

Nanotechnology today: where we are and challenges

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Laboratorio de Microscopias Avanzadas (LMA)**



<http://ina.unizar.es>

Jaca 2013



The world of the nanoscale: The nanoscience



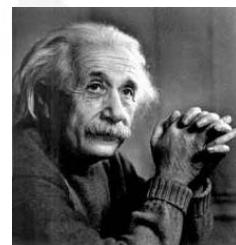
THE QUANTUM ERA



J.J. Thomson discover the electron (1897)



M. Planck quantification of the thermal radiation (1918)



A. Einstein Photon as quantum of energy
(1920)



L De Broglie Electrons are waves
(1929)



W. Heisemberg Bases
of quantum
mechanics (1932)



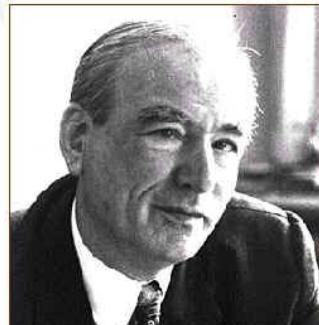
THE MICROSCOPY



Optical microscopy

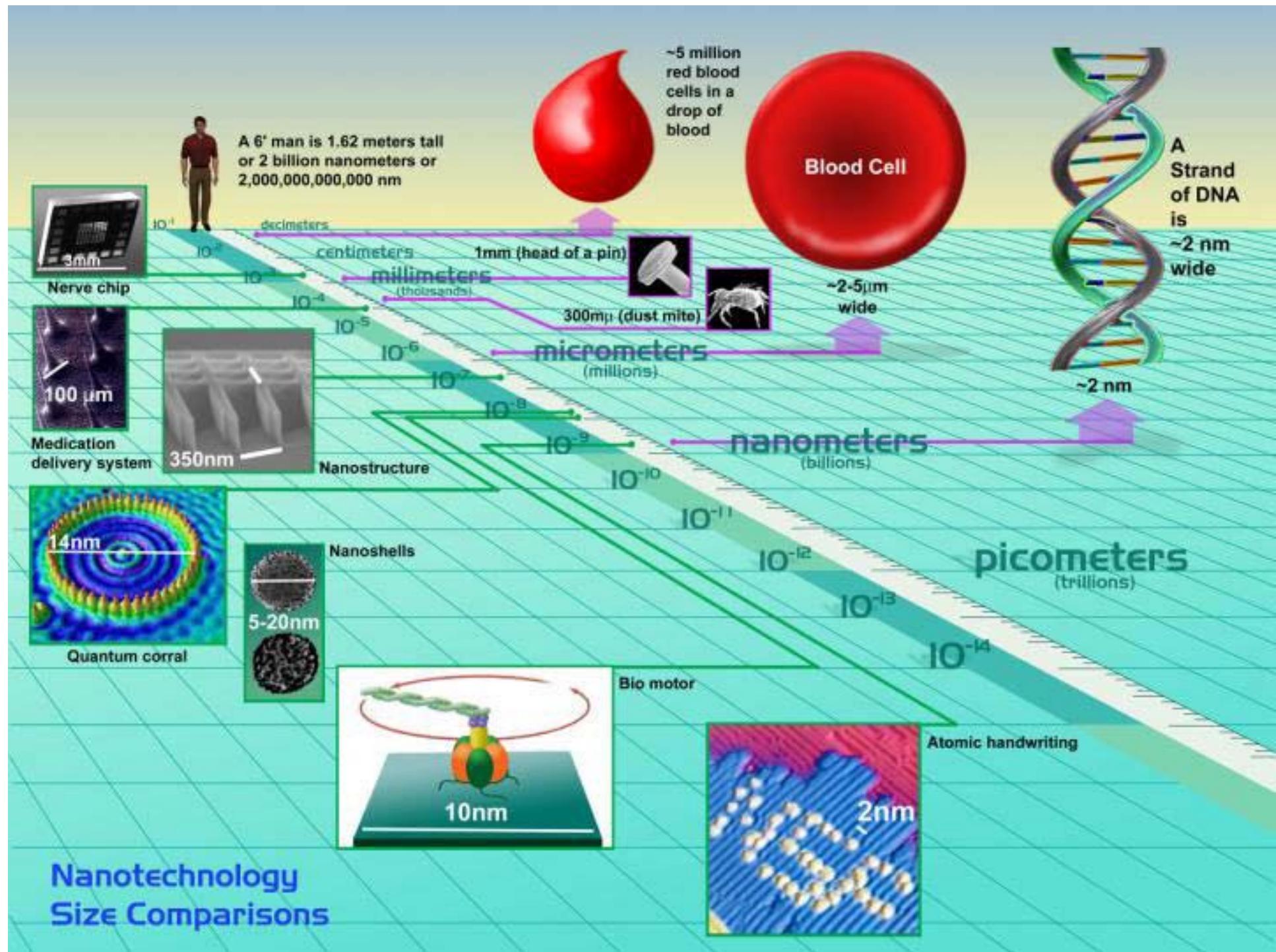


Electron microscopy
(Ruska 1933)



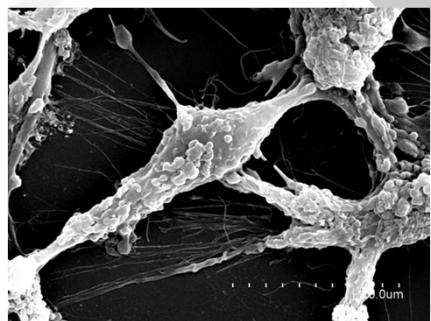
Scanning Tunnel microscopy
(G. Binning & H. Rohrer 1986)



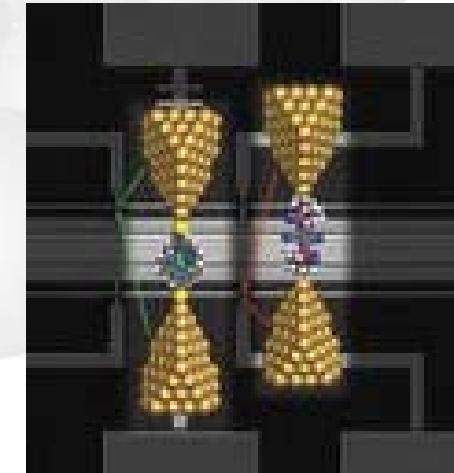




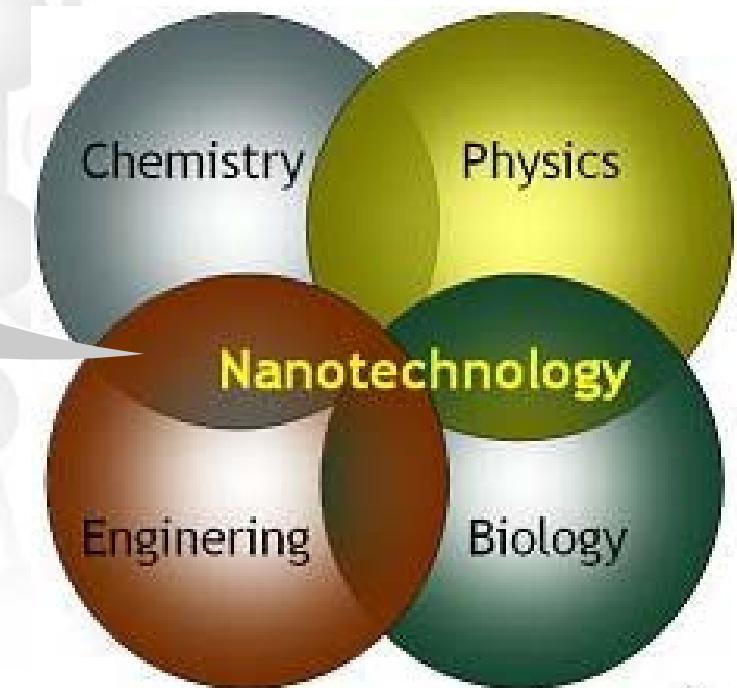
Therapy & Diagnosis



Living organisms



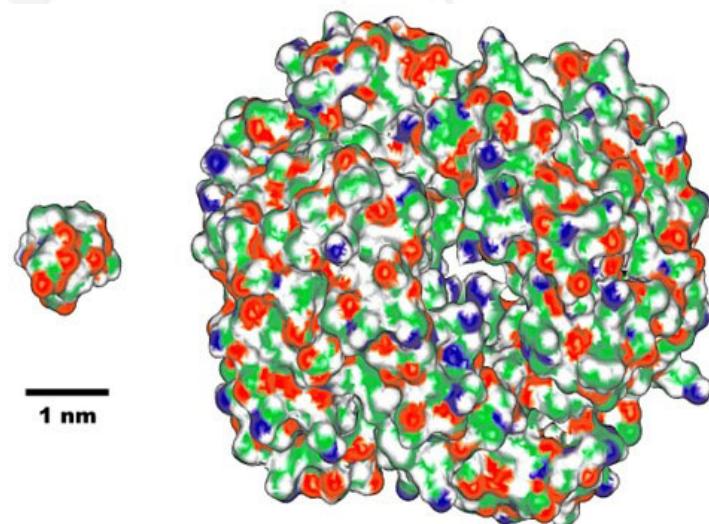
Inert matter



30 nm → 5% atoms surf.

10 nm → 20% atoms surf.

3 nm → 50% atoms surf.



**Aminoacids complex
(chignolin)**



**Human
Hemoglobin
protein**

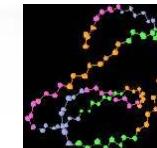
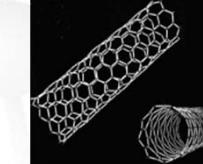
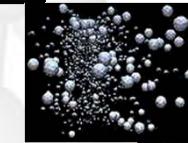
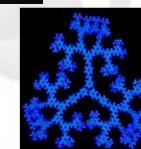
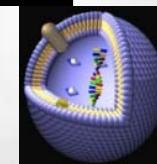
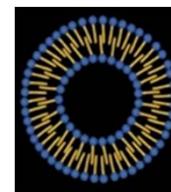
TABLE 2.1 The relation between the total number of atoms in full shell clusters and the percentage of surface atoms

Full-shell Clusters	Total Number of Atoms	Surface Atoms (%)
1 Shell	13	92
2 Shells	55	76
3 Shells	147	63
4 Shells	309	52
5 Shells	561	45
7 Shells	1415	35

Illustrations of full-shell clusters for 1, 2, 3, 4, 5, and 7 shells, showing increasing size and complexity. The clusters are represented as spheres packed in a hexagonal close-packed arrangement.

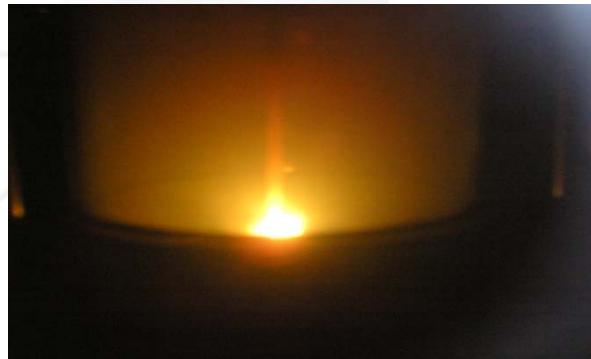
Nanovehicles for drug delivery

- *Micelles*
- *Liposomes*
- *Dendrimers*
- *Nanoparticles*
- *Nanotubes*
- *Complex polymers*

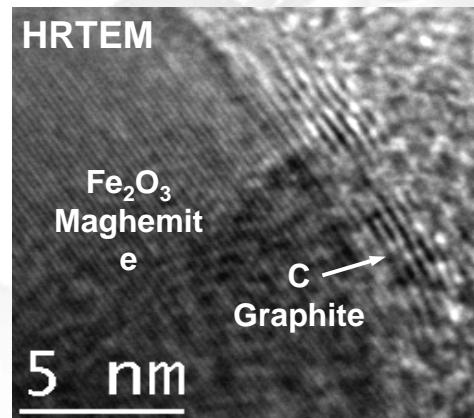
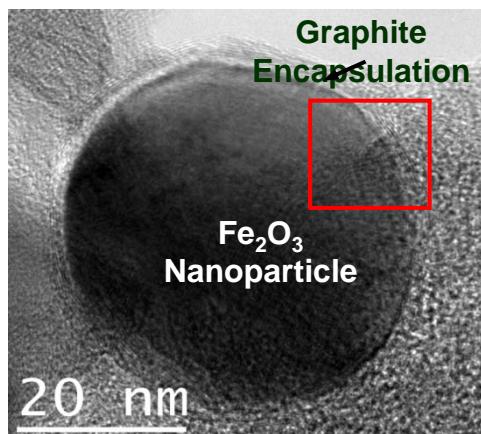


NANOPARTICLES

Physical methods



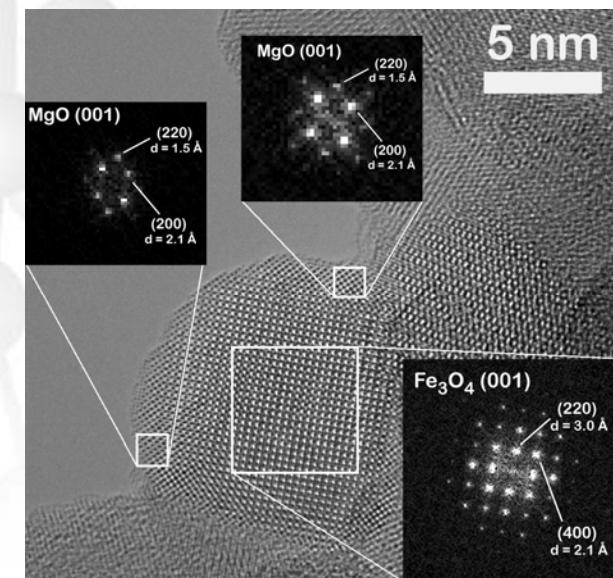
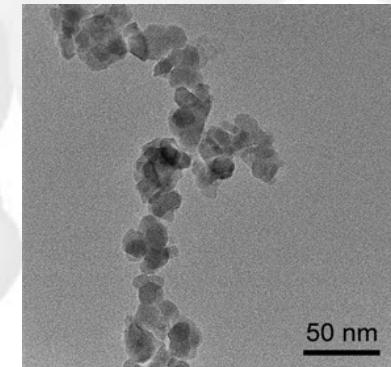
Plasma Krästchmer-Hoffman



FexOy @ C



Chemical Synthesis



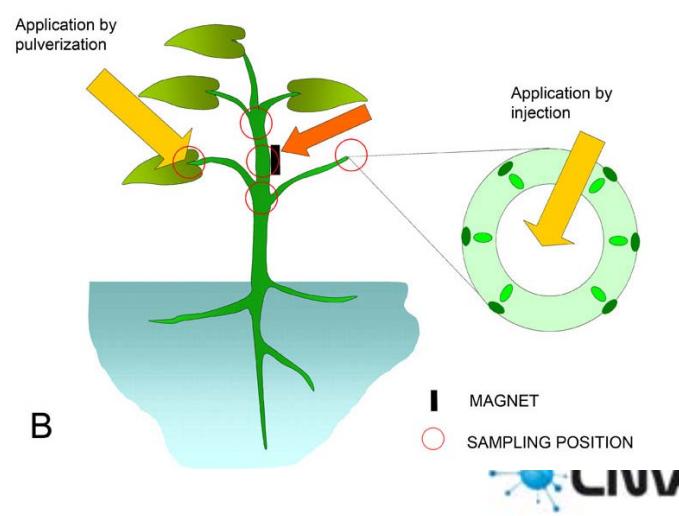
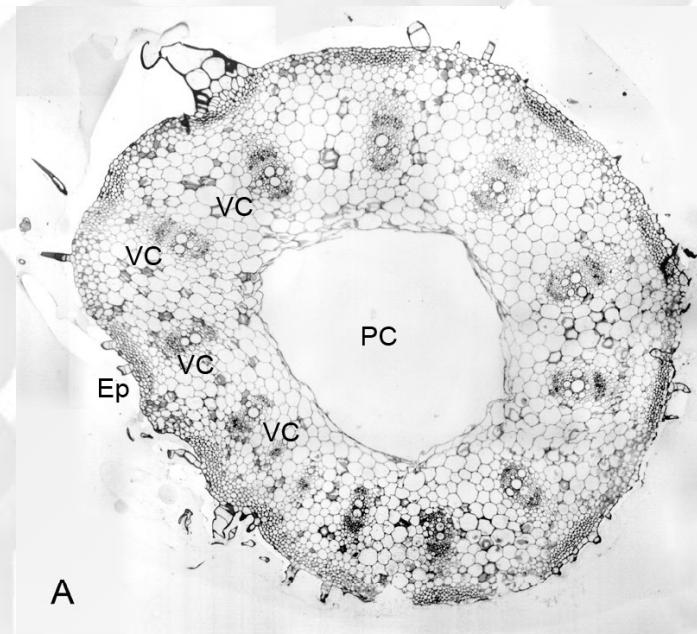
Fe₃O₄ @ MgO



