functionalization for specific targeting of cancerous cells

Taking advantage of retention



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A. Tumorous tissues suffer of Enhanced Permeability and Retention effect

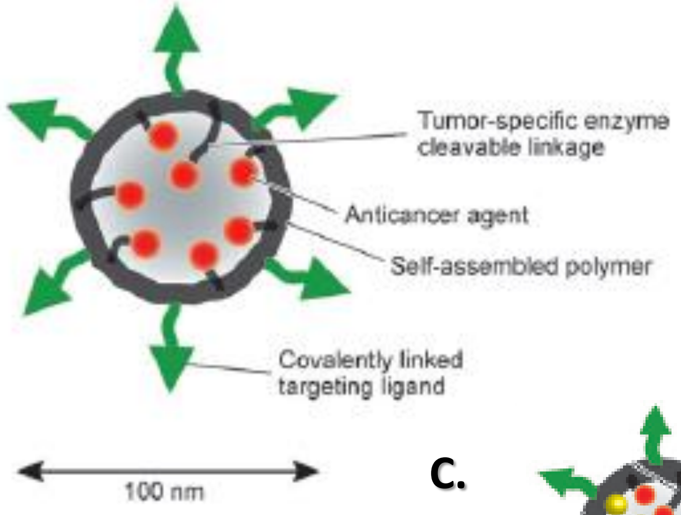
B. Nanoparticles injected in the blood stream do not permeate through healthy tissues

C. Blood vessels in the surrounding of tumorous tissues are defective and porous

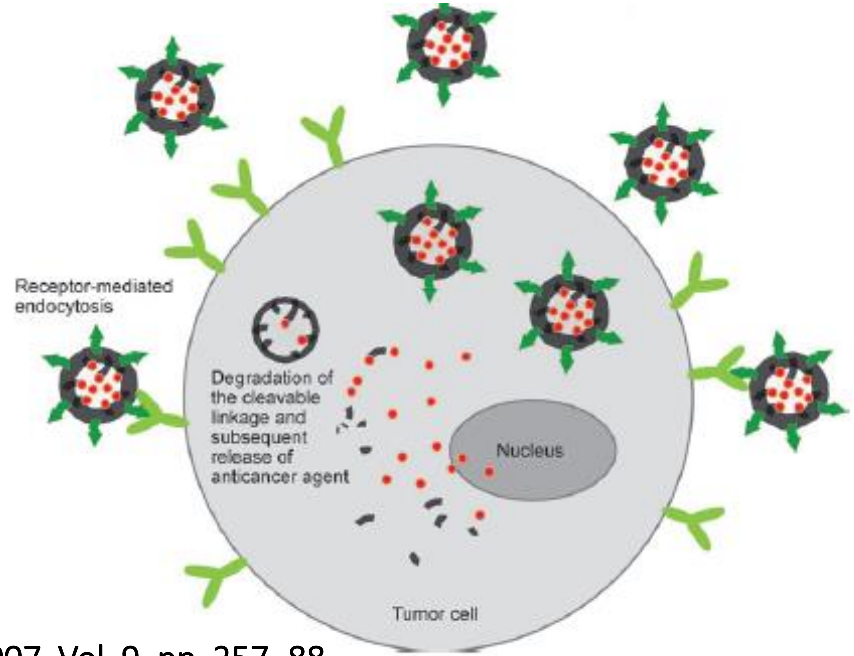
D. Nanoparticles injected in the blood permeate through blood vessels toward tumorous tissues, wherein they accumulate

A Targeted Polymer Nanoparticle

A. A dual Nanoparticle, the targeting ligand allow it to diagnose if a cell is healthy or sick, and bind specifically to the tumorous cell

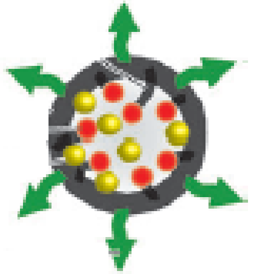


B. Once inside the cell, the polymeric nanoparticle degrades and the anticancer agent is set free



C.

Imaging agent



An imaging agent can be added as well

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SECTION III

Promising work

What are the most promising fields of nanomedicine?

