Le giornate della salute e del benessere: Innovazione e Ricerca

Milano, 30 Giugno - 1 Luglio

FAST, Piazzale Morandi 2

L'utilizzo dei nanomateriali e delle nanotecnologie nell'industria e nel settore medico: vantaggi problemi e prospettive future

Giovanni Baldi

Cericol Research Center Colorobbia Consulting

Good incorporating nanotechnology-enabled elements

Nano-Enabled Products

Intermediate products with nanoscale features

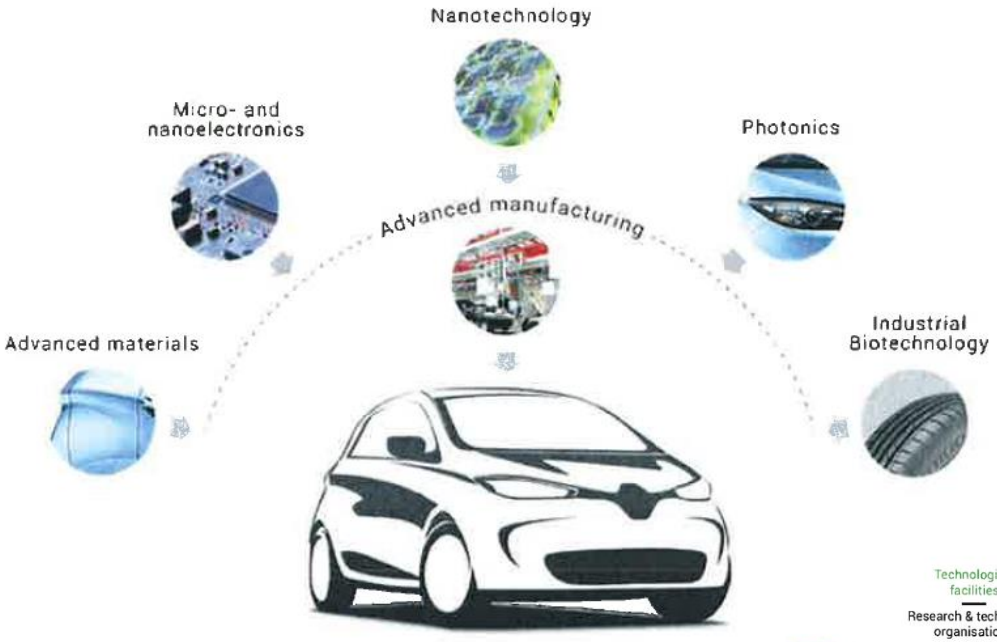
Product Formulation

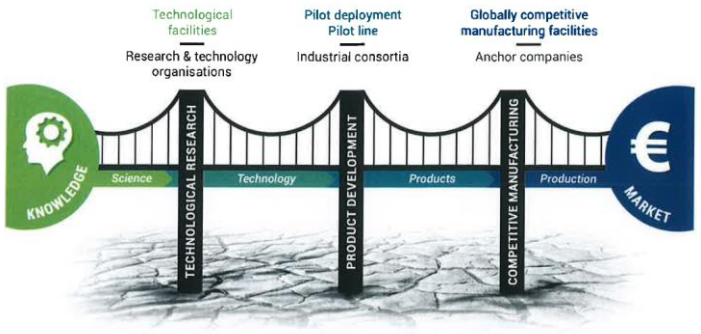
materials science nanotechnology

Nanoscale materials in unprocessed form

(Nano)materials development

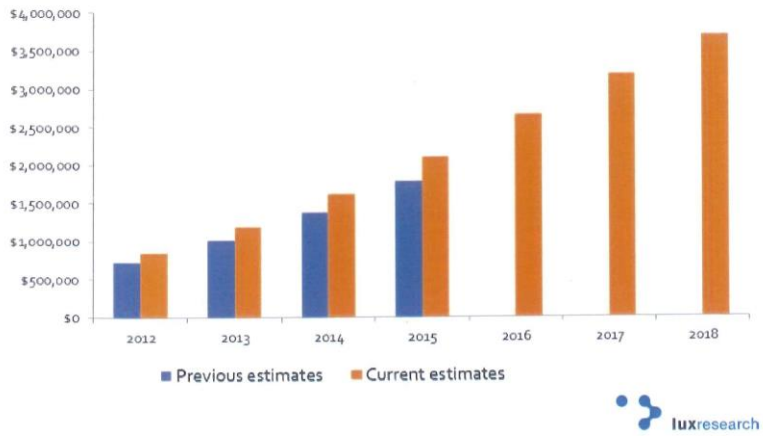
Key enabling technologies



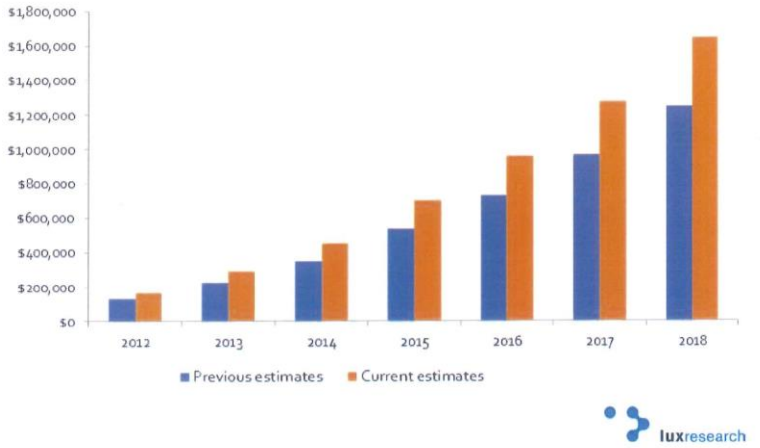


Crossing the KETs "valley of death"

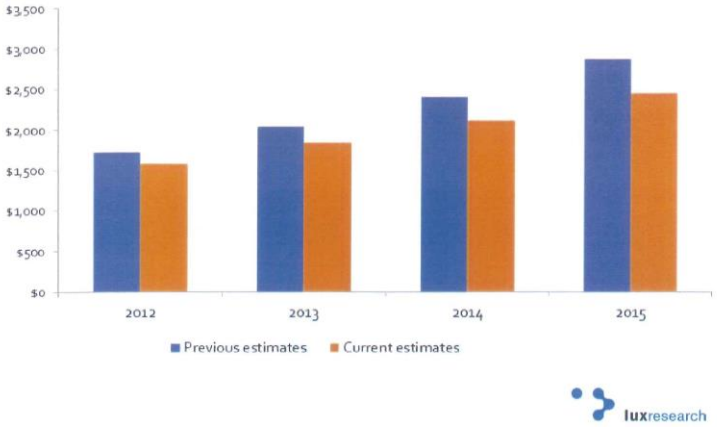
Nano-enabled product revenue
(US$ millions)