MRI TOMOGRAPHY

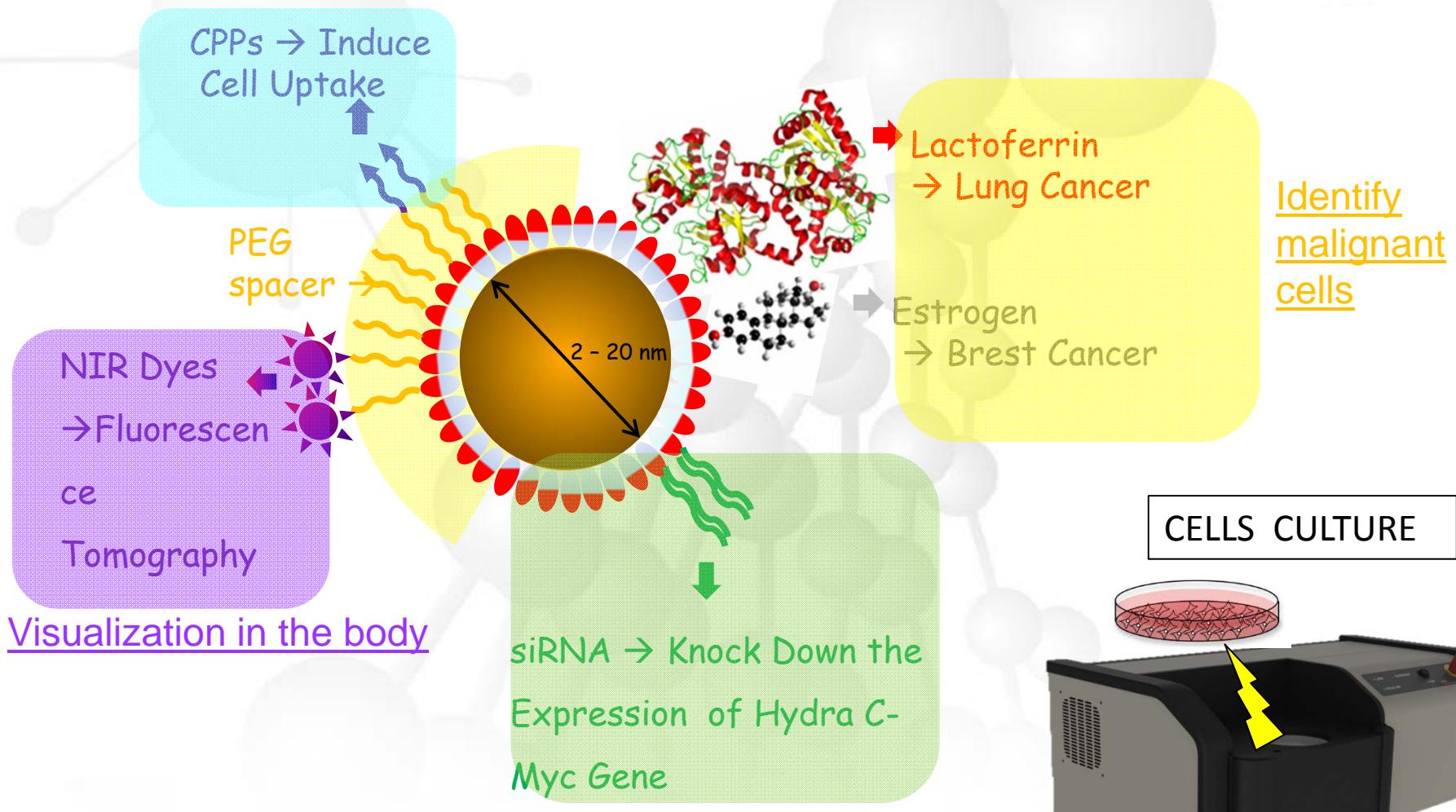


MAGNETIC TARGETING IN PLANTS

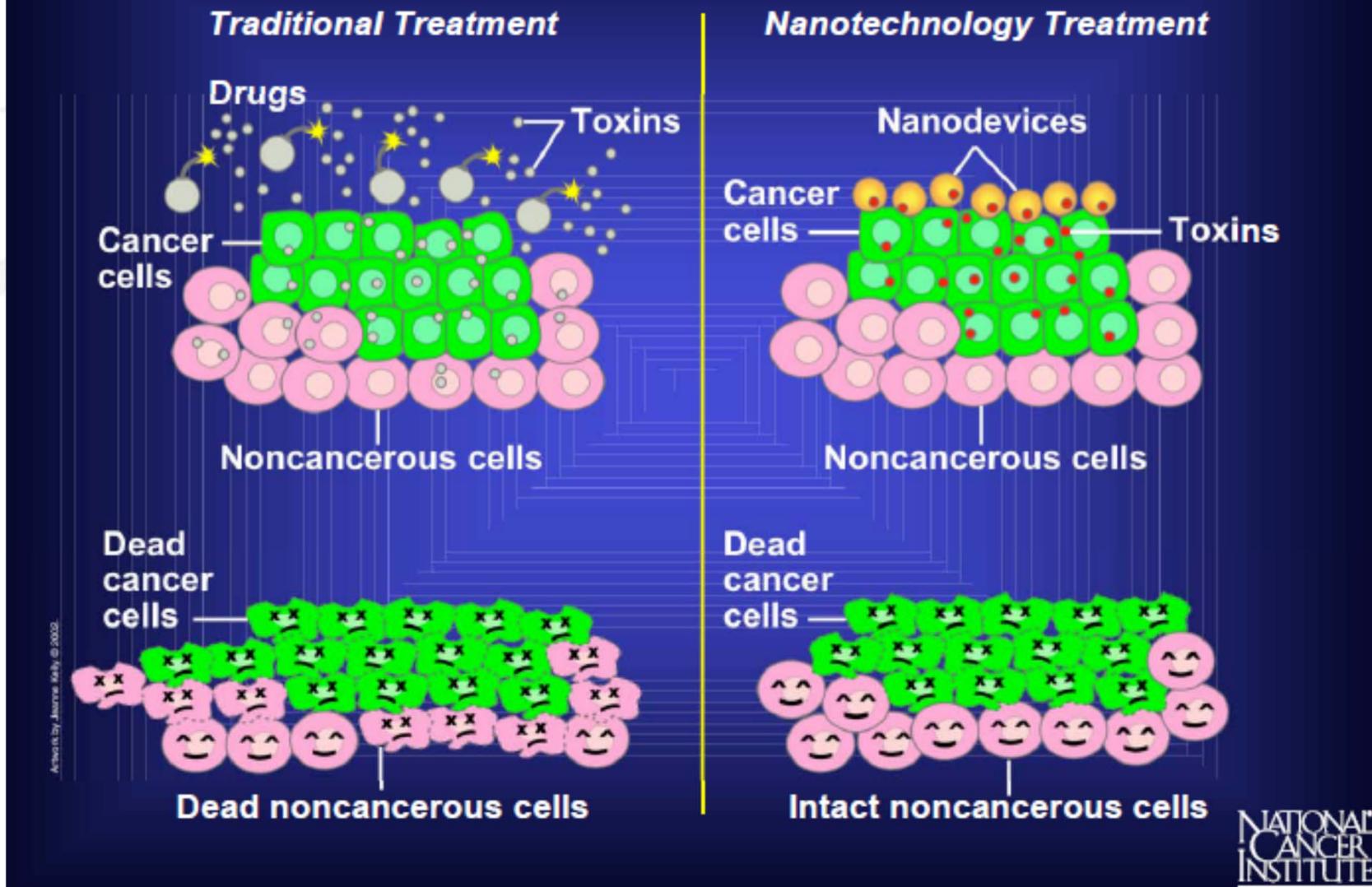


Multifunctional Nanoparticles

Cell internalization



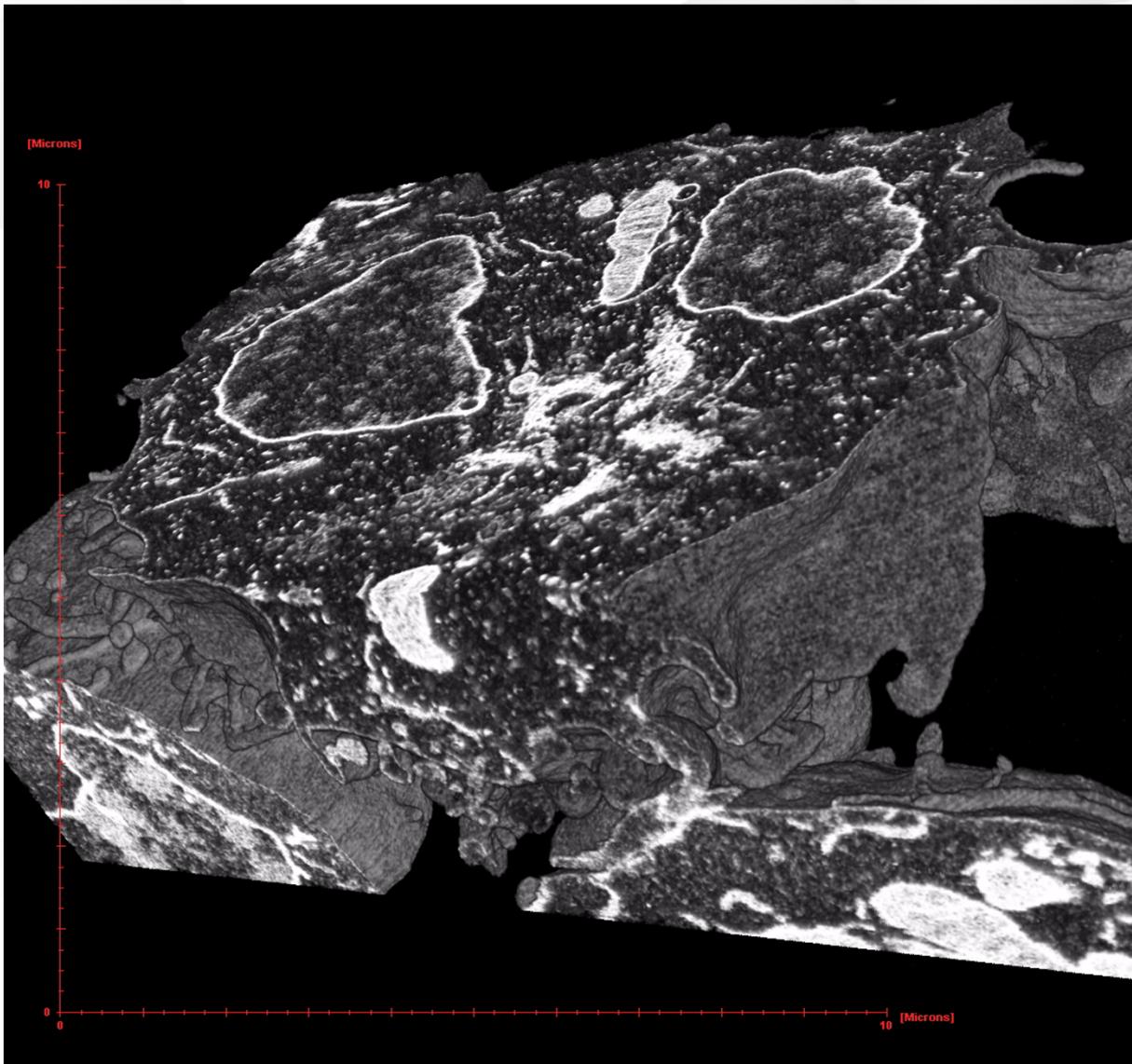
Improving Cancer Treatment



NATIONAL
CANCER
INSTITUTE

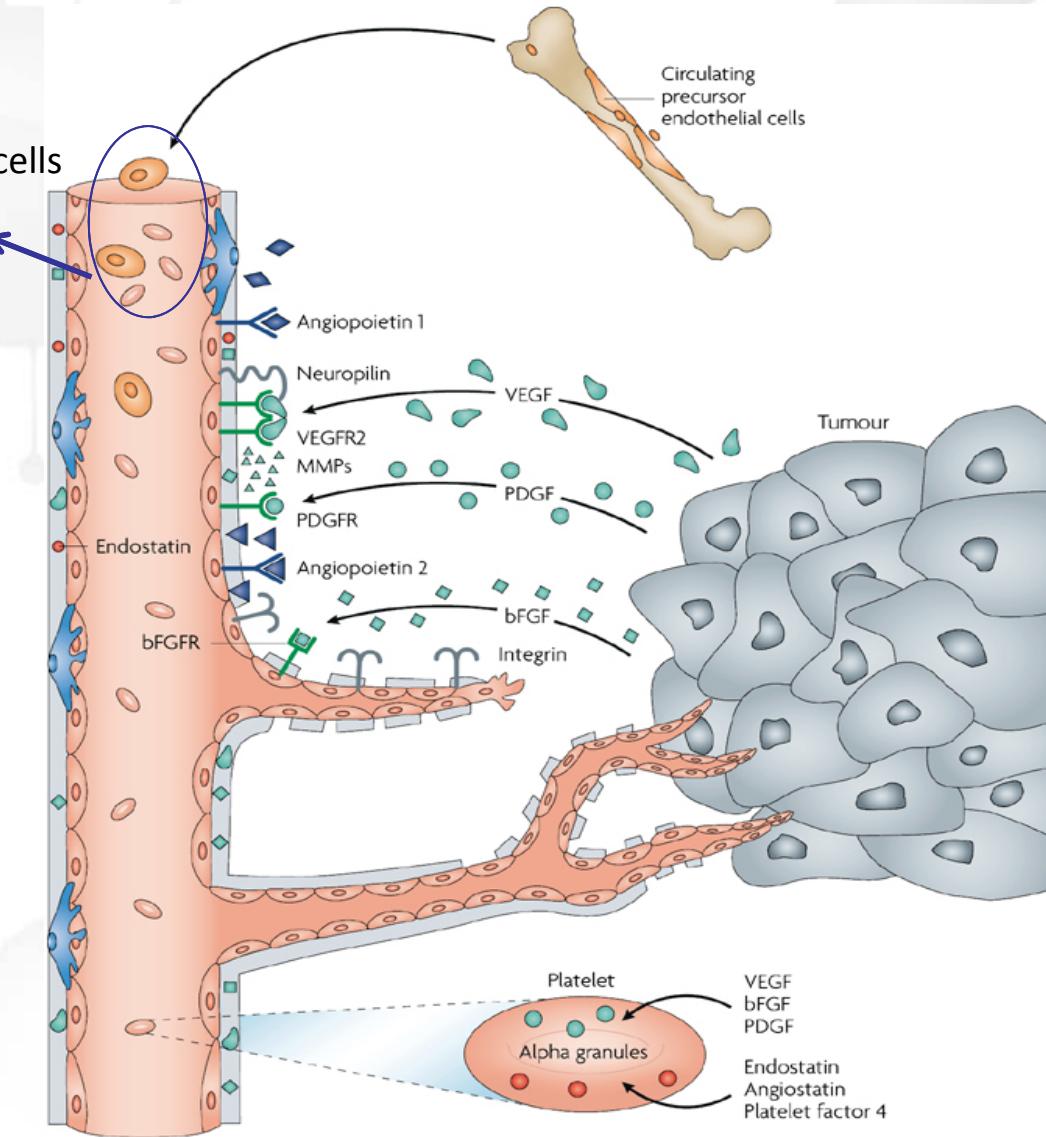


Dual Beam tomography of a dendritic cell



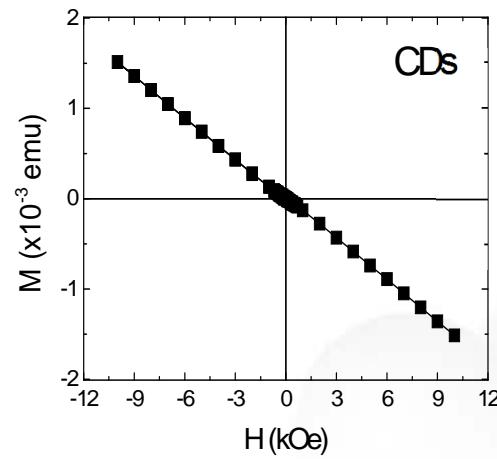
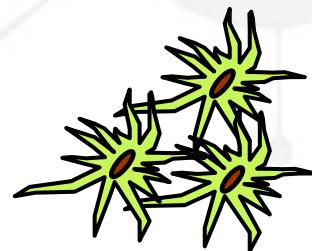
Cells vehicles: Dendritic cells in tumors