- Principles of nanomedicine, including basic research and theoretical applications
- Nanotechnological advances and their potential medical applications
- Disorders/conditions and the benefits of nanomedical tools versus traditional techniques
- Pre-clinical testing of novel nanomedical tools
- Implanted nanodevices for the prevention and treatment of disease and the alleviation of pain
- Nanomedical tools in gene therapy for inherited diseases
- Tissue, cell and genetic engineering involving nanomedical tools
- Drug delivery using nano-particles (natural and artificial) or devices

Applications of Nanorobots

1. **Drug delivery-** Pharmacytes are the nanorobots designed for the action of drug delivery. The dosage of drug will be loaded into the payload of the pharmacyte. The pharmacyte will be capable of precise transport and targeted delivery of drug to specific cellular targets. The pharmacytes upon arriving at the vicinity of tumor or any target cell would release the drug via nanoinjection or by progressive cytopenetration until the payload delivery is reached.
2. **Body surveillance**: Monitoring continuously of vitals and wireless transmission could be possible using nanorobots, leading to a quantum leap in diagnostics. This would also help in quick response in case of sudden change in vitals, or could warn against a possibile risk, such as high blood glucose in case of diabetics.
3. **Dentistry**- The nanorobots designed for dental treatment are referred to as dentifrobots. These nanorobots can induce oral analgesia, desensitize tooth, manipulate the tissues to realign and straighten irregular set of teeth .

Applications of Nanorobots

4. **In surgery-** The surgical programmed nanorobot can act as a semi-autonomous onsite surgeon inside the body. It would perform various functions such as detection of pathology, diagnosing, correcting lesions by nano-manipulation coordinated by an on-board computer.

5. **Cancer detection and treatment-** The nanorobots are made with a mixture of polymer and a protein known as transferrin which is capable of detecting tumor cells. The nanorobots would consist of embedded chemical biosensor that can be used in detection of tumor. The medical nanorobots with chemical biosensors can be programmed to detect different levels of E-cadherin and beta-catenin, aiding in the target identification and drug delivery. The nanorobot could also carry the chemicals employed in chemotherapy to treat the cancer at the site. The robots could either attack tumors directly using lasers, microwaves or ultrasonic signals or as a part of a chemotherapy treatment, delivering medication to the cancer site.

Applications of Nanorobots

6. Diagnosis and treatment of diabetes- The glucose molecules are carried through the blood stream to maintain the human metabolism. The hSGLT3 molecule can define the glucose levels for diabetes patients. The glucose monitoring nanorobot uses the chemo sensor which involves in the modulation of hSGLT3 protein gluco-sensor activity. These chemical sensors can effectively determine the need of insulin in the body and inject.

7. Gene therapy- The medical nanorobot can treat genetic diseases by comparing the molecular structure of both DNA and proteins found in the cell. The chromosome replacement therapy can carried out using chromallocytes

Applications of Nanorobots

8. Delicate surgeries: Nanorobots could be soon used for performing micro surgery of the eye as well as surgeries of the retina and surrounding membranes. In addition, instead of injecting directly into the eye, nanorobots could be injected elsewhere in the body and delivery of the drug can be guided to the eye. Foetal surgery, one of the most risky surgeries today because of the high mortality rate of either the baby or the mother, could soon have a 100% success rate, due to the fact that nanorobots can provide better access to the required area inducing minimal trauma. Similarly, other difficult surgeries could also benefit from advances in nanorobotics

SECTION IV

Assesment

What have we learned?

NANOGENTOOLS

- Nanoparticles have very special properties that make them attractive for nanomedicine
- Nanoparticles can be functionalized with antibodies to target their binding toward specific cells
- Nanoparticles can be used in diagnosis through the detection of biomarkers

What have we learned?

NANOGENTOOLS

- Nanoparticles can respond to external radiation and release heat, killing cells around them
- Nanoparticles can be made of lipids or polymers than decompose once a target is reached and deliver a pharmaceutical agent
- Quantum dots are special nanoparticles that emit light of different colors according to its diameter, and can be used for complex diagnosis

What have we learned?

NANOGENTOOLS

- PEG is the most used polymer to coat nanoparticles due to the biocompatibility and biomobility that confers to the nanoparticle
- Targeted nanoparticles offer a light of hope for the fight against cancer
- An ideal nanoparticle is **three-modal**: *detects*, *diagnoses* and *attacks* tumorous cells

Unsolved issues

Long-term toxicity

Signal penetration

Biomarkers library

3-D spatial resolution

Success in human trials

Challenges

- Multiple modality and functional nanoparticles
- Fight against the tendency of nanoparticles to be adsorbed by reticuloendothelial system
- Avoid aggregation of nanoparticles for in vivo viability
- Improve retention times of the nanoparticles inside the body to allow the therapeutic effect
- Substitute potentially toxic elements

Challenges

- Compromise between coating and hydrodynamic radius
- Eliminate the inflammatory and immune response triggered by some polymer coatings
- Avoid undesired degradation exposing toxic elements (QD) or untimely delivering cargo
- Increase contrast for human medical imaging (tissues are naturally fluorescent)

Challenges

- Real-time monitoring of drug distribution, action mechanism and patient's response
- Fast detection of biomarkers at lower limits
- Understanding the mechanism of diseases (cancer)
- Diagnosis leading to personalized treatments
- Detection of deep tumors
- Selective targeting in extremely heterogeneous tissues.


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Thank you!

NANOGENTOOLS

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