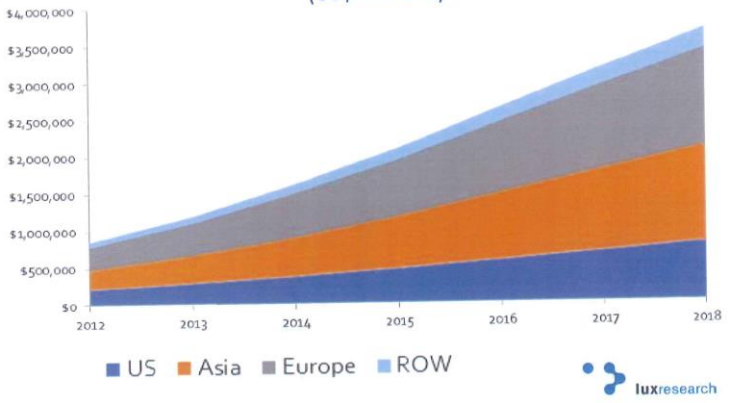
Nanointermediates revenue
(US$ millions)



Nanomaterials revenue
(US$ millions)



Nano-enabled product revenue geographical distribution
(US$ millions)

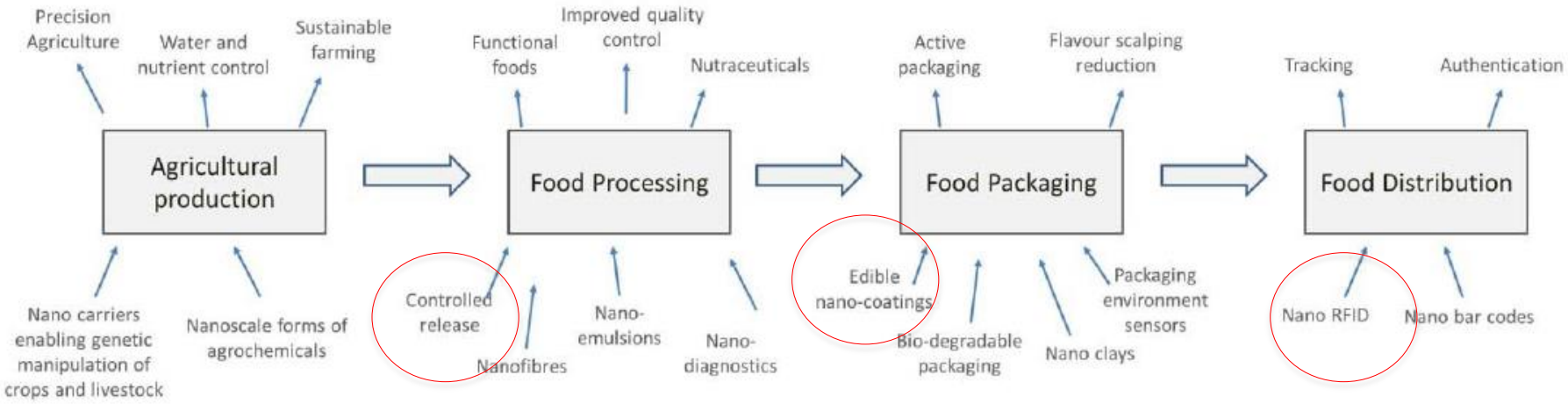


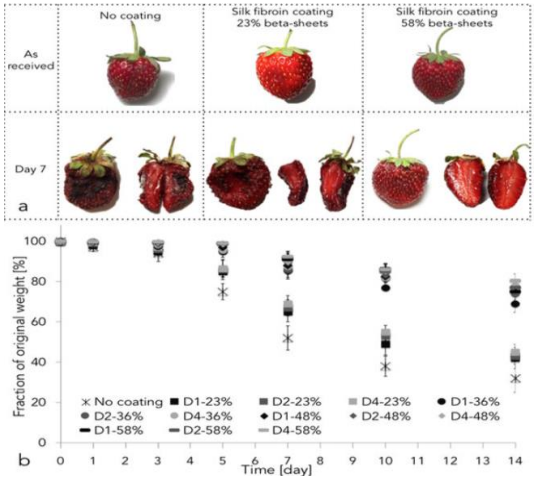
Value chains examples and technology convergence areas

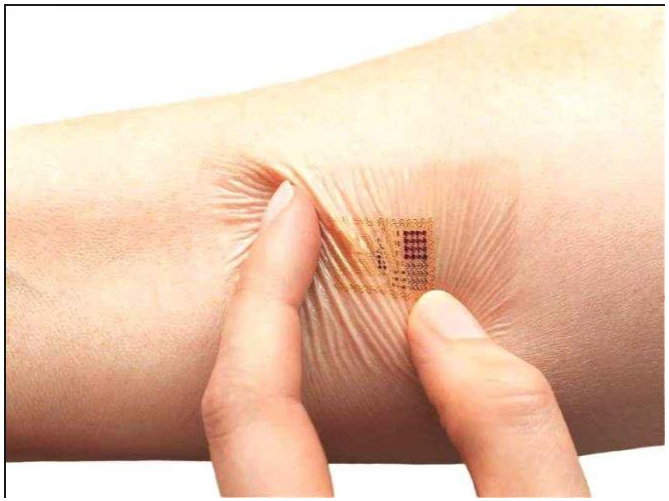
Nano-element	Function/role	Enabled innovation	Envisioned product
Nanomaterial	Antibacterial coating	Food processing	Safe Jam / Jelly
Nanocrystal	Photon conversion	Photo-voltaics	Competitive solar cell options
Nanobiosensor	Improved detection	Medical diagnostic	Disease detection
Nanobiopolymer	Biopolymer with Rigid and fluid impermeable	Food and drink packaging	Biodegradable and biosourced packaging

- Sustainable and green packaging (using nanobiomaterials)
- Targeted drug delivery and controlled drug release (using nanoparticles and nanobiomaterials)
- Neurotechnologies for healt and well-being (using nanomaterials and sensors)
- Food safety and security (throught advanced sensors)