Among these cells there are DCs

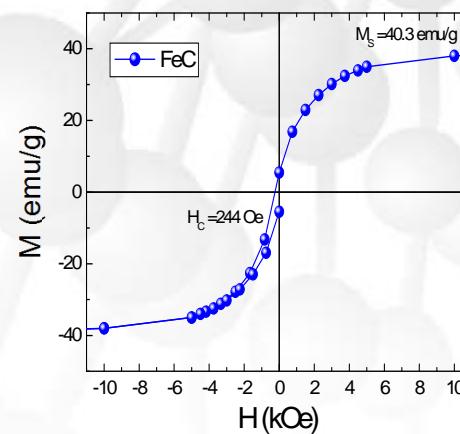


MAGNETIC CELLS

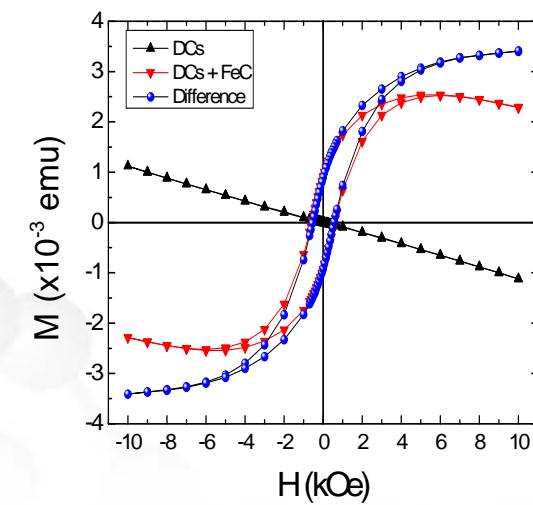
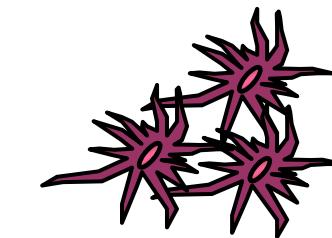
Dendritic cells



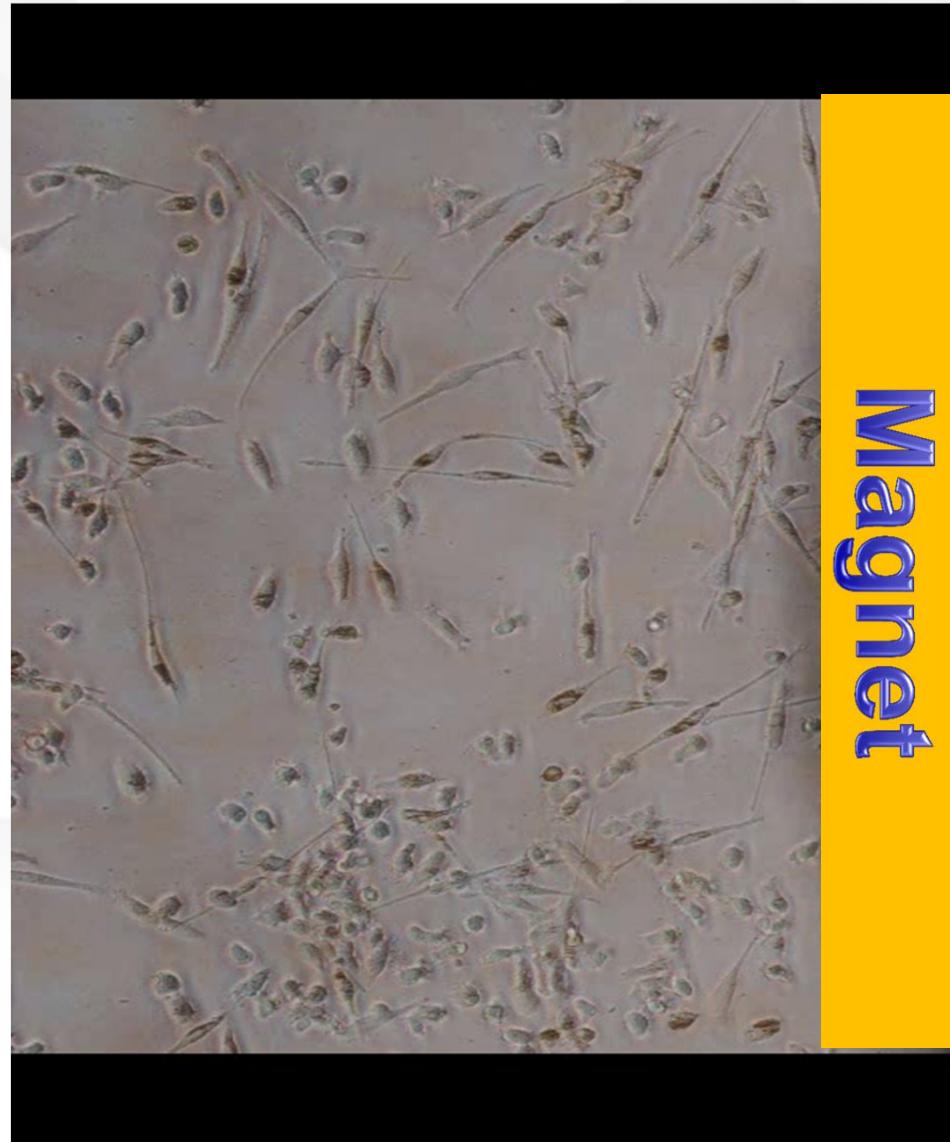
Magnetic colloid



Magnetic cells



Magnetic dendritic cells

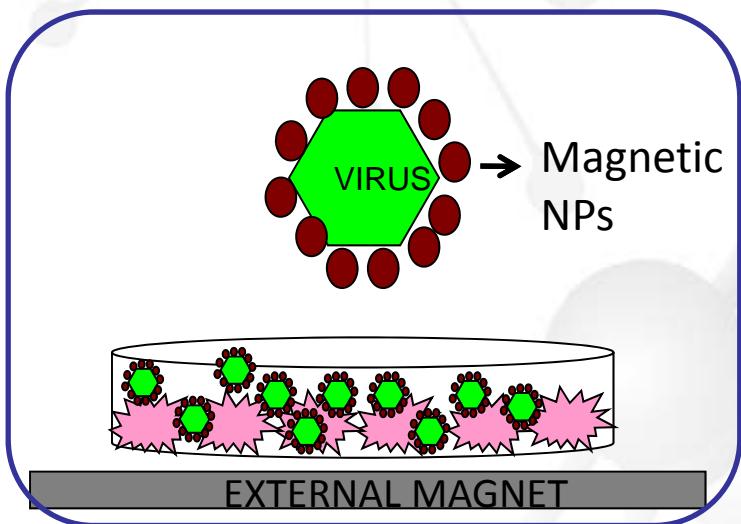


Magnet

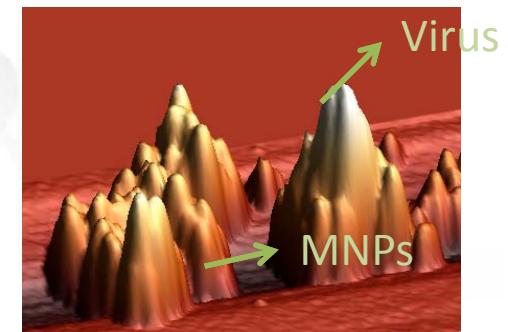
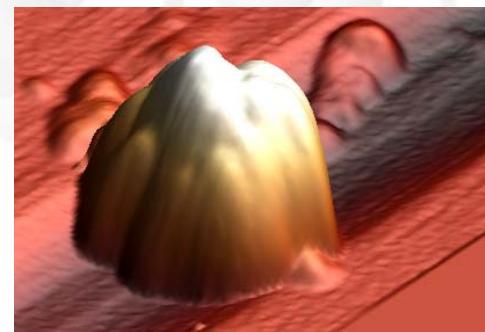
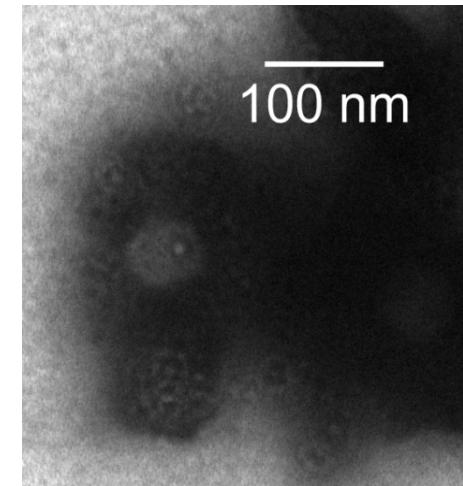
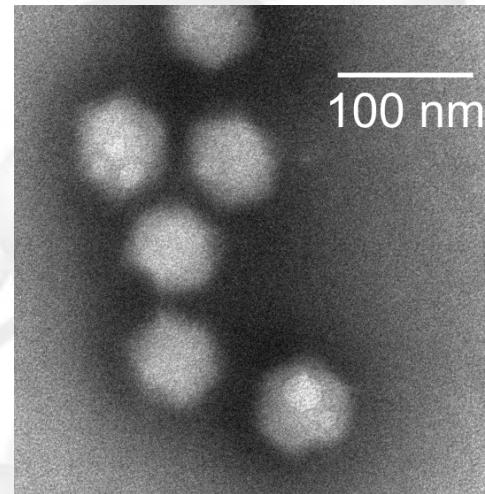


Viral complexes: Magnetofection

Virus based gene delivery: Magnetofection is the nucleic acid delivery under the influence of magnetic field acting on nucleic acid vectors, which are associated with MNPs

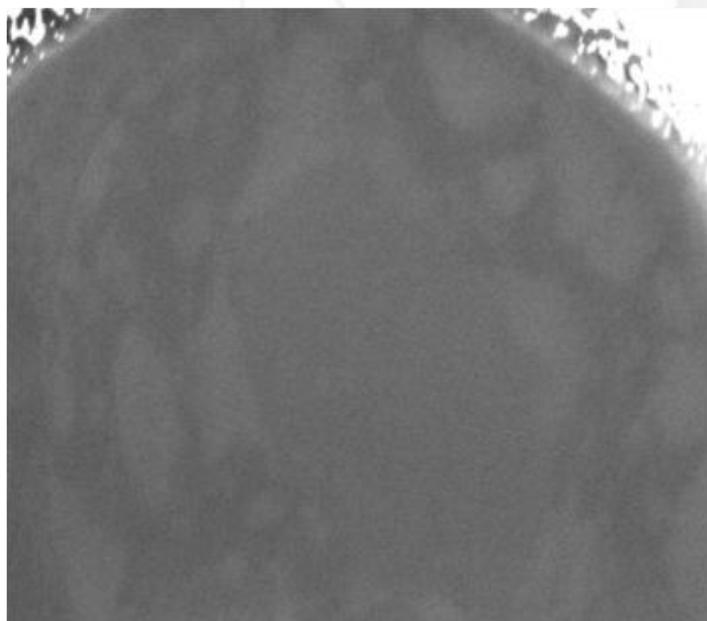


↑ Efficiency
Control at a distance: magnet

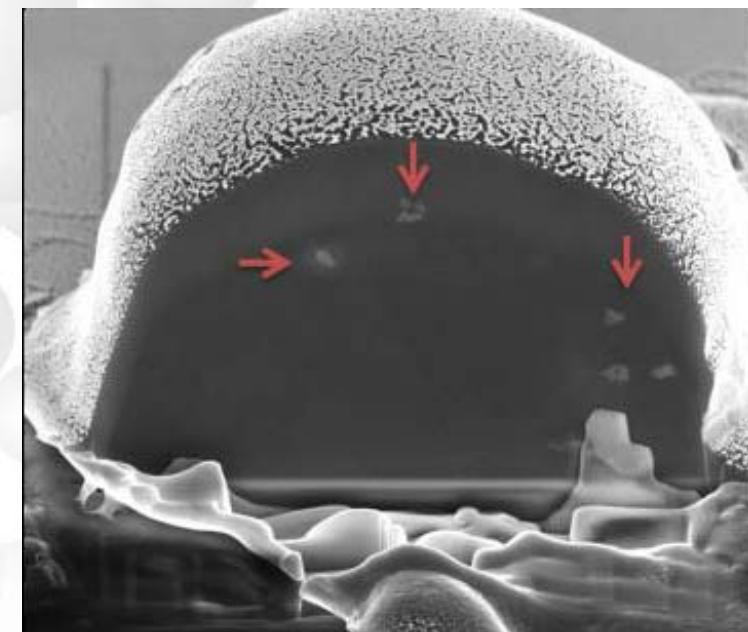


LMA

Images of glial cells taken during slicing in Dual Beam mode before and two days after the infection with viral magnetic complexes



Control N2A cell



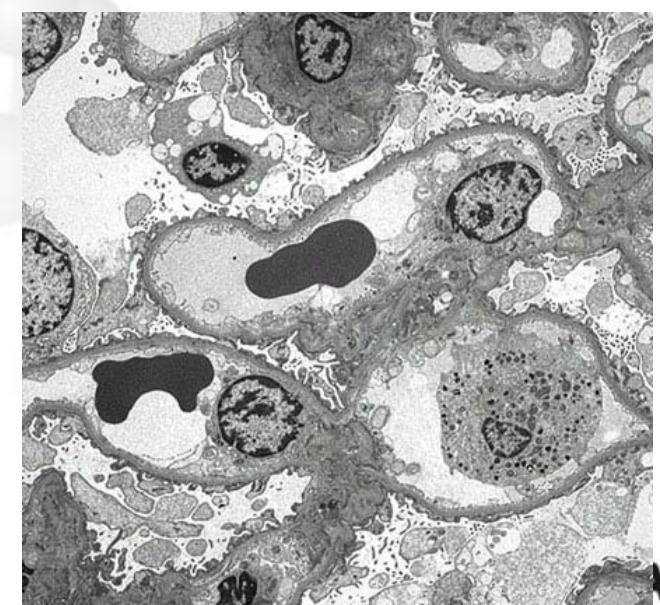
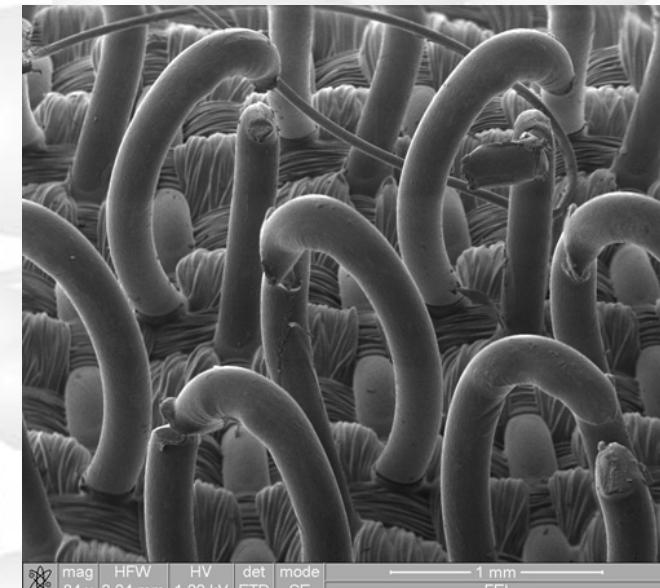
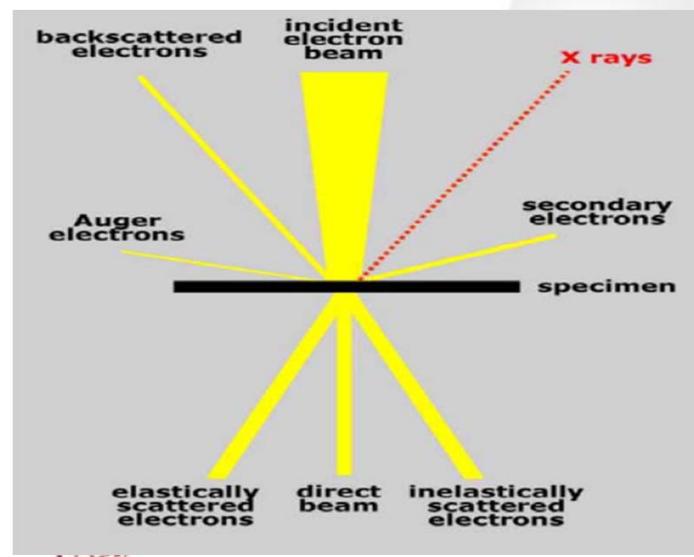
N2A cell infected with magnetic adenovirus complexes