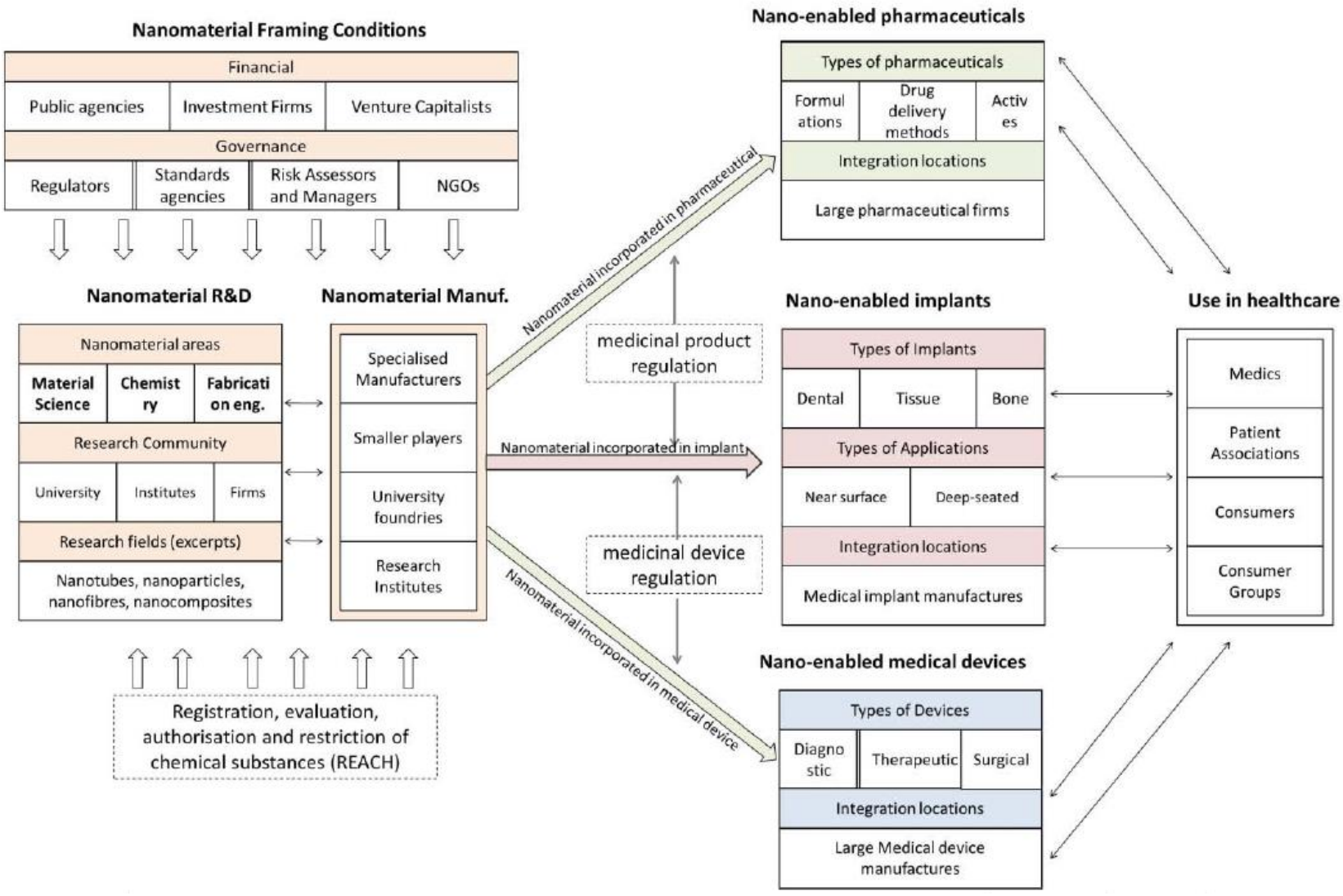
Food value chain from farm to fork



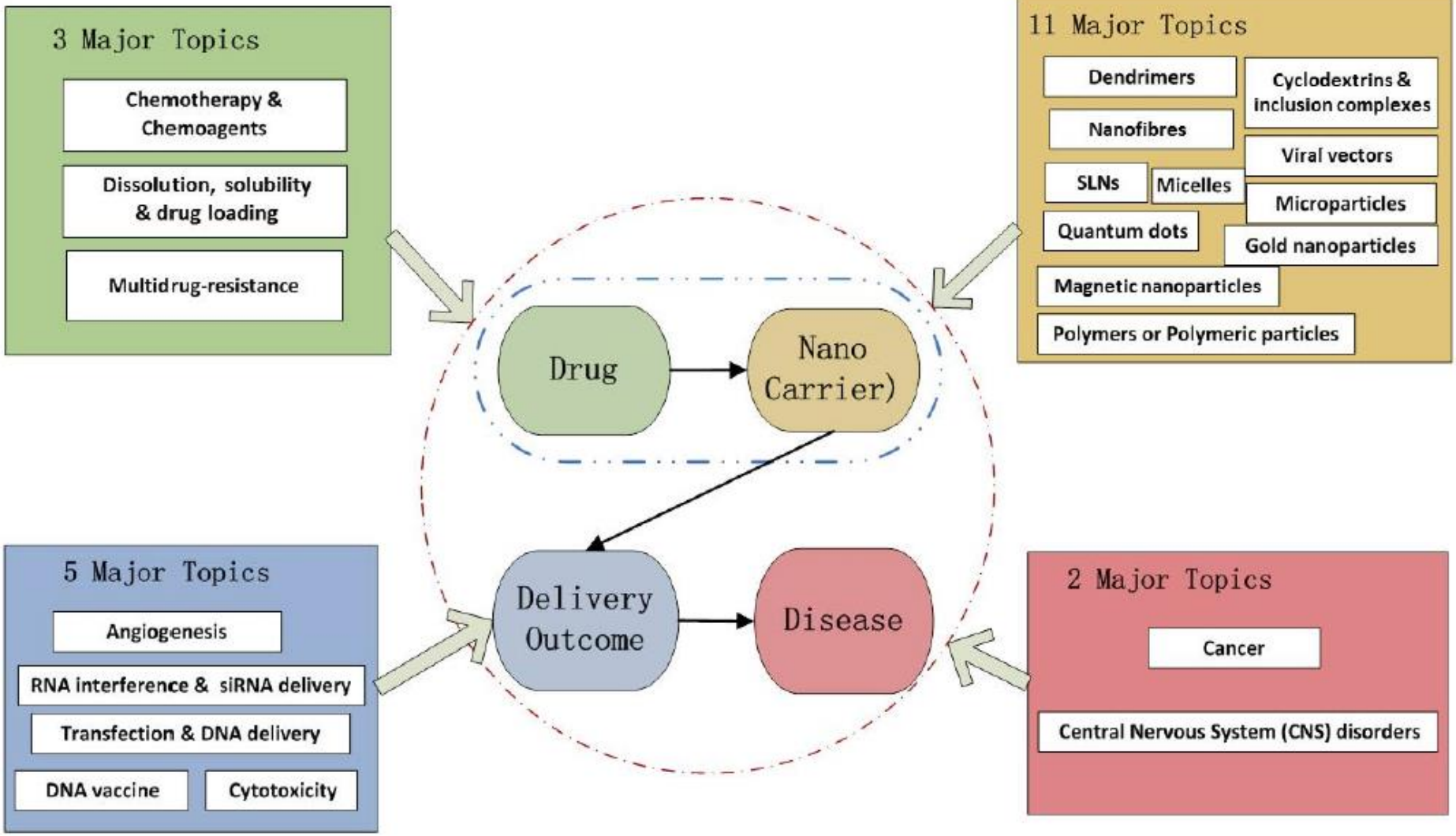




Nano enabled products in medical areas



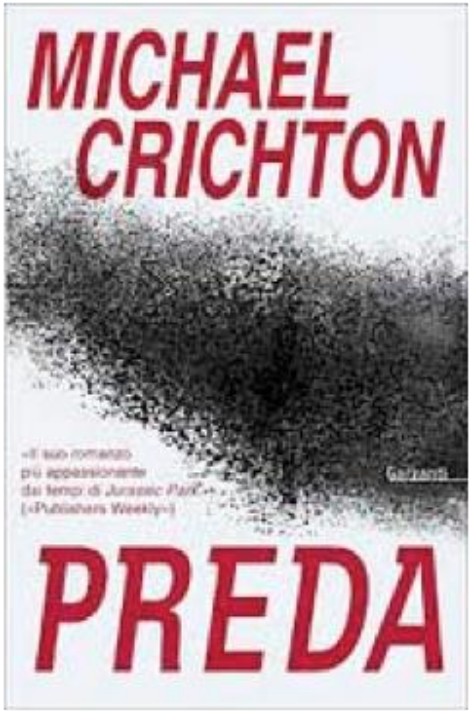
Nano enabled drug delivery system

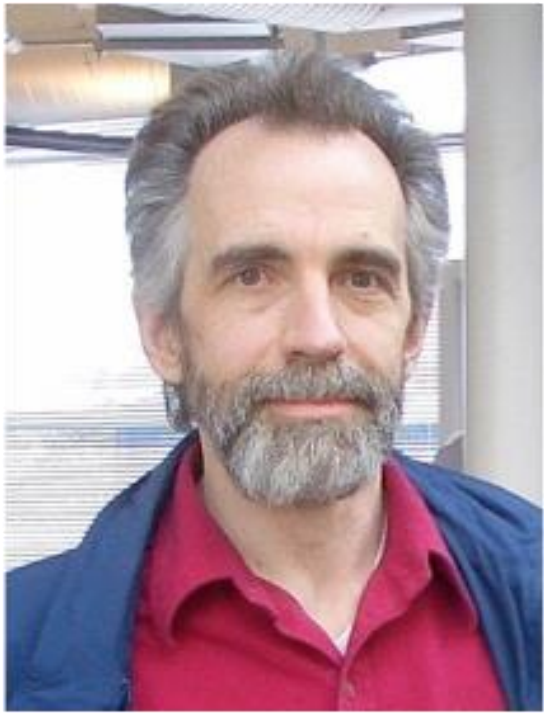


Adapted from Zhou, X., A.L. Porter, D. K. R. Robinson and Y. Guo, (201

Nanomateriali: opportunità o minaccia?

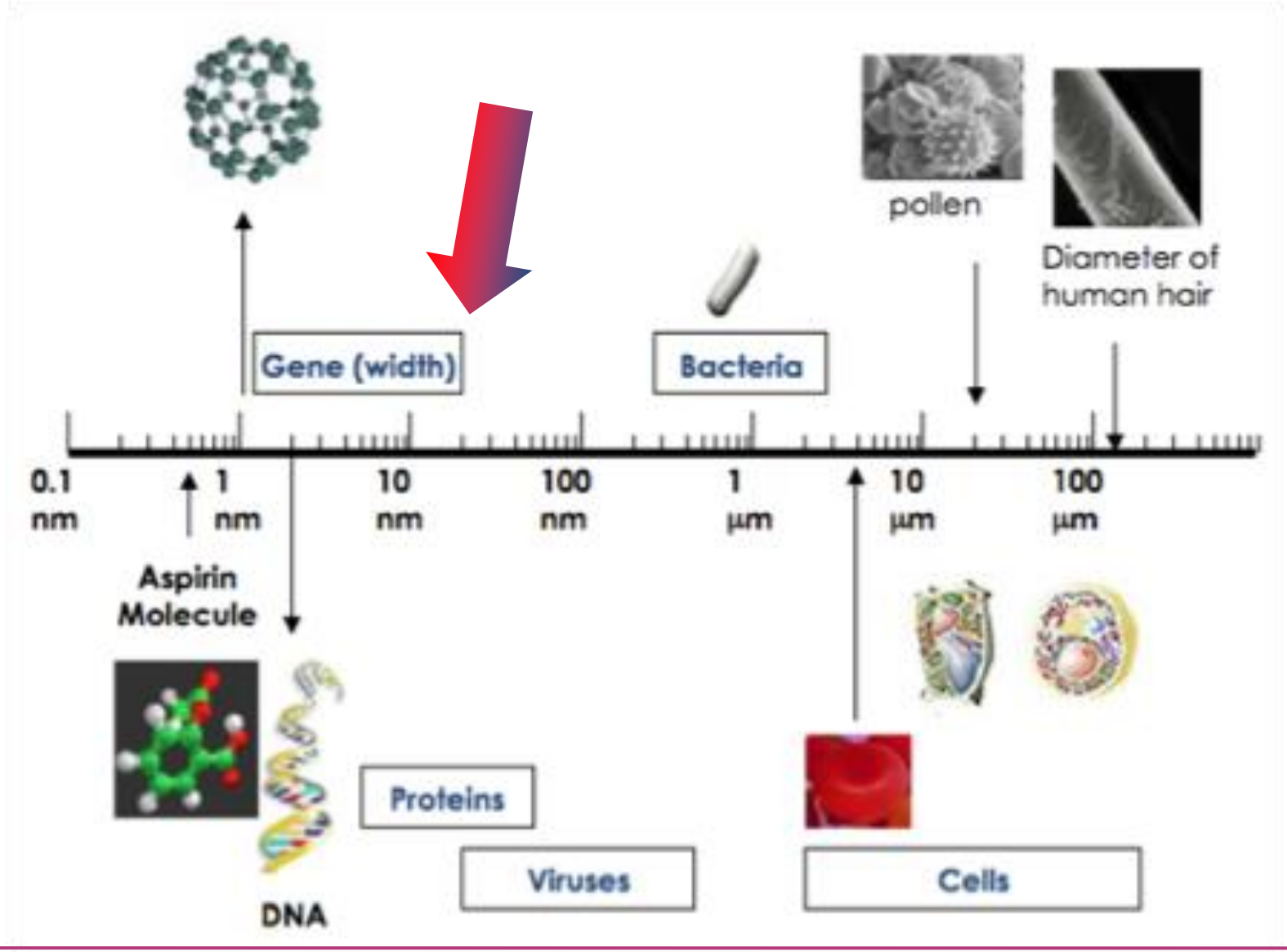
GREY GOO, la “nuvola oscura” dell’apocalisse