NEW METHODS OF OBSERVATION AND NANOFABRICATION



SCANNING ELECTRON MICROSCOPY

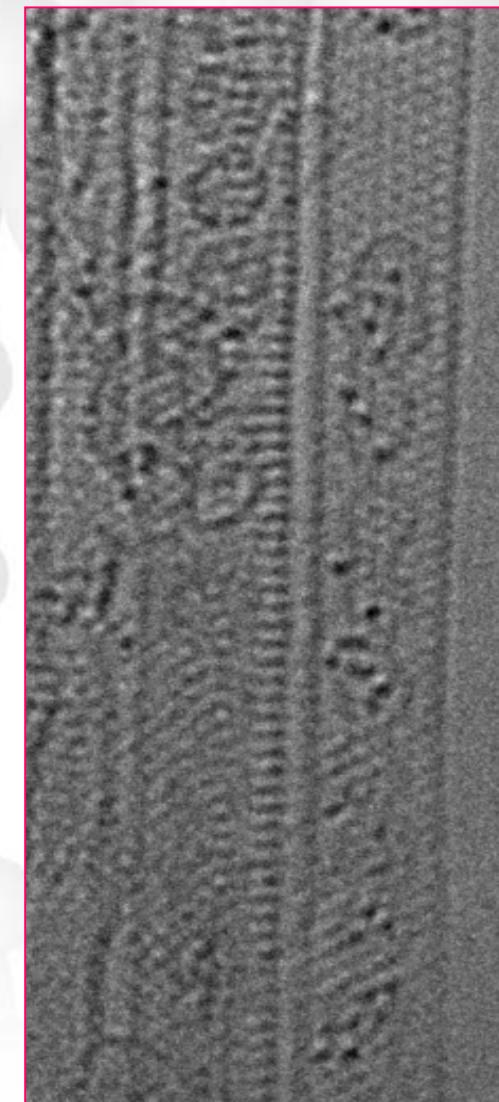
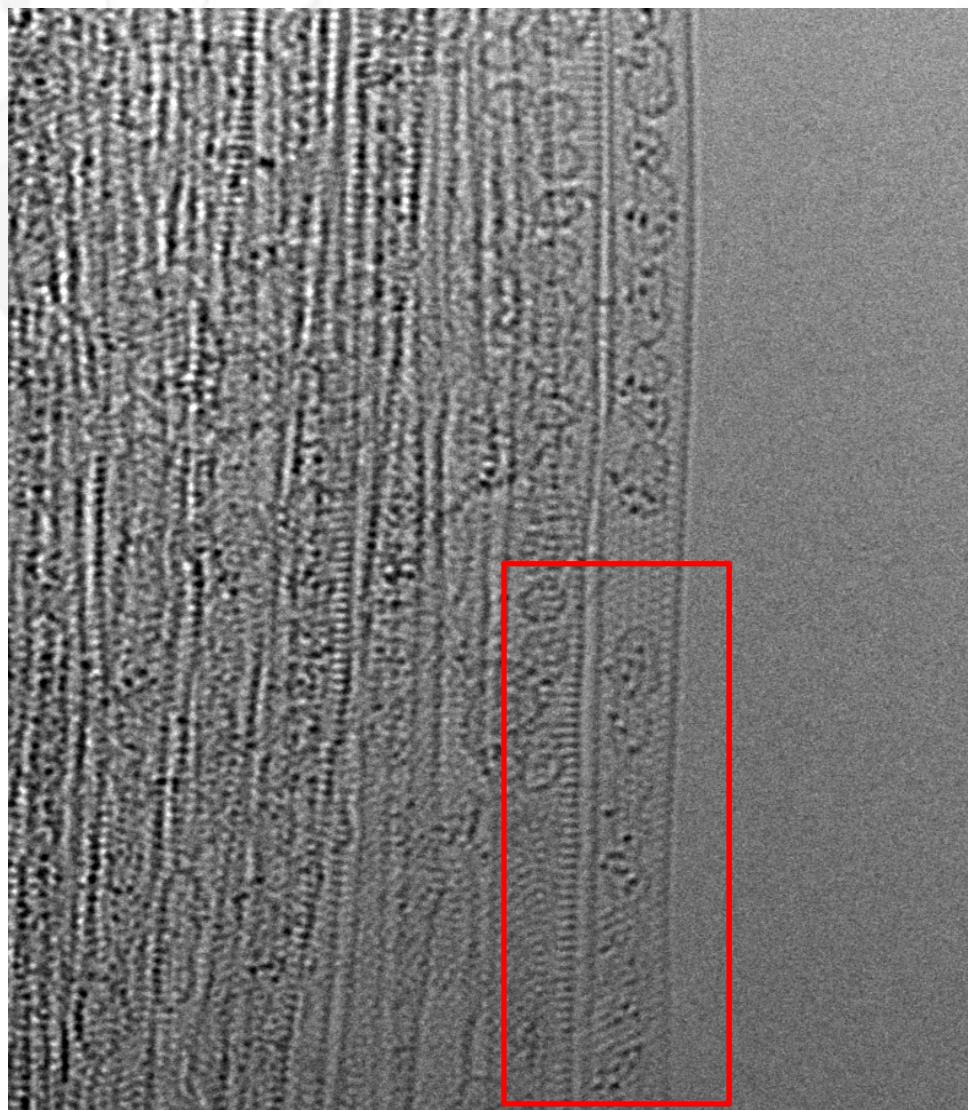


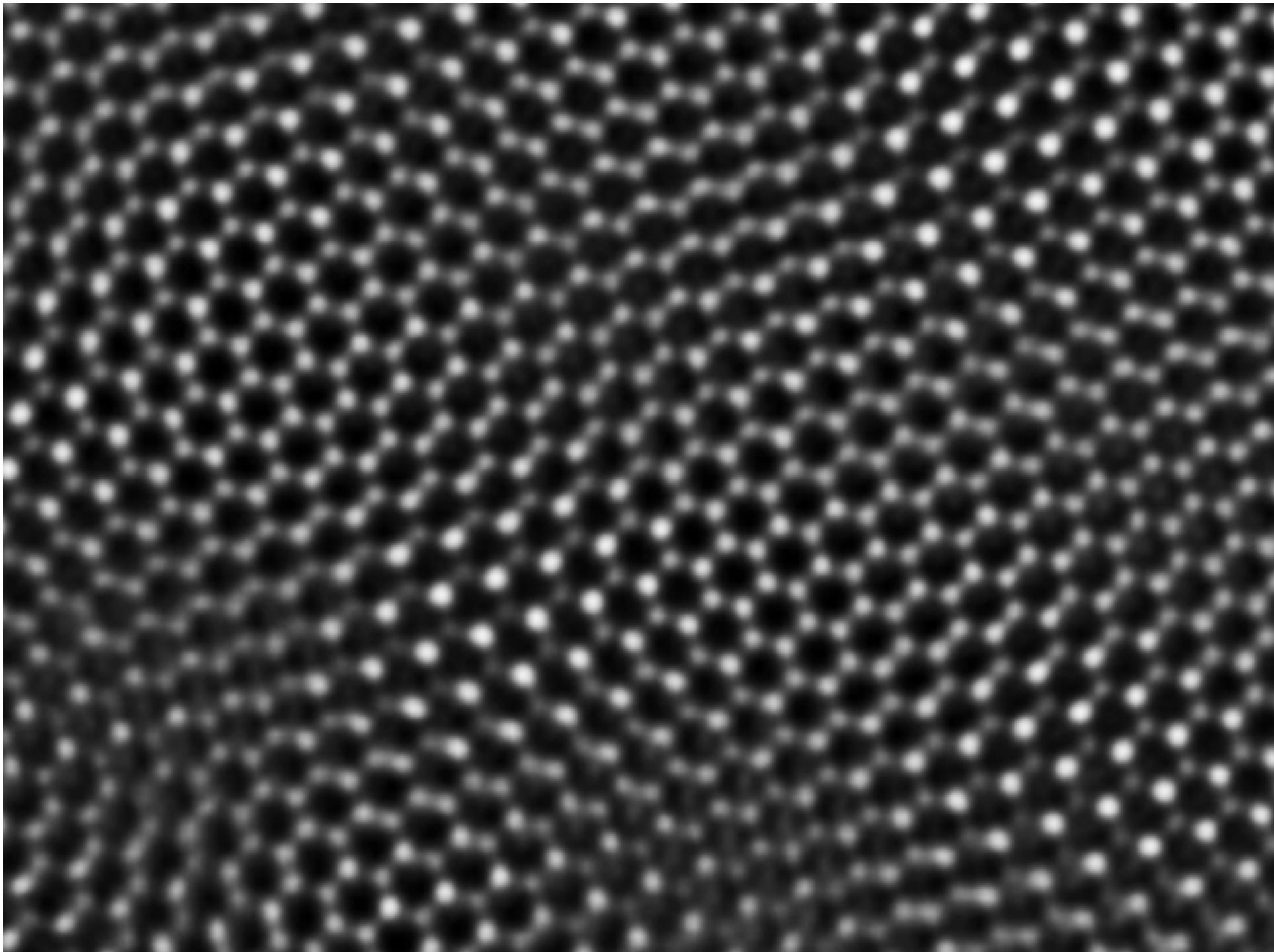
Courtesy of: Dr. Jim Ito, Yorkhill Hospital, Glasgow Scotland, UK



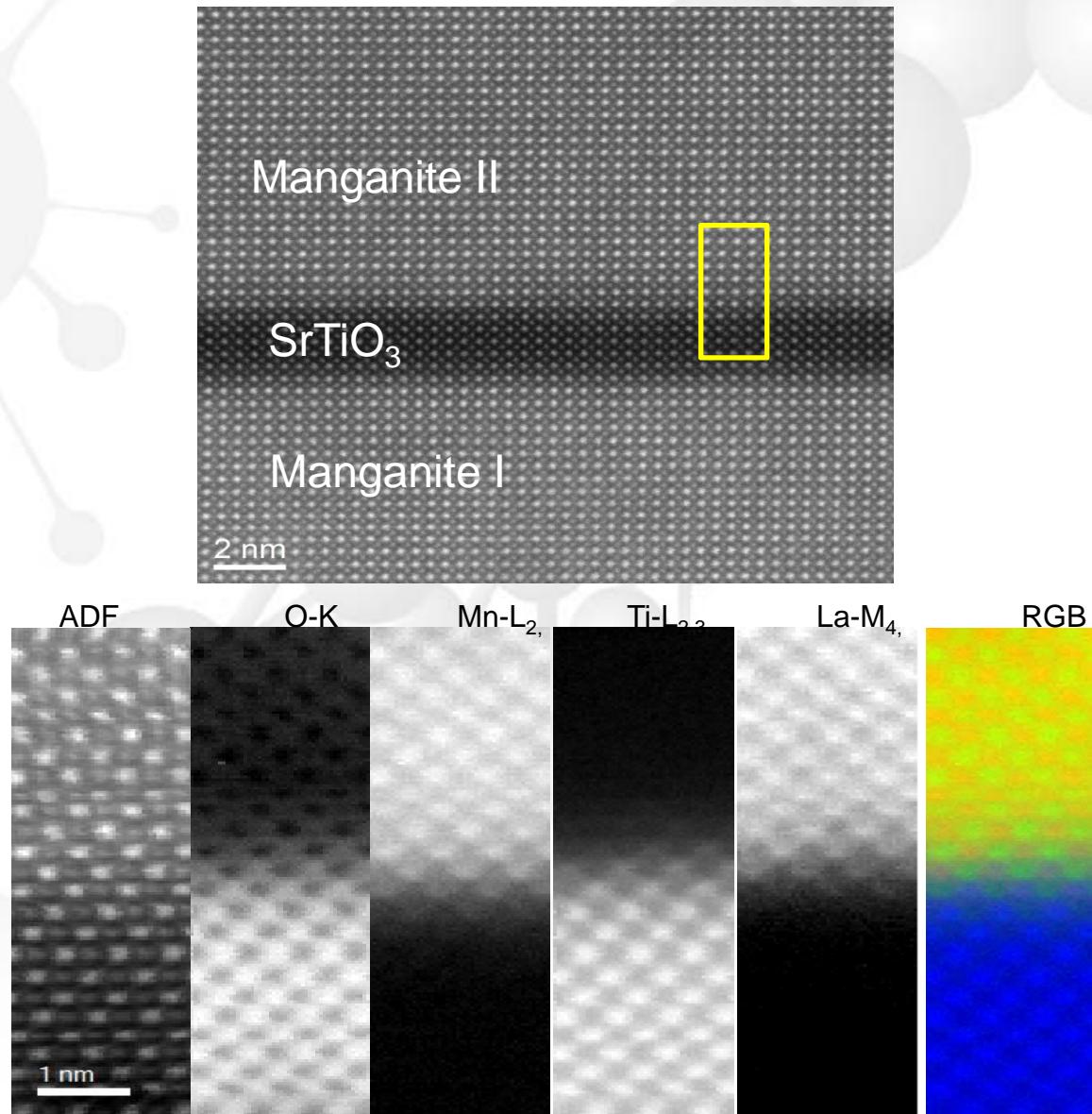
MICROSCOPIOS ELECTRÓNICOS DE TRANSMISIÓN



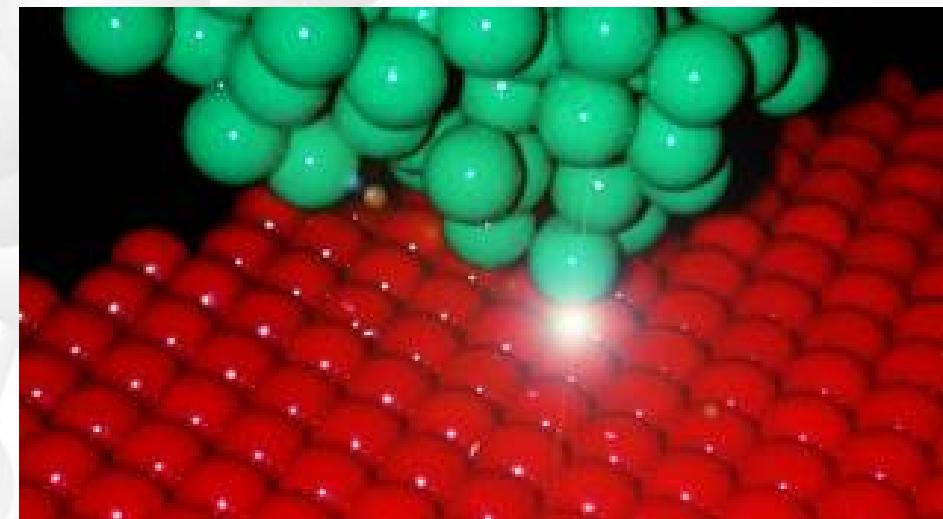
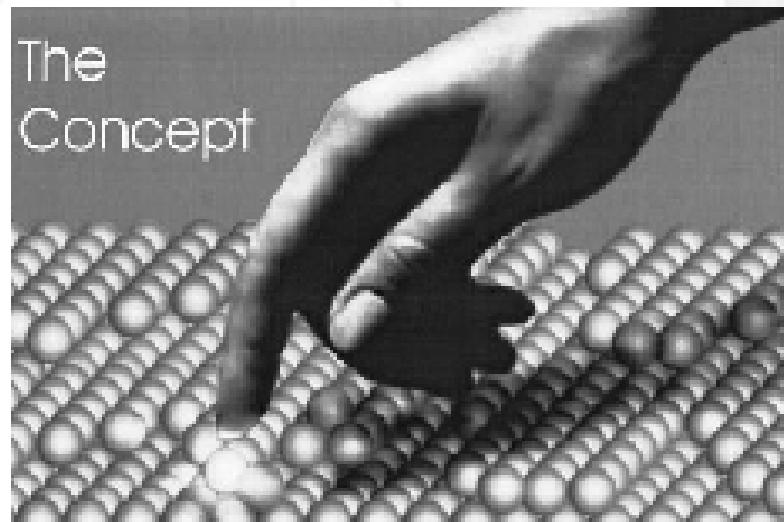




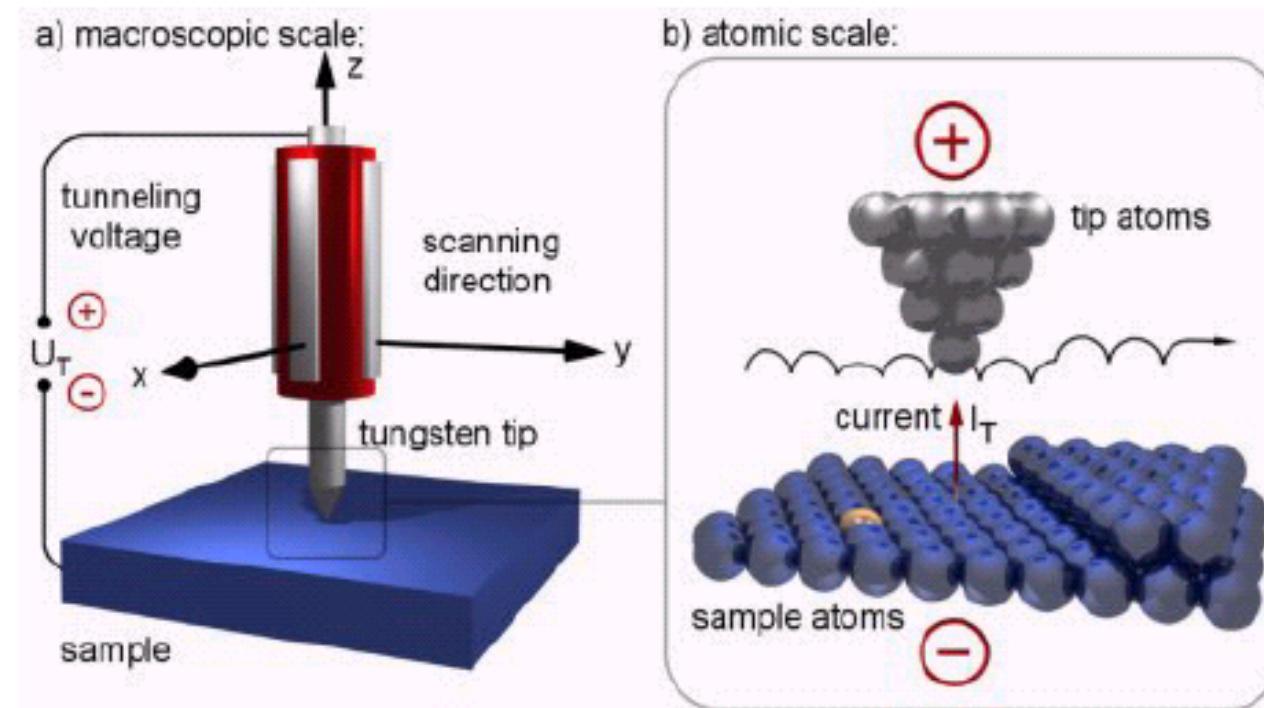
TEM with aberration correctors: Multilayers



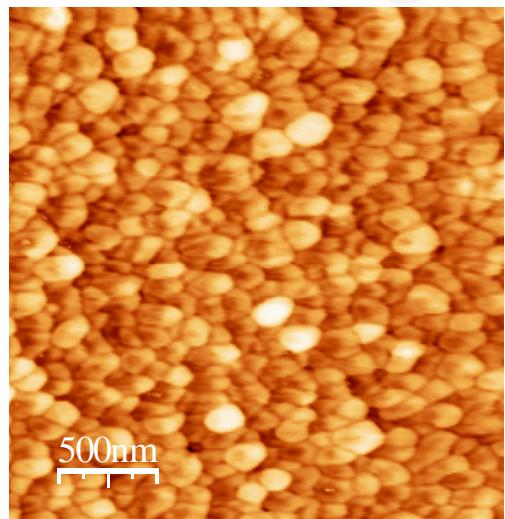
SCANNING PROBE MICROSCOPE



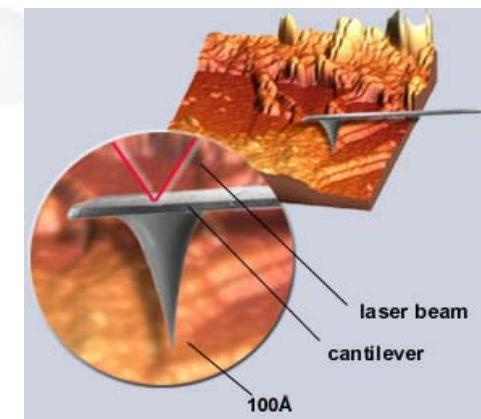
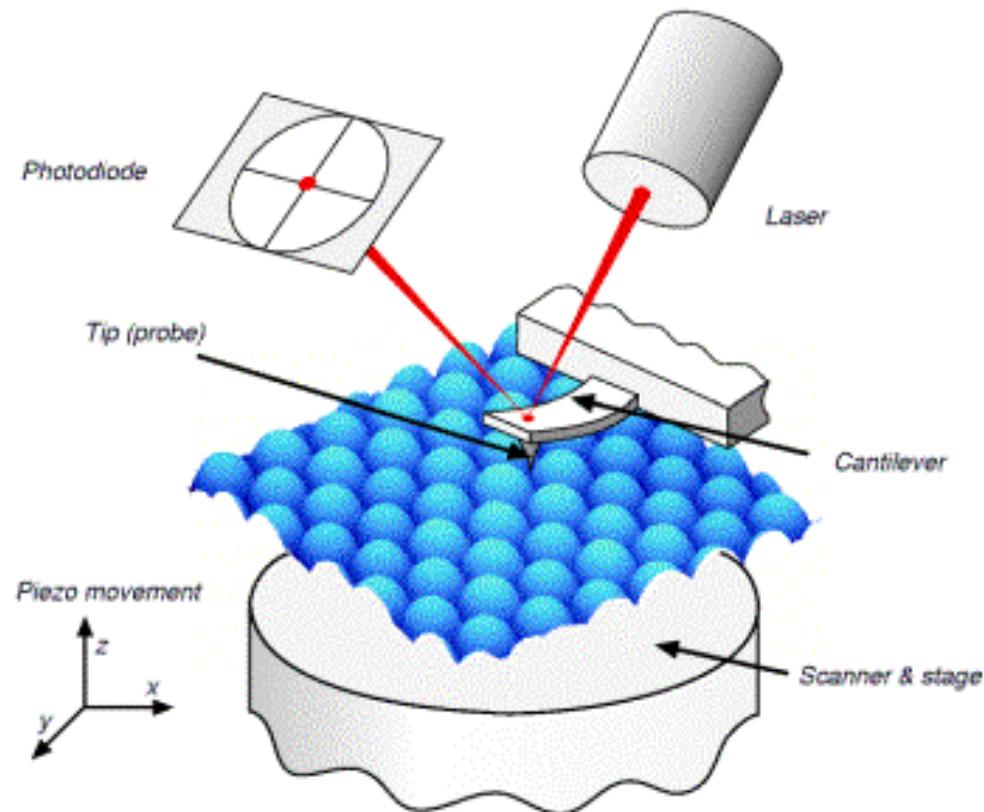
Scanning Tunneling Microscope: STM



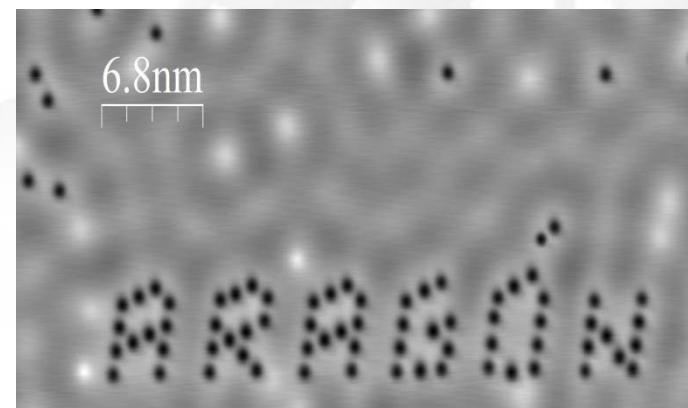
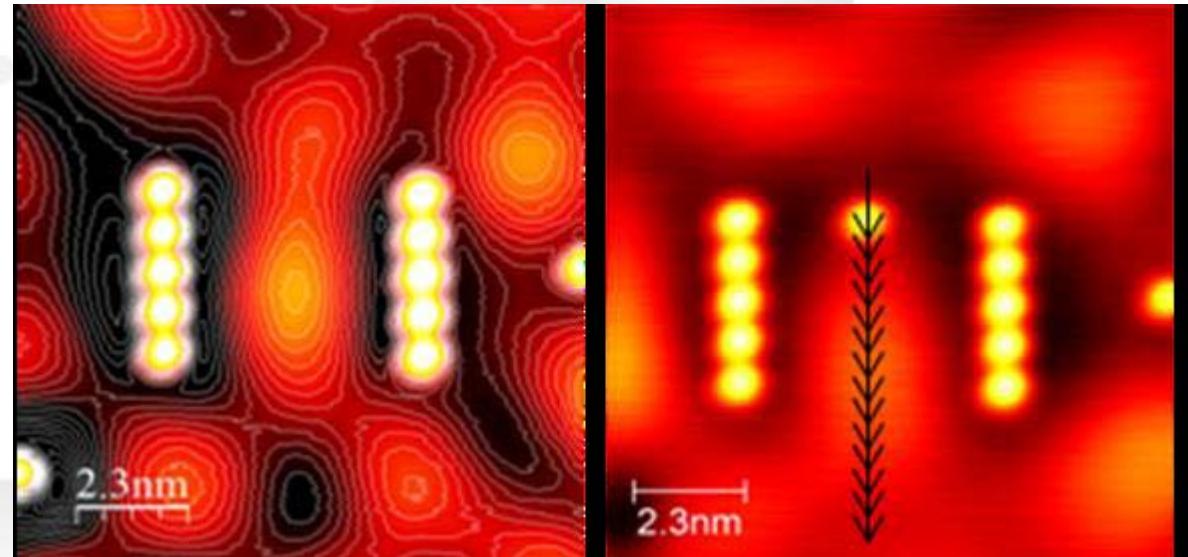
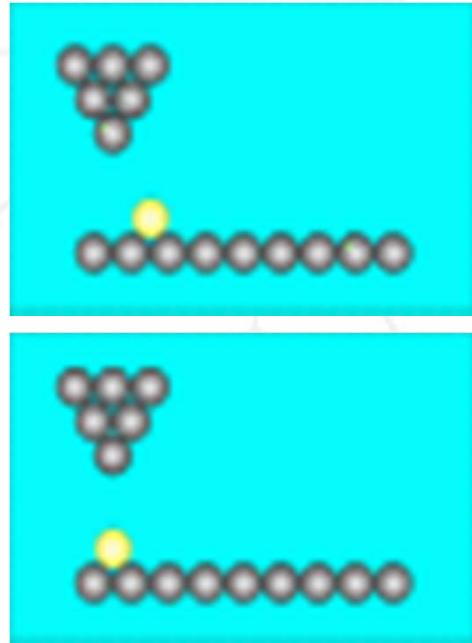
Atomic Force Microscope: AFM



Porous
sputter



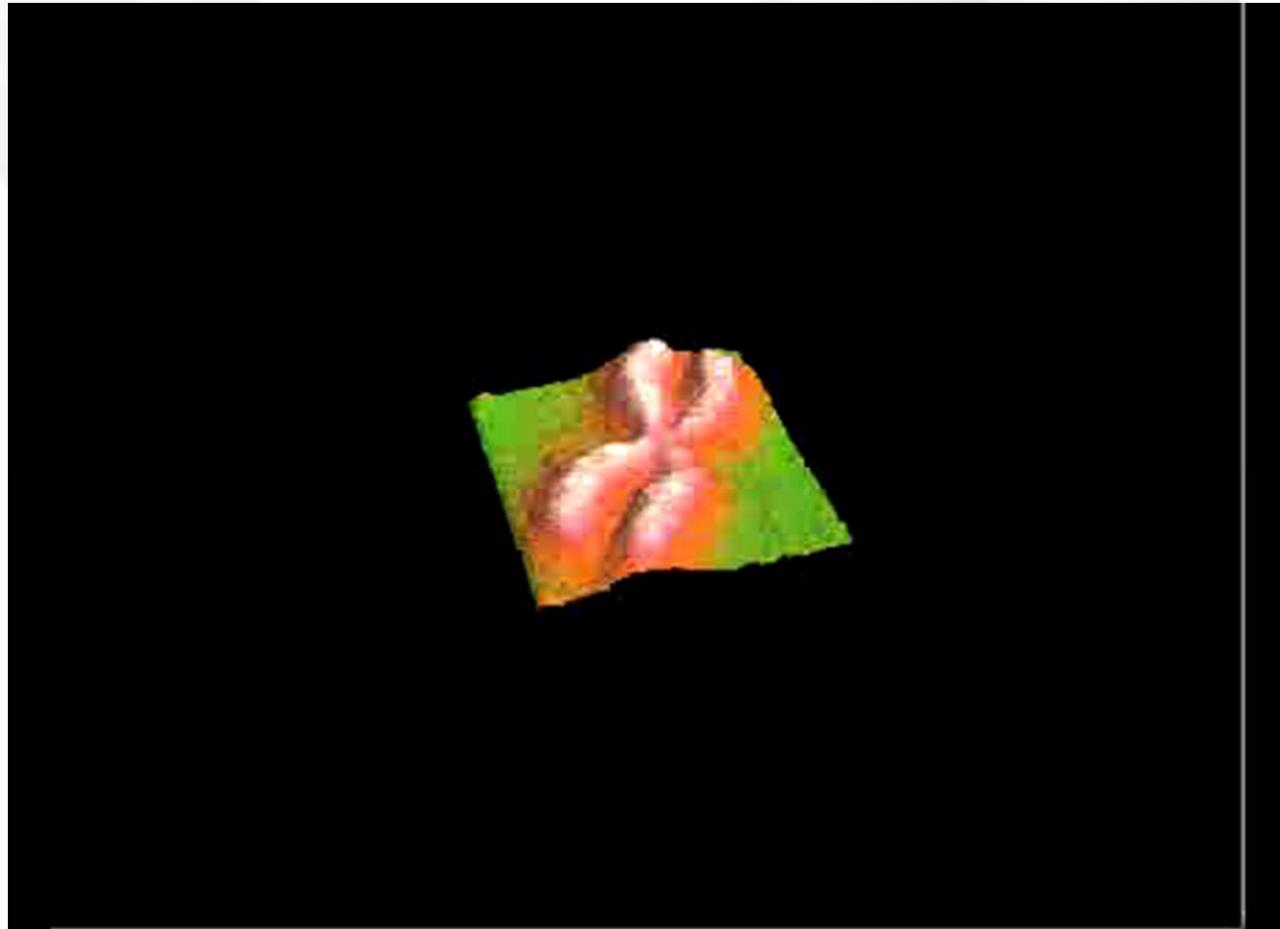
SPM Nanomanipulation



Co/Ag (111)



CROMOSOMA MICROSCOPIA AFM

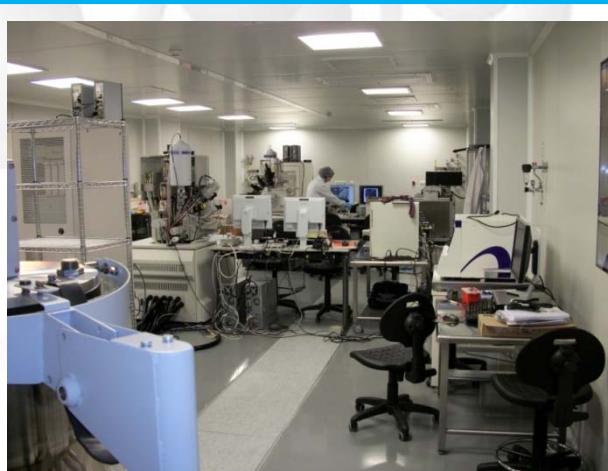


Clean room: Micro and nanofabrication



20 m², CLASS 100

- Photoresist station
- Mask aligner
- E-beam evaporator
- μ -contacts
- Optical microscope

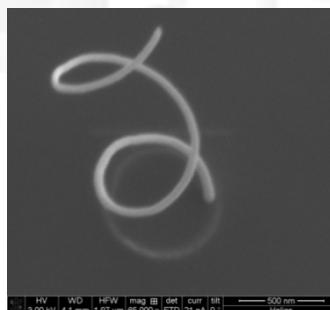
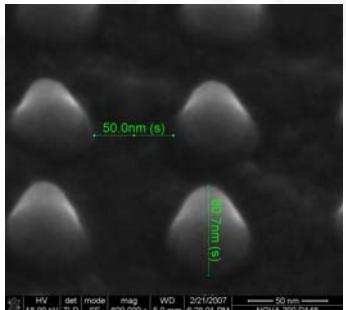
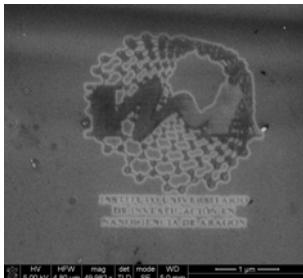
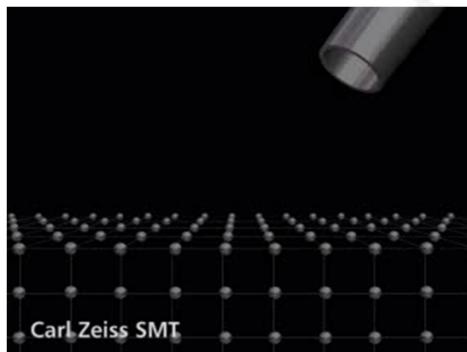
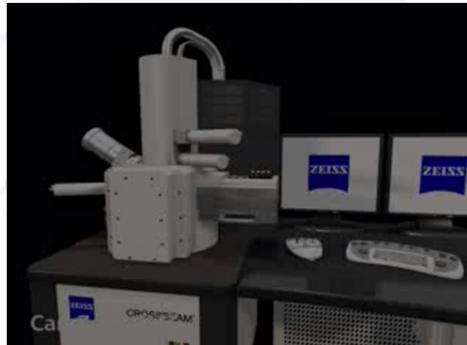


125 m², CLASS 10.000

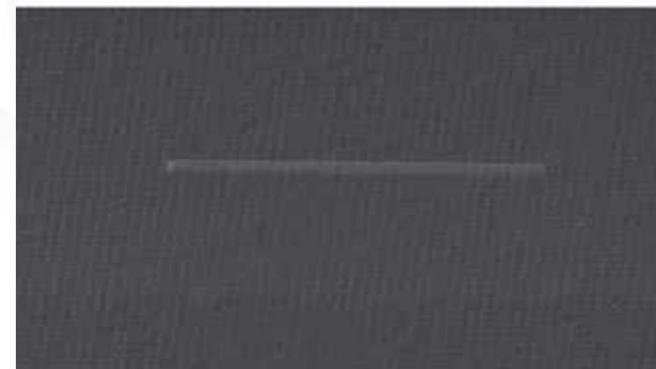
- HELIOS Dual Beam
- NANOLAB Dual Beam
- Cryo SEM&FIB
- RIE/IBE
- PECVD



Laboratorio microscopia “Dual beam”