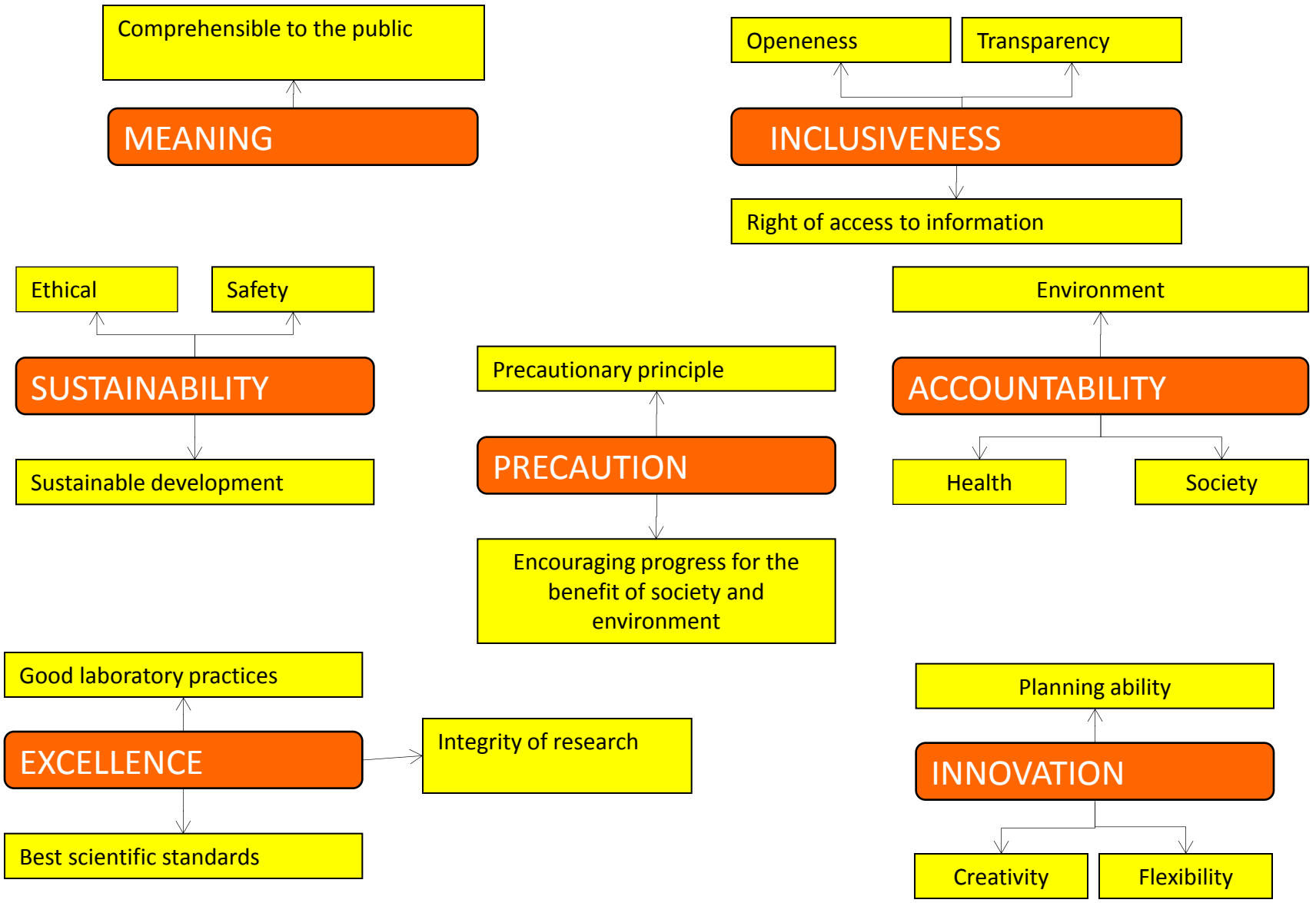


Eric Drexler: Motori di Creazione

Nanomateriali: opportunità o minaccia?

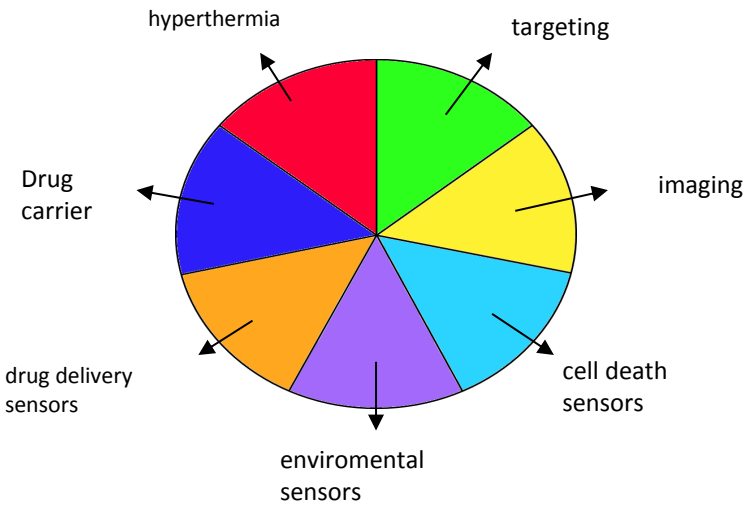


The Nano-map to the sustainable development of nanotechnology



The THERANOSTIC platform

(THERApy +-diagNOSTIC)