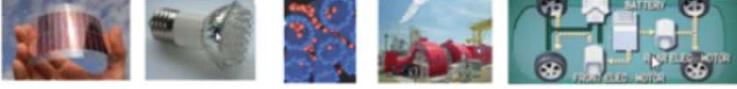
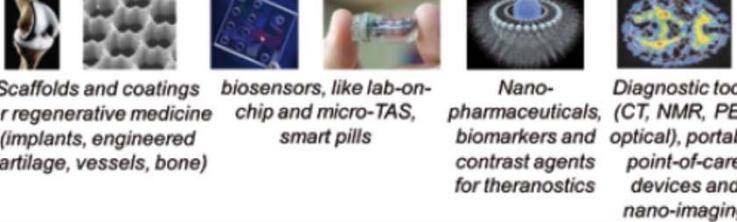


- Imaging
- Etching
- Deposition
- Analysis
- Nanopatterning
- e-beam lithography



Impact of nanotechnology

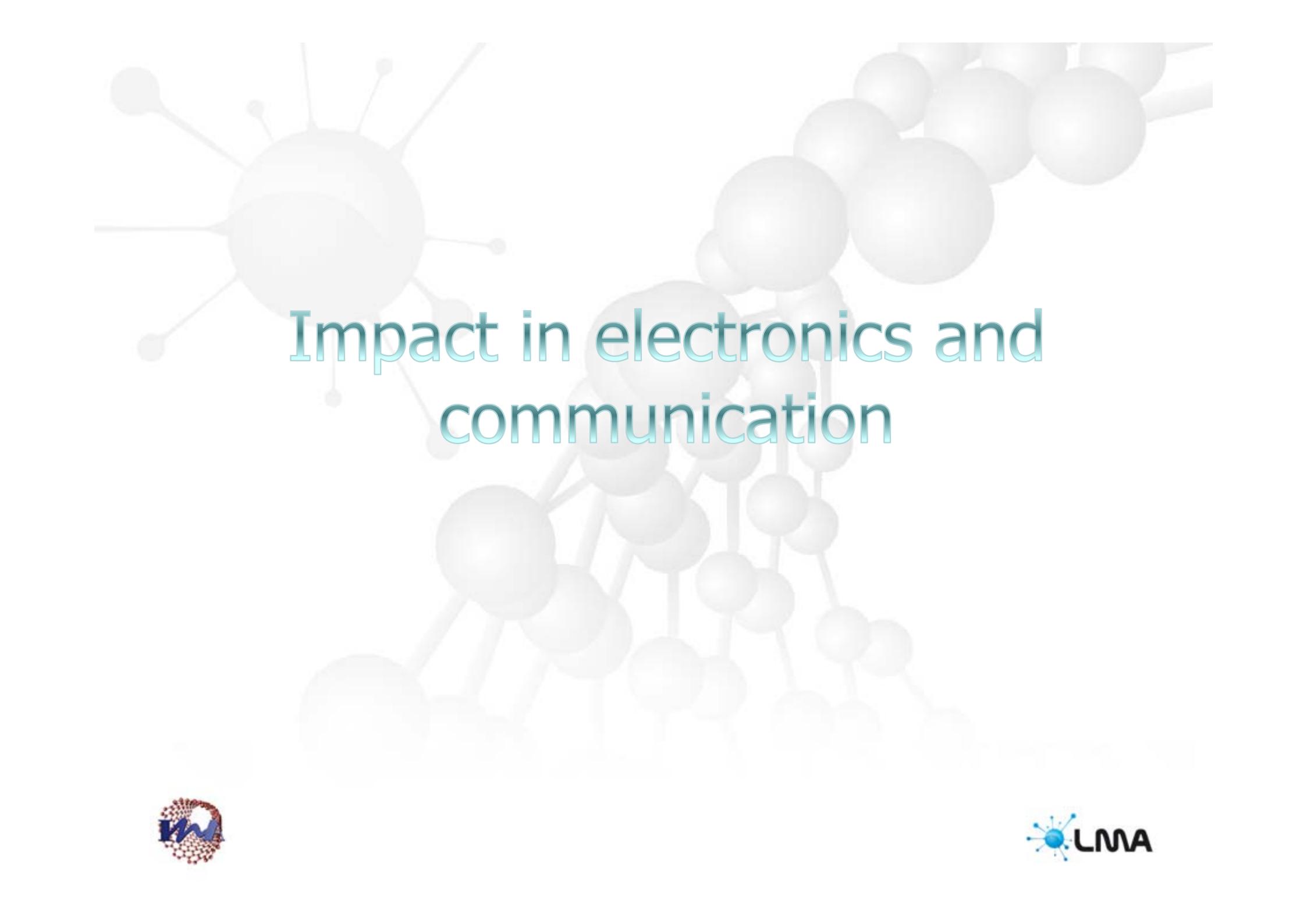


	ENERGY	
	TRANSPORTATION	 <p>Long time, low cost fuel cell membranes and batteries; Low friction engines & lubricants; Smart glass surfaces; Lightweight metal or plastic sheet for chassis; efficient tires, wiper blades, seals; sustainable lightings and heating systems; smart sensors and radar systems</p>
	CONSTRUCTION & BUILDINGS	 <p>Self-cleaning/Anti-microbial/solar reflective paints for building envelopes or indoor environment (e.g. HVAC)</p> <p>Advanced insulating systems for new and existing building envelopes</p> <p>Green high performance concrete (CO₂ trapping) & recycled building composites</p> <p>Smart integration of technologies (incl. Sensors) at building level</p>
	MEDICINE & PHARMA	 <p>Scaffolds and coatings for regenerative medicine (implants, engineered cartilage, vessels, bone)</p> <p>biosensors, like lab-on-chip and micro-TAS, smart pills</p> <p>Nano-pharmaceuticals, biomarkers and contrast agents for theranostics</p> <p>Diagnostic tools (CT, NMR, PET, optical), portable point-of-care devices and nano-imaging</p>
ICT		 <p>Lasers (optical communications, medical diagnostics and treatments, manufacturing tools, printers)</p> <p>ink-jet printers</p> <p>LCD-, silicon-, LED- and OLED-based Displays and Photovoltaics</p> <p>Consumer Electronics (smart phones, TV set, digital cameras etc.)</p>

NANOfutures Impact – examples of final nano-enabled products, for each target market

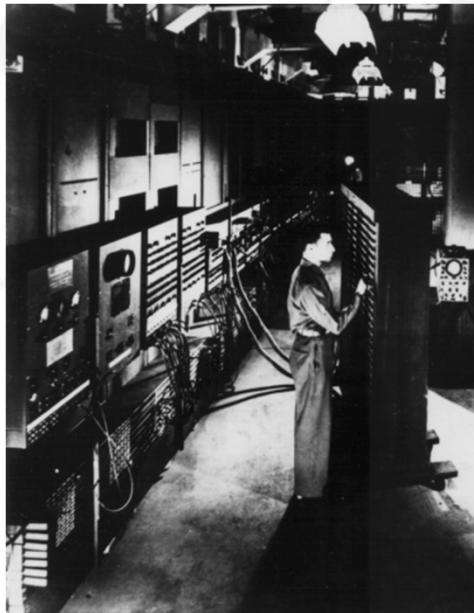
NANOfutures, European Technology Integrating and Innovation Platform on Nanotechnology



A faint, semi-transparent background image of a molecular structure composed of spheres connected by lines, forming a complex network.

Impact in electronics and communication





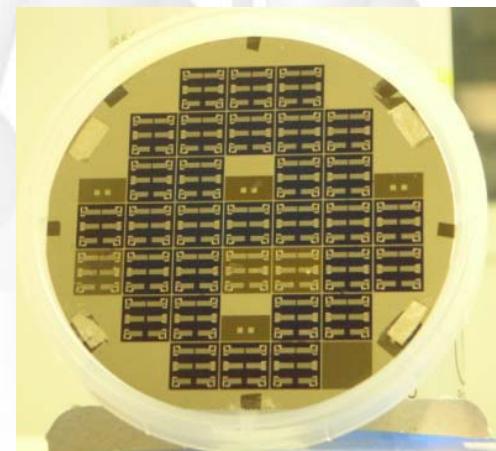
ELECTRONIC DEVICES BASED IN NANOTECHNOLOGY



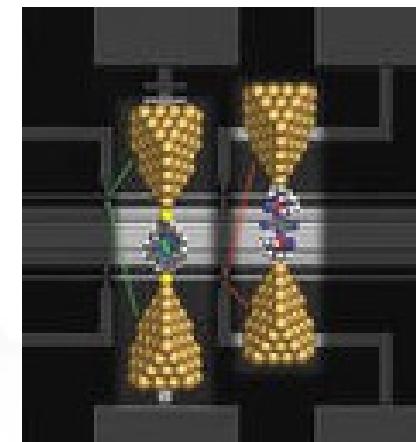
Reading head of hard discs



Prof. Albert Fert
Premio Nobel Física 2007

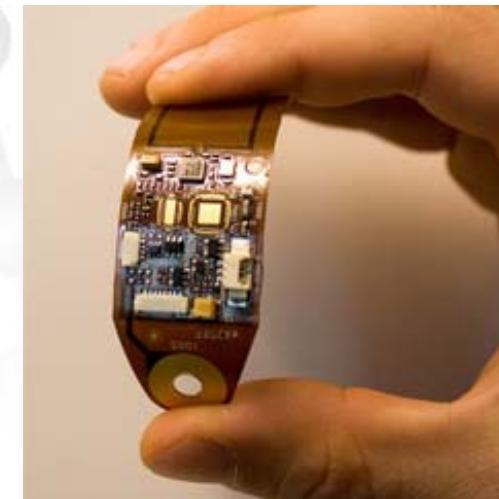
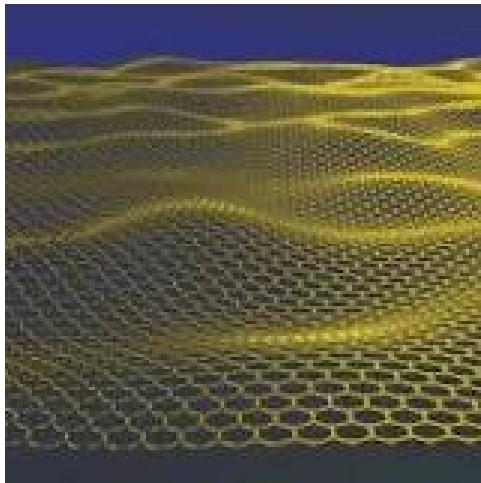


Detector for biosensors



Impact in energy

- Lighter materials for vehicles: increased fuel efficiency
- Materials to increase efficiencies of electrical components and transmission lines
- Nanomaterials arranged in superlattices that could allow the generation of electricity from waste heat in consumer appliances, automobiles, and industrial processes
- Materials that could contribute to a new generation of photovoltaic cells and fuel cells



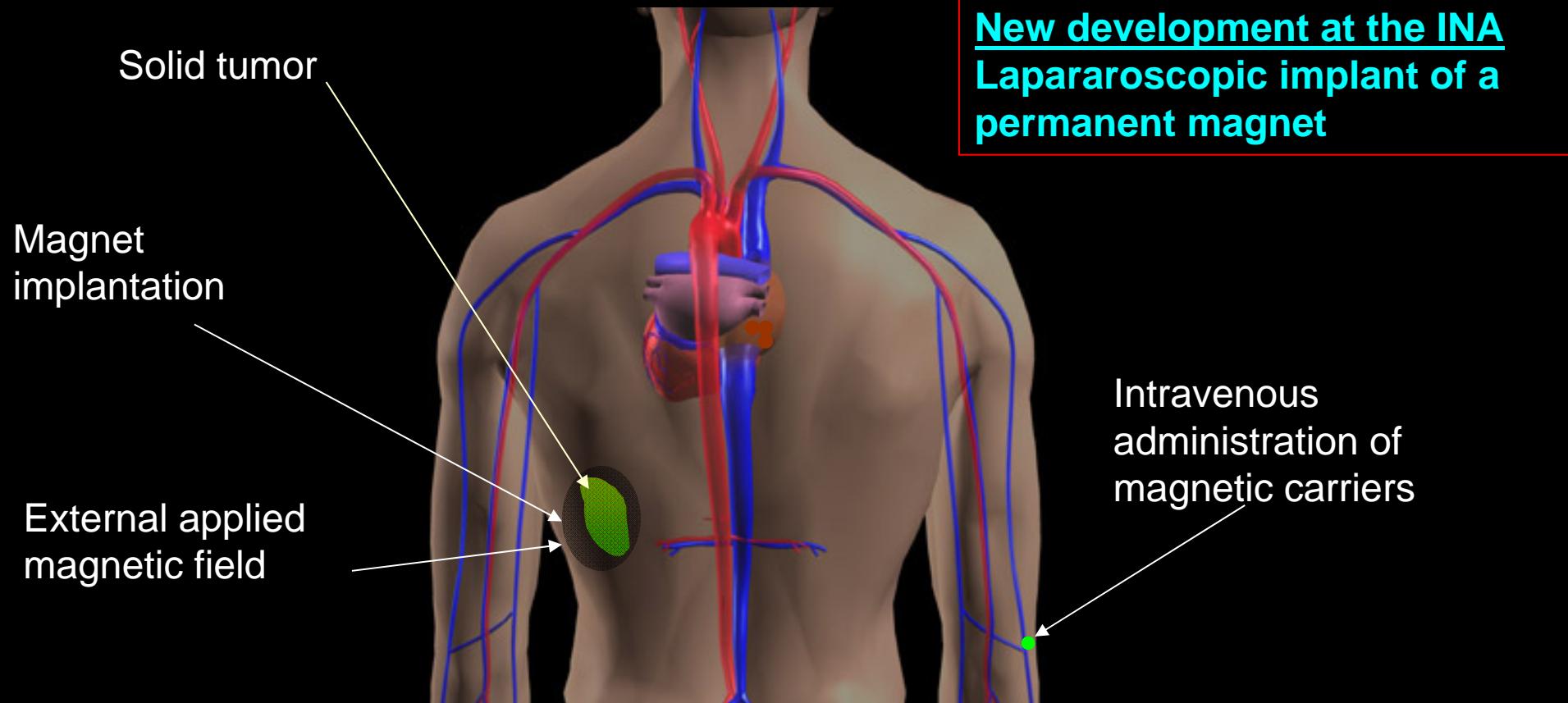
Impact in health sciences



Drug delivery

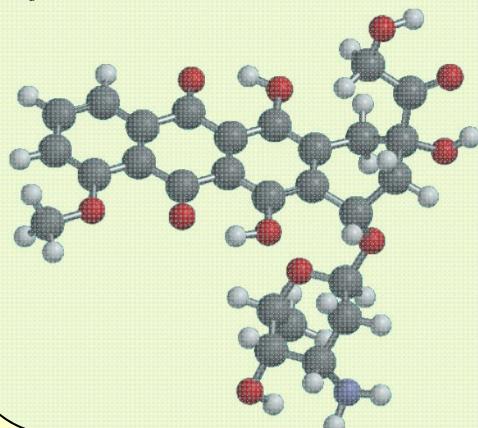


TARGETING USING MAGNETIC IMPLANT FOR DRUG DELIVERY



NEW DRUGS

Doxorubicina ($11 \times 13 \text{ \AA}$)



CURRENT DRUG

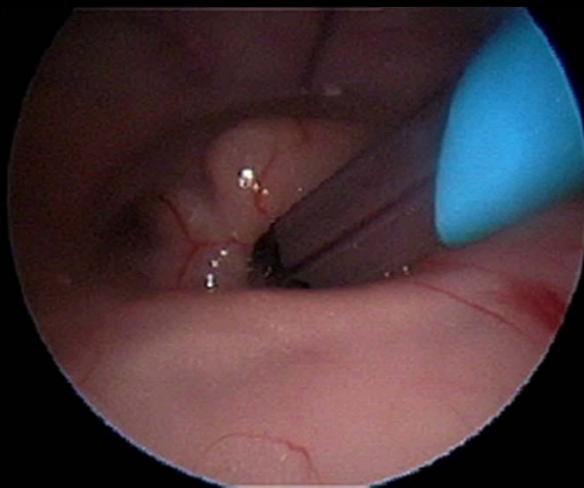
NANODRUG

Fe_2O_3
Nanoparticle

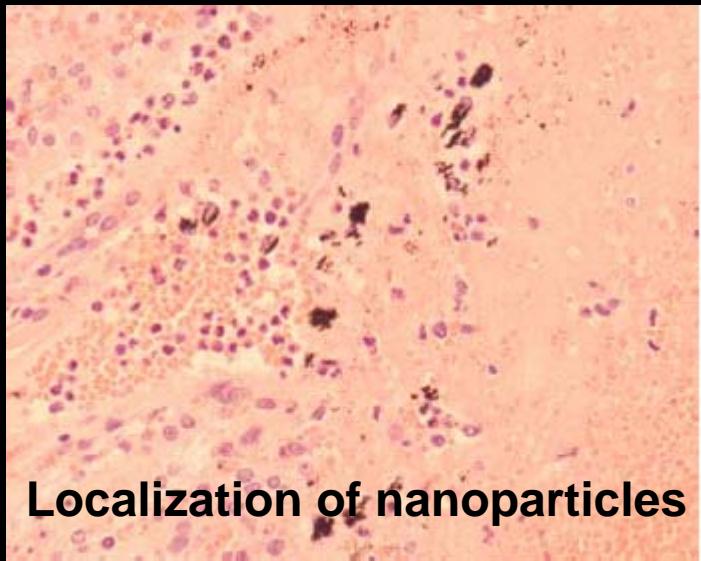
20 nm

Graphite
Encapsulation

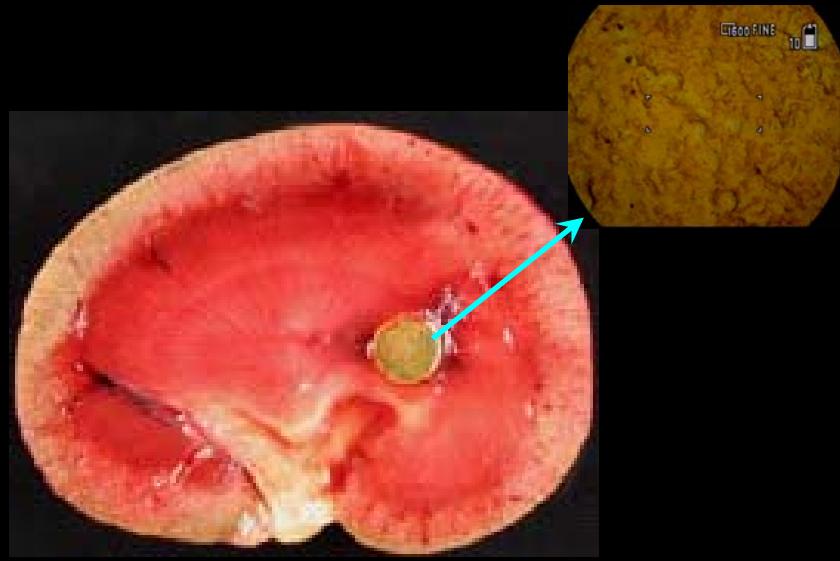
NANOPARTICLES



Magnet implant in the left kidney

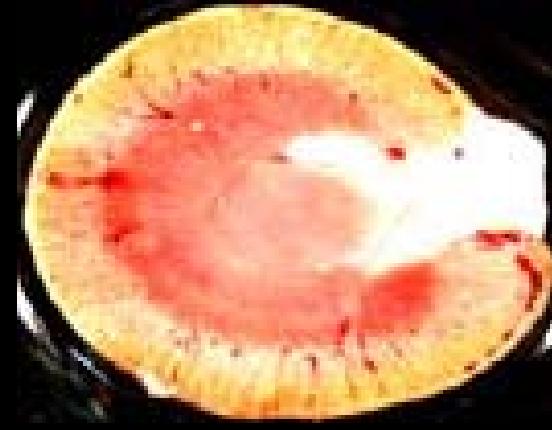


Localization of nanoparticles

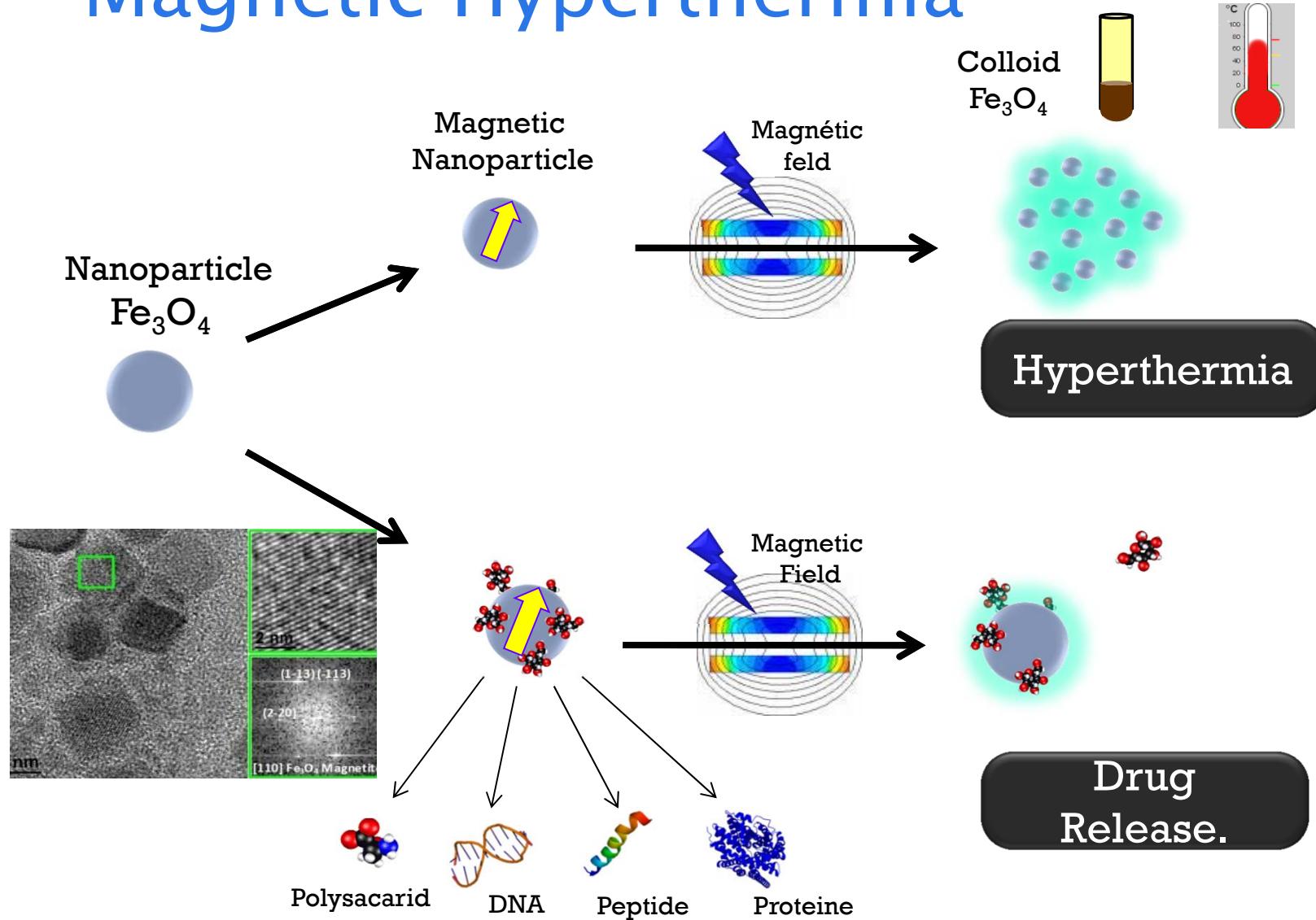


Lack of nanoparticles

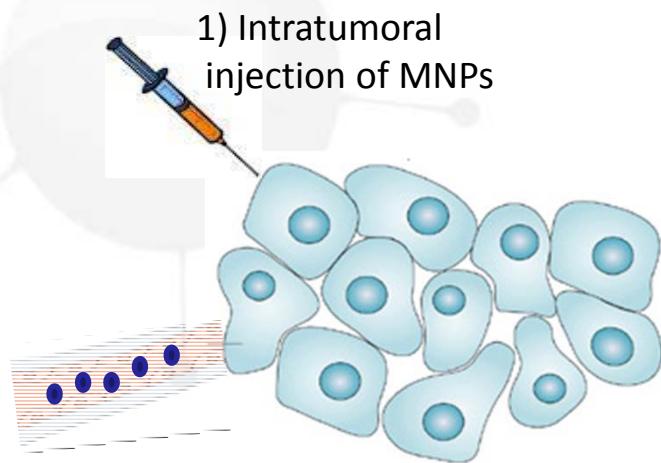
Right kidney without magnetic implant



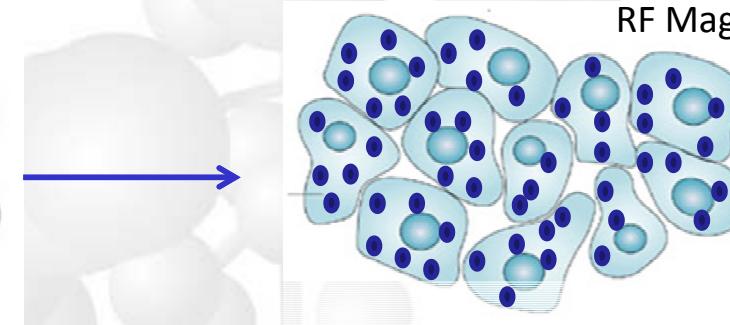
Magnetic Hyperthermia



MAGNETIC HYPERHERMIA

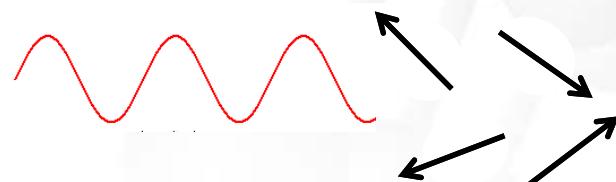


2) Intravenous administration of MNPs



Selectivity
Allows to attack deep tissues

Why MNPs heat?



Brownian rotation Neel relaxation



Physical movement
of the MNPs



Rotation of the magnetic
moment of the MNPs





Nanoscale Biomagnetics S.L. Spin-Off Zaragoza University



DM-100 Series

www.nbnanoscale.com

COLLOIDS



DM1

CELLS CULTURE



DM2



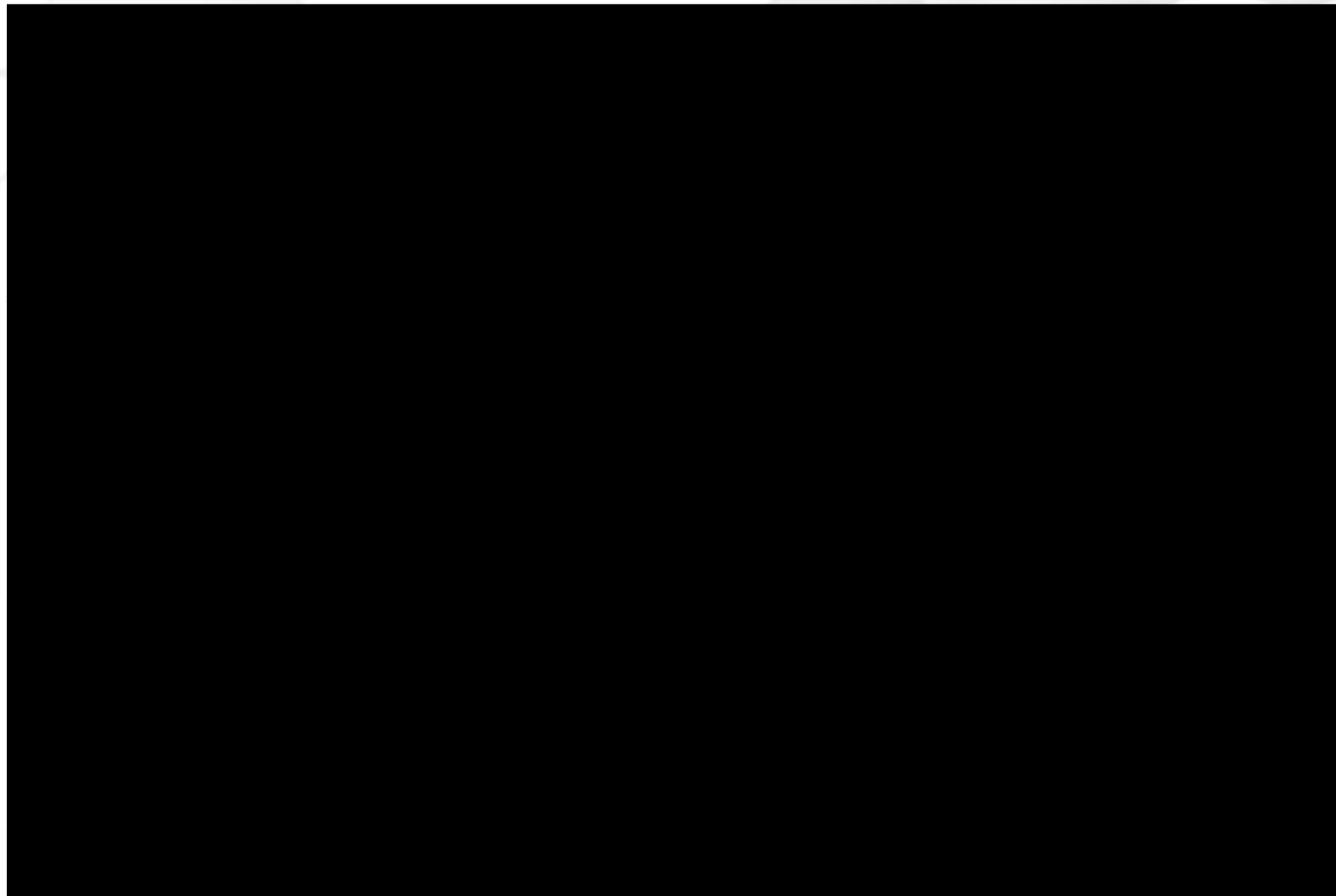
MOUSE



DM3



Magnetic Hyperthermia at clinic

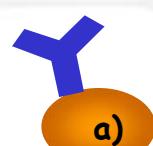


Nanodiagnostic



Magnetic Nanoparticles for Lateral flow Biosensors

Sample 1
(without hormone)



+



Anti-hCG (clone 5014)

Biotin

Test line

Control line

Negative test



Control line
Test line

Sample 2
(with hormone)



+



Anti-hCG (clone 5014)

Biotin

Test line

Control line

- a) Magnetic NP
- b) Control Particle
- c) Hormone



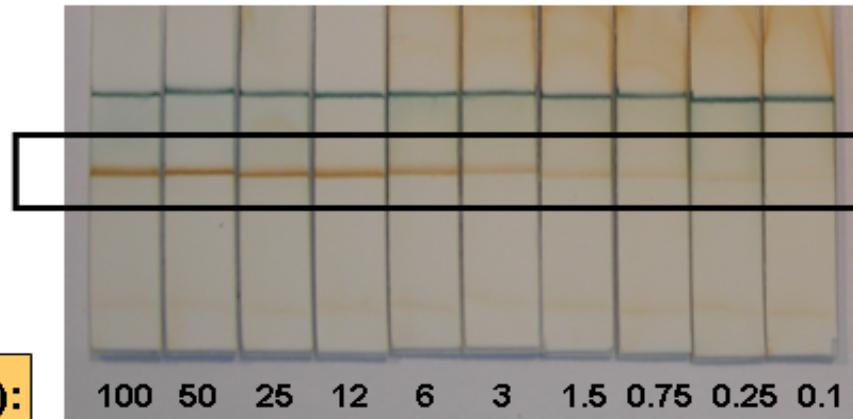
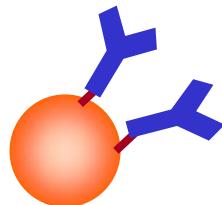
Positive test



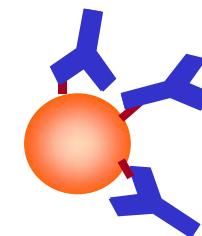
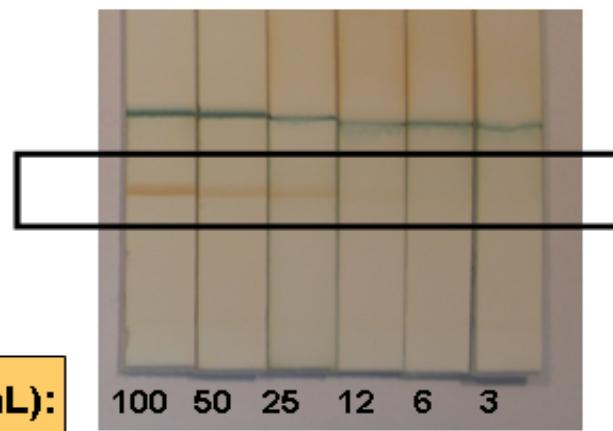
Control line
Test line

LMA

Anti-hCG linked through sugar chains



Anti-hCG linked through amino moieties



Test Line





nanoimmunotech
global solutions
in nanobiotechnology

<http://nanoimmunotech.eu>

nanoimmunotech offers a complete range of products, services and tailor-made projects to help you from the design of nanoparticles, nanomaterials or complex nanosystems by means of bioconjugation, to check the properties of your products, the reproducibility of their production or their biological effects, among others.