THERAPY

- Magnetic Fluid Hyperthermia
- Heat-Drug Action

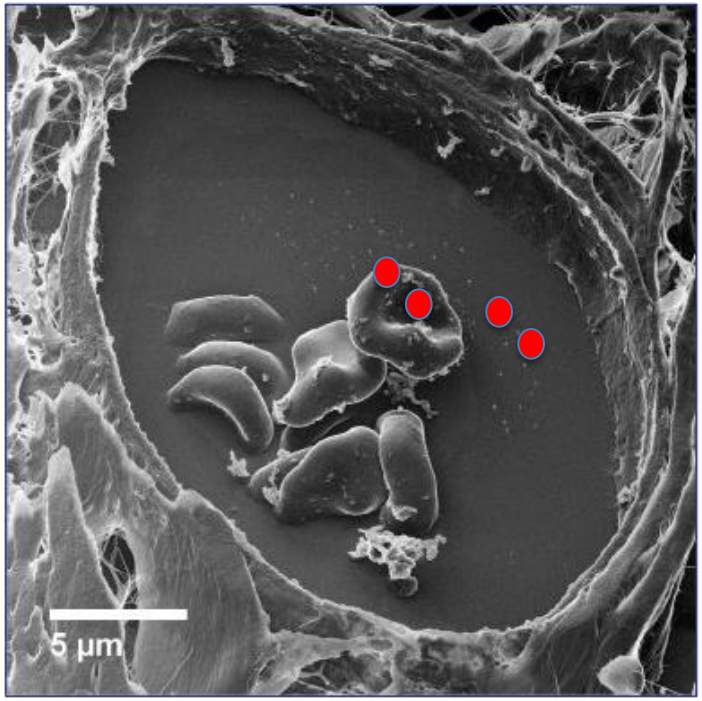
DIAGNOSIS

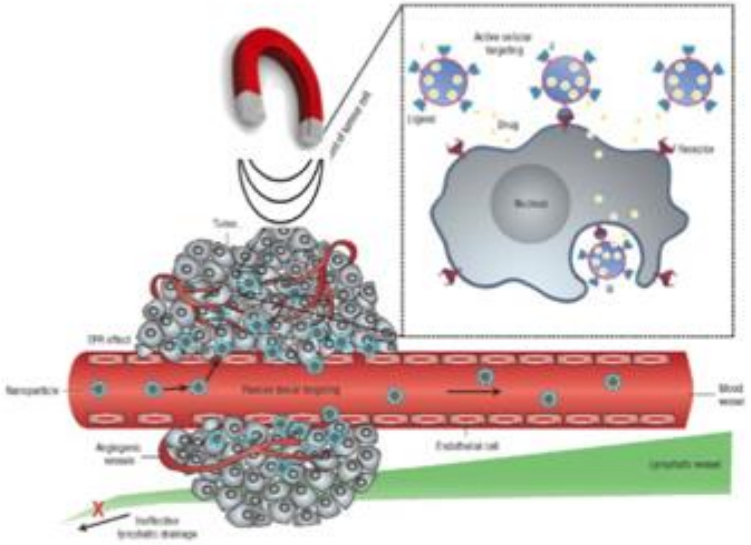
- Imaging MRI
- NIR Imaging
- SPECT-PET

SENSORING

- Temperature, pH nanosensors
- Drug release sensors
- Cell death sensors

Mechanism of systemic nano delivery





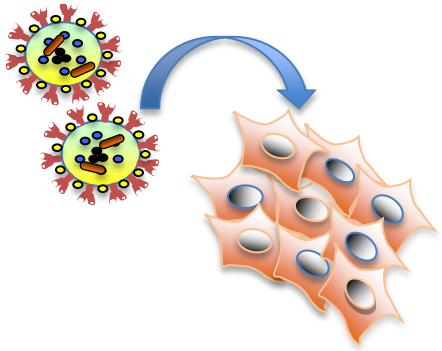
- **EPR Enhanced permeation and retention**
- **Active Cellular Targeting**
- **Magnetic targeting**

The THERANOSTIC approach

Hybrid Au/magnetic nano-carrier features

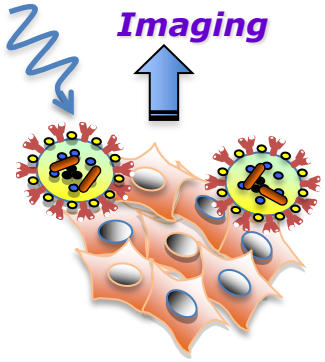
TARGETING

Systems containing specific targeting unit may be selectively accumulated around the tumor cells



DIAGNOSIS

The loaded magnetic nanoparticles can be visualized with specific imaging techniques (**MRI**); the labeling with ***fluorescent dye*** allows the Nano Bio Reactor to be used in **fluorescence imaging**



THERAPY

The hyperthermic activation, the controlled drugs release (**paclitaxel, doxorubicin, cis-platinum, gemcitabine**) and/or their joint action, act as therapeutic effect

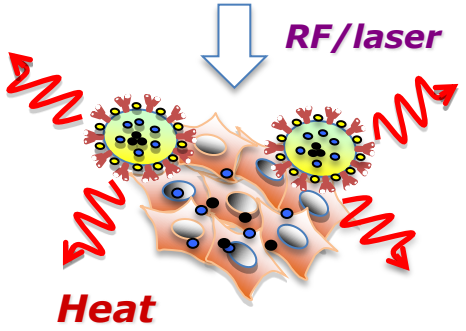


Photo-thermal transducer (gold nanorods): hyperthermia and drug release triggered by laser activation (surface penetration, ultra-fast conversion → extreme localization of the thermal effect), dark field microscopy, TC

Magneto-thermal transducer (magnetite nanospheres): hyperthermia and drug delivery triggered by magnetic activation (excellent penetration → no endoscopy/laparoscopy, slow conversion); MRI

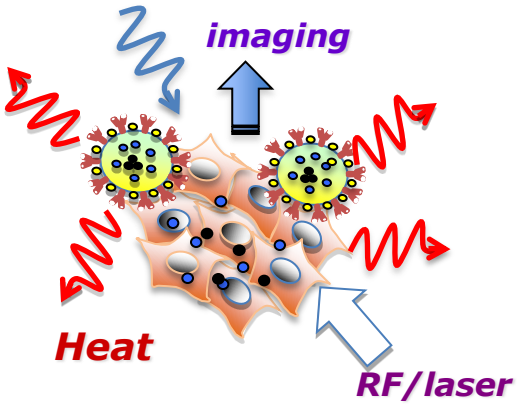
Fluorescent dye

Monoclonal antibody (***hERG; EGF***; …)

Biocompatible Copolymer (***PLGA-PEG***)

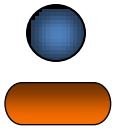
Theranostic Object: Therapeutic and diagnostic Joint action.

THERANOSTIC



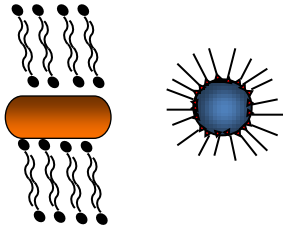
Nano-engineering platform

Magnetic nanoparticles synthesis



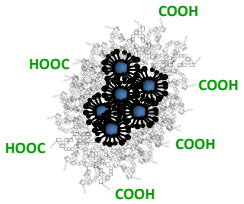
Gold nanorods synthesis

Functionalization



Functional Biopolimer

Encapsulation



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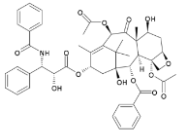
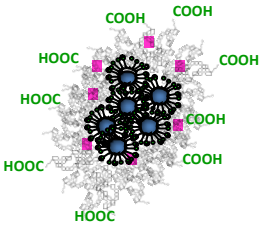
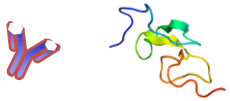


PLGA-PEG-COOH

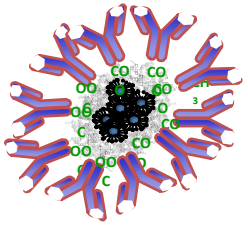


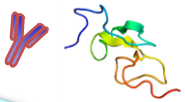
Drug loaded nano bio reactor

Targeting

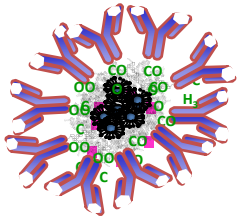


Targeting
Labelling
Loading



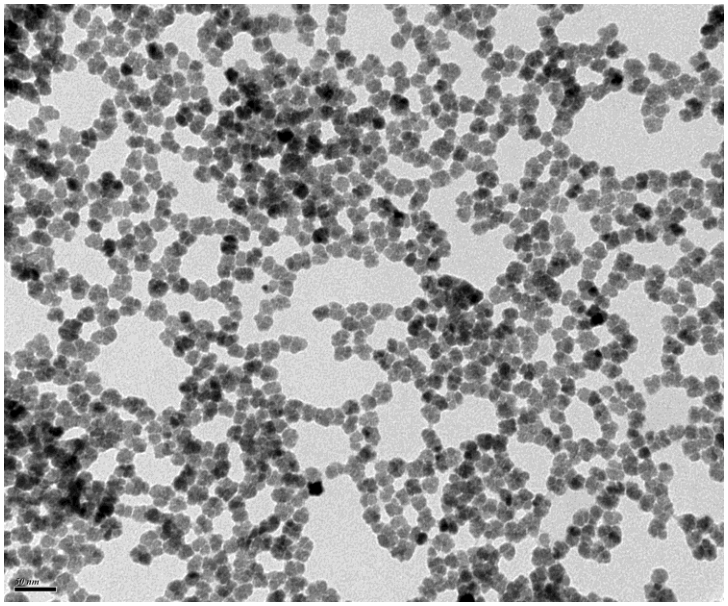


Targeting

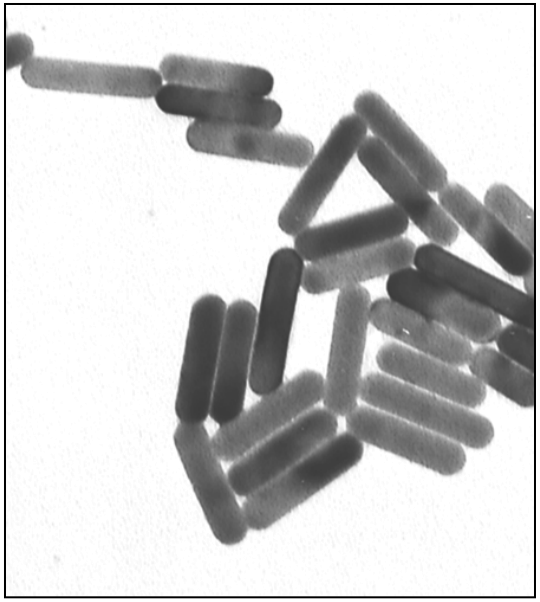


Nano-engineering platform

Nanoparticles



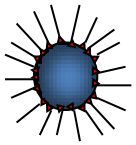
Fe3O4 superparamagnetic nanoparticles



Au^0 nanorods

Nano-engineering platform

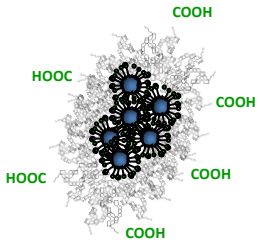
Magnetic nano bio reactors

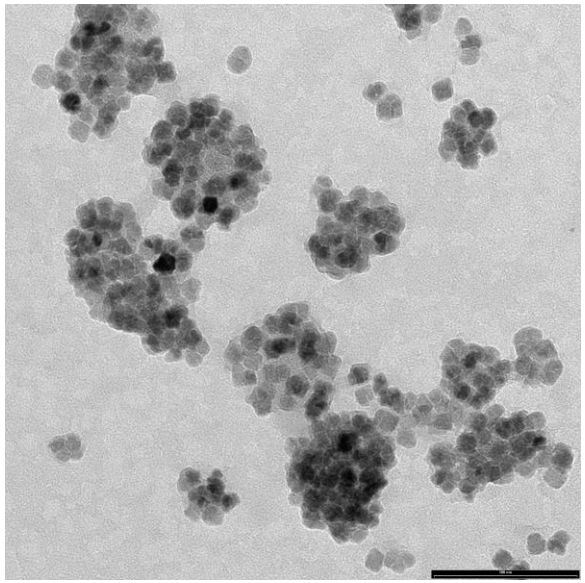


Fe_3O_4 nanoparticles

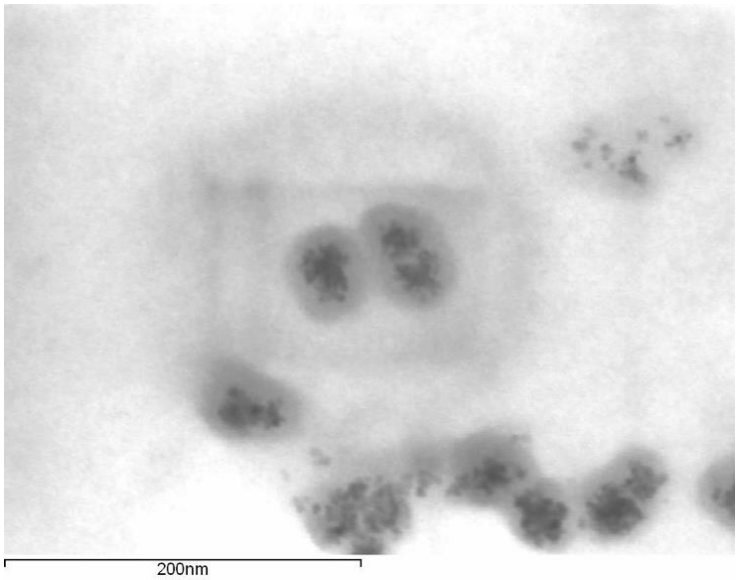
PLGA-PEG-COOH

HSA





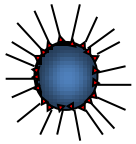
Hybrid magnetic Nps coated with PEG-PLGA polymer