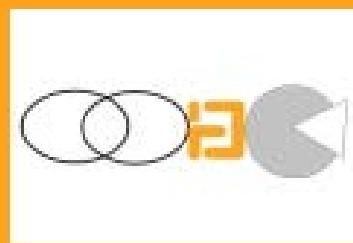
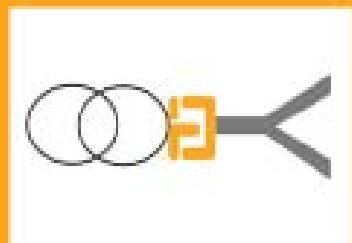
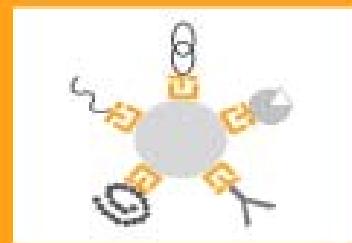
The Bioconjugation solution
nitzipper® products

nitzipper

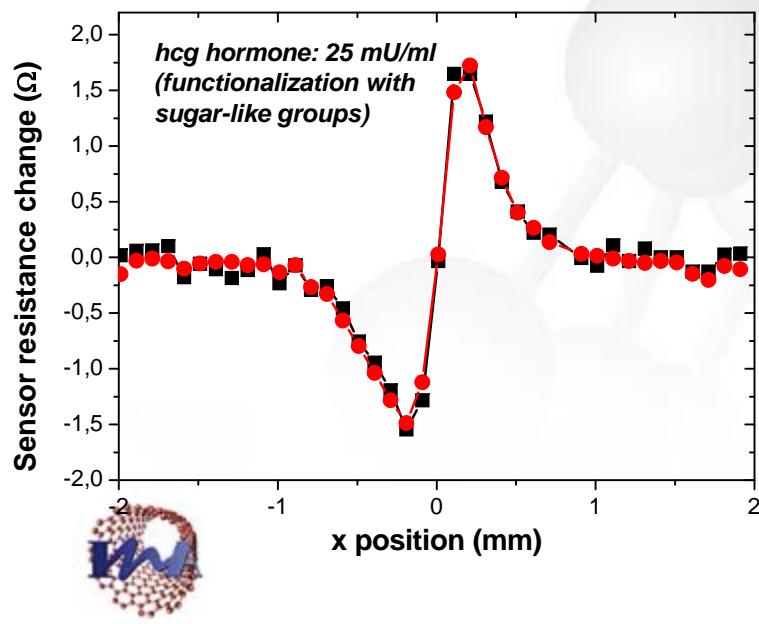
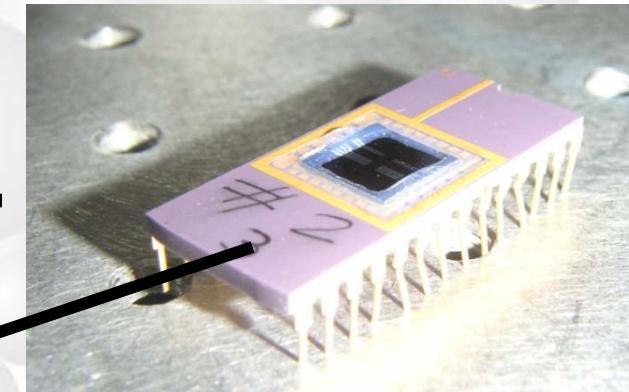
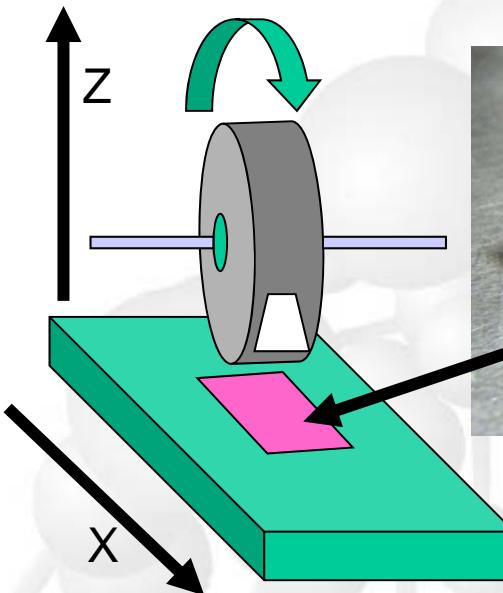
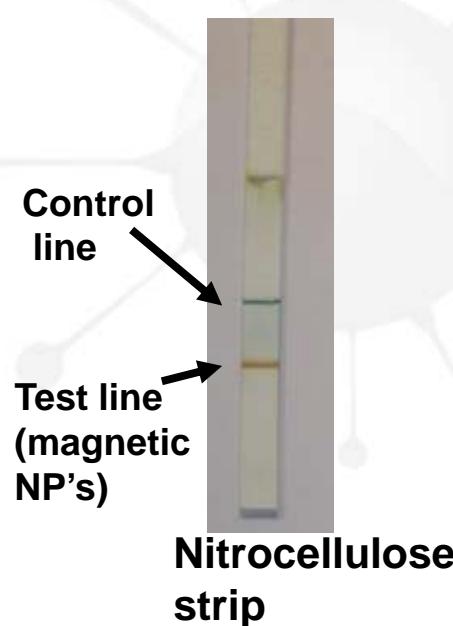


anticuerpos, enzimas, péptidos, fluoróforos, linkers y
oligonucleótidos

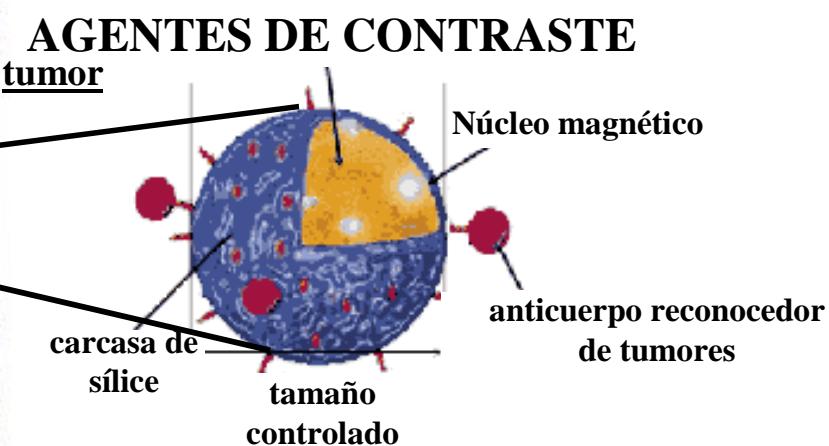
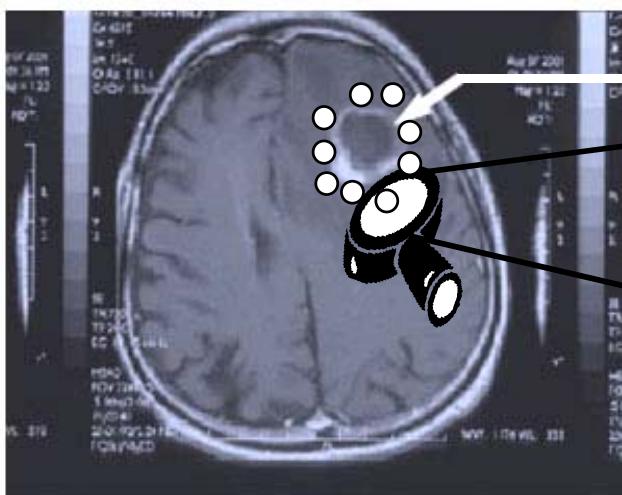
MULTIPLE SOLUTIONS/APPLICATIONS



IMMUNOMAGNETIC BIOSENSOR



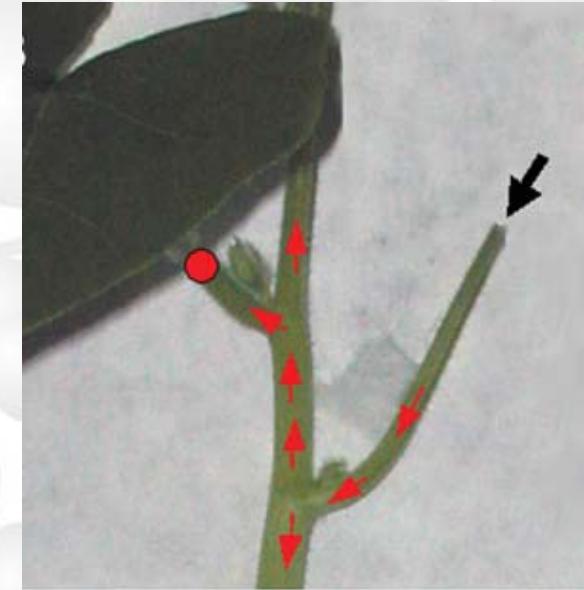
Tomografia de Resonancia Magnética Nuclear



Magnetic nanoparticles in plants



Targeting using magnetic nanoparticles in plants



Bioferrofluid were prepared from Fe&C nanoparticles.

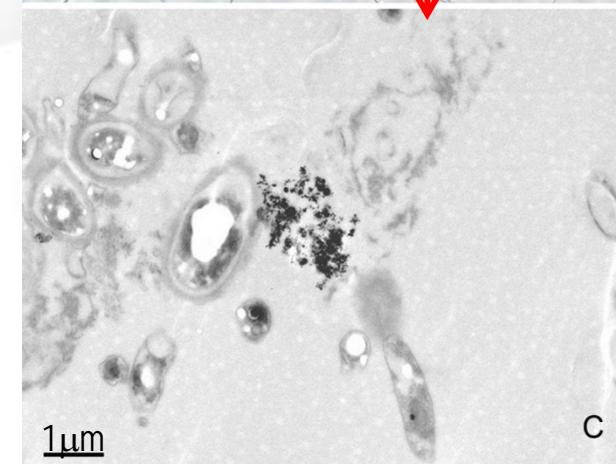
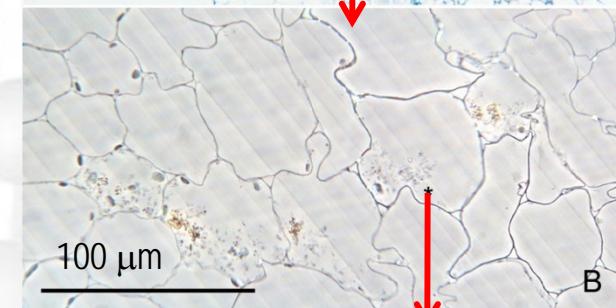
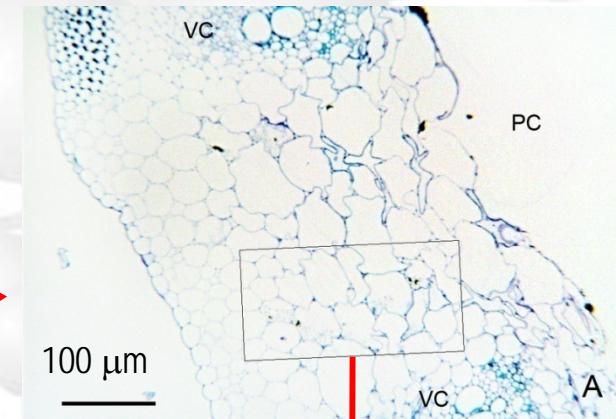
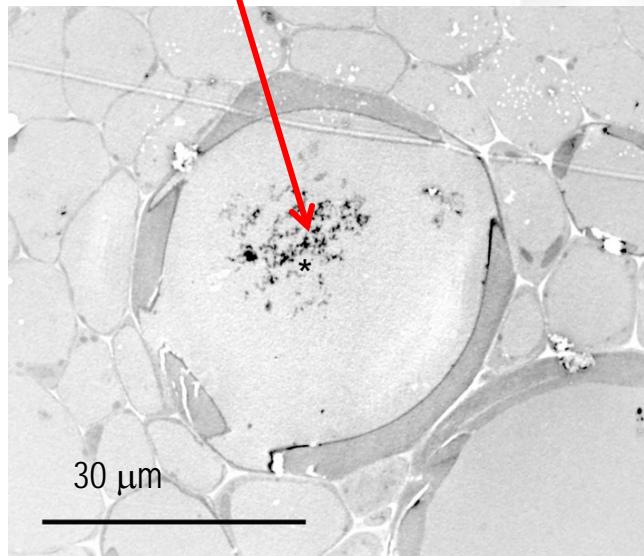
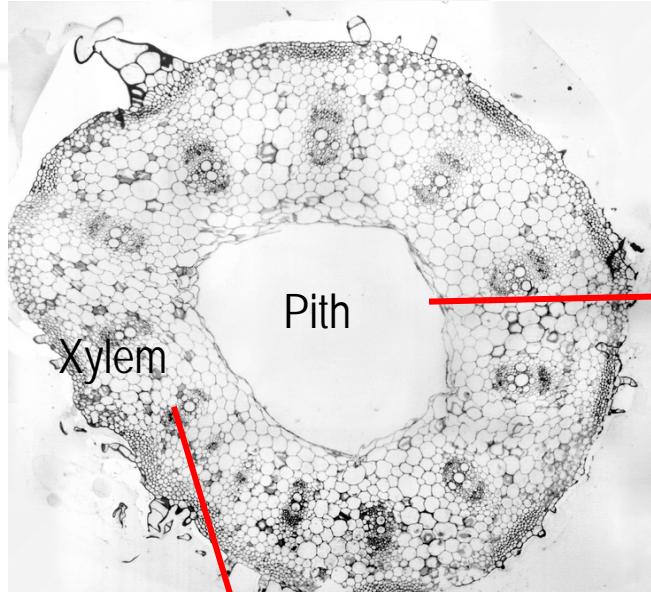
Pumking plants were selected due to the large size of the vessels

Method: Injection of the bioferrofluid inside the internal hole hollow of the leaf petiole

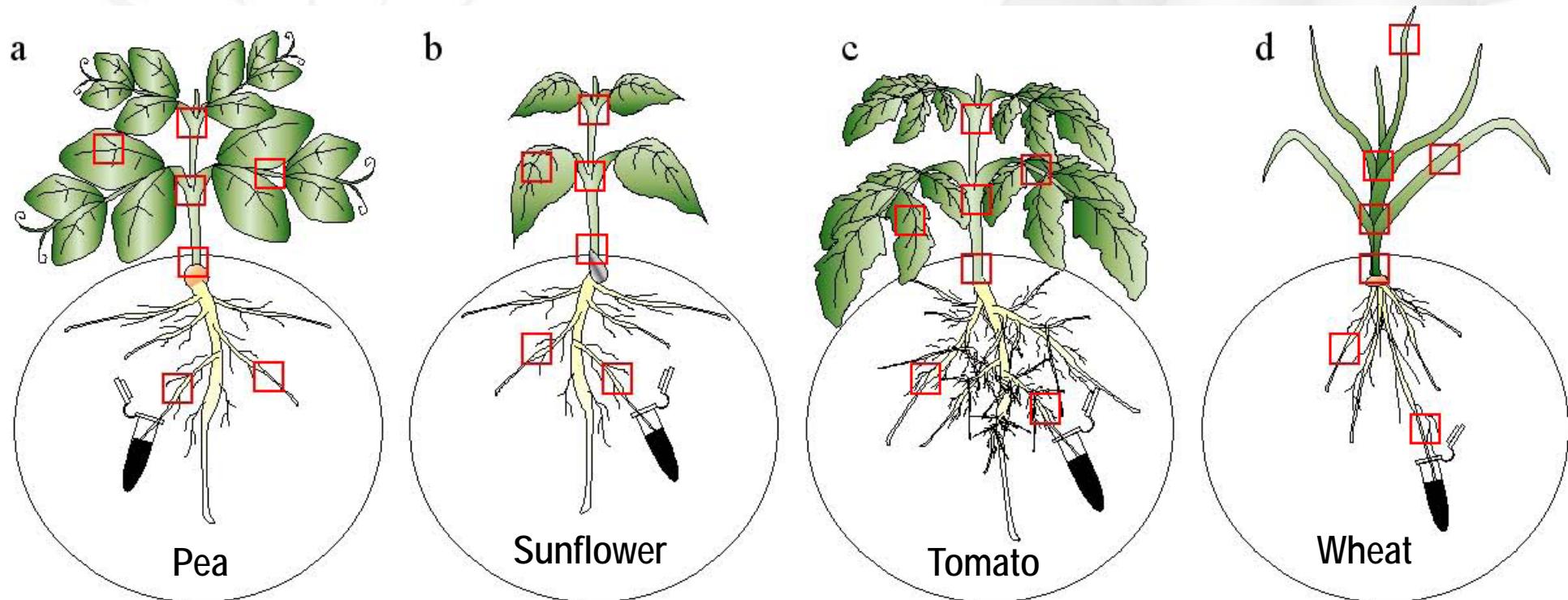


LOCATION OF NANOPARTICLES AT PARENCHYMATIC CELLS

Ecology 9 (2009) 45



MECHANISM OF NANOPARTICLES TRANSLOCATION IN PLANTS



-Nanoparticles move upwards through the xylem vessels following the transpiration stream and also downwards by source-sink pressure gradient perhaps through the phloem

-There are evidences of the radial transport out of vascular system after 48 h probably by transcytosis mechanisms.

-It is clear that plants can tolerate the core-shell nanoparticles, and that they can be used for localized treatments and gen transformation, but research activity should be focused on the possible accumulation and trafficking to the animals blood stream by the food chain

Impact in environmental sciences



-Clean water

-Sensors to detect chemical and biological agents

- Nanofiltration for more efficient filters

- Particles including zeolites, nanoscale magnetite, dendrimers, and tunable biopolymers to scavenge metals

- Nanocomposites to remove metals from smokestack emissions

- Nanoscale photocatalysts, nanoscale zero valent iron, and polymeric nanoparticles to address organic contaminants





Nano-bio team

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- Rosana Mayoral
- CERTEST-BIOTECH
- Prof. Paulo Freitas

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- Nanoscale Biomagneti

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- Veterinarian Hospital
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