Hybrid magnetic Nps coated with albumine

Nano-engineering platform

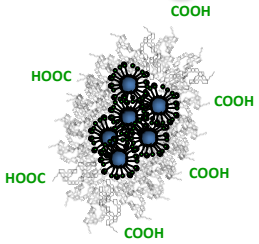
The magic bullet



Fe_3O_4 nanoparticles

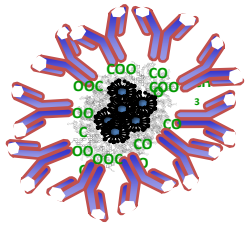
PLGA-PEG-COOH

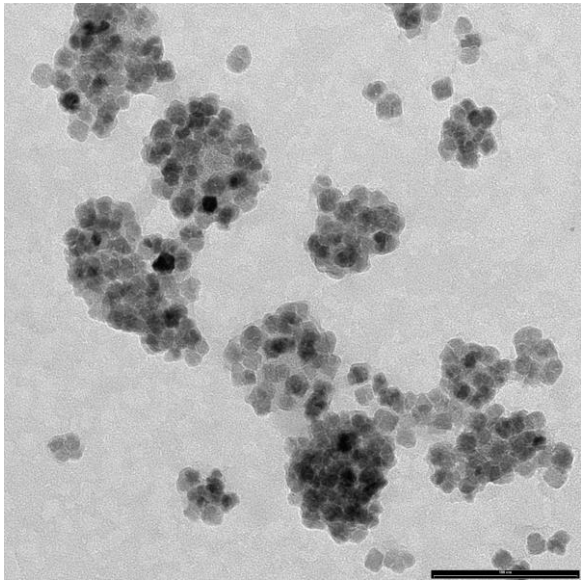
HSA



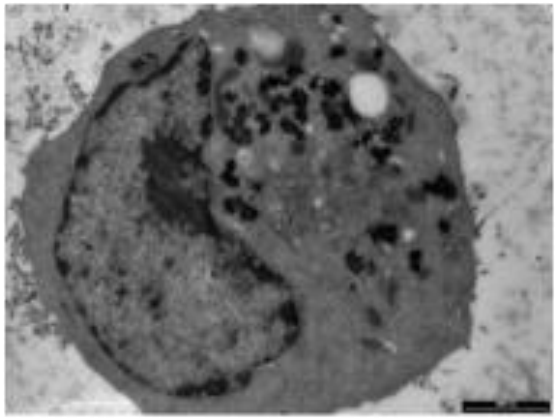
Peptides, MbA

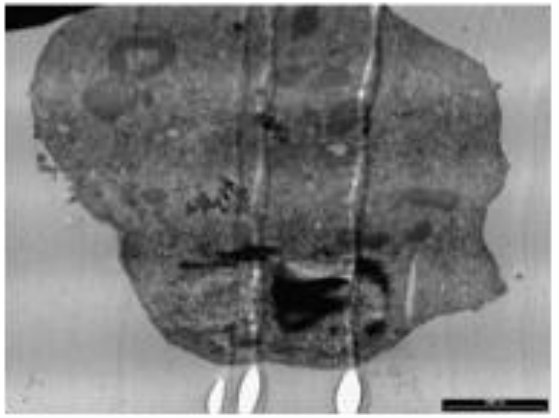
Fluorophores



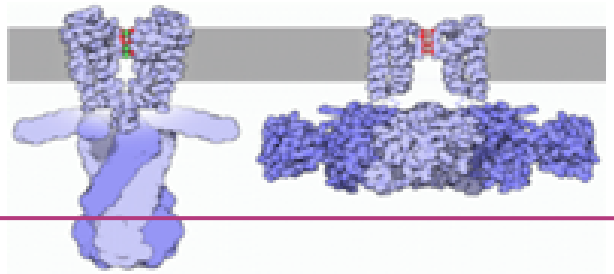


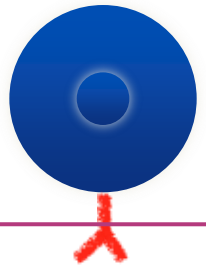
Hybrid magnetic Nps coated with PEG-PLGA polymer and linked with h-Erg1





Up-take in MIA PaCa-2s





Steps towards theranostic: Magnetic Fluid Hyperthermia

Experimental approach to the determination of the power generated by magnetic fluids

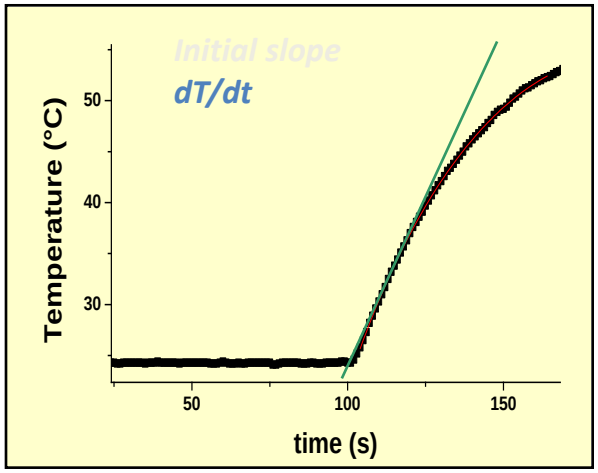
$$SAR = \frac{\sum_i m_i C_{si}}{m_{Oxide}} \cdot \frac{\Delta T}{\Delta t} \quad \left[\frac{W}{gr}\right]$$

i: *species involved in heat exchange;*

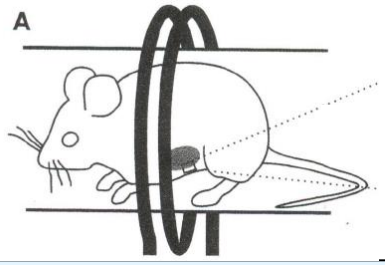
m_{Me}: *metal mass in the sample [g];*

t_{risc}: *irradiating time [s];*

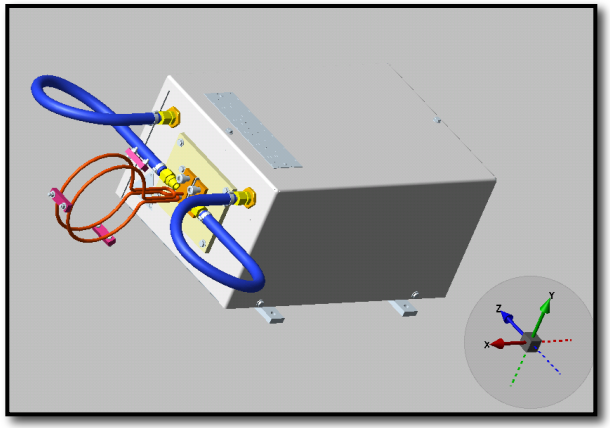
Q_i: *heat absorbed by each species ($Q_i = m_i * c_s * \Delta T$).*



Different coil diameters in order to host different samples (ϕ 3 - 15 cm)



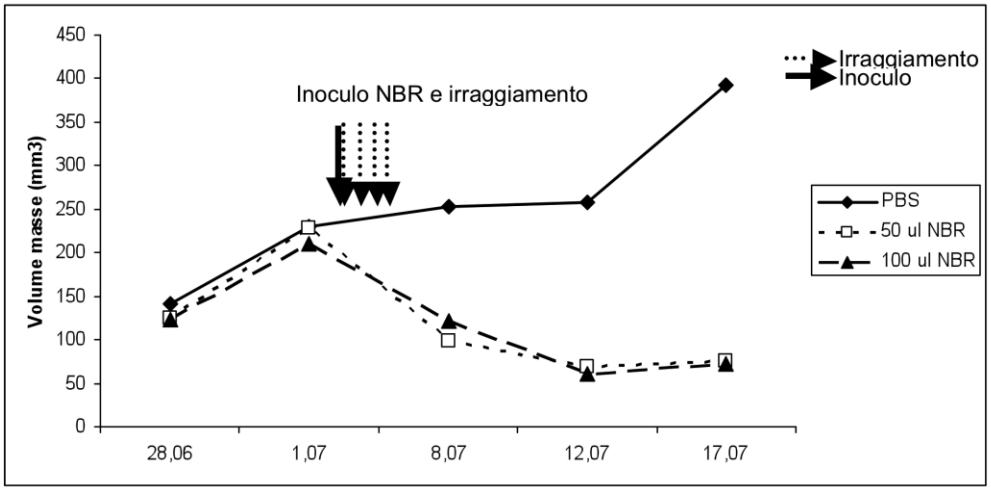
Even suitable for in vivo tests



Applied Conditions:	
Irradiating frequency	*100 - 400 kHz*
Heating time	*30 - 60 minutes*
Applied field	*15 - 20 kA/m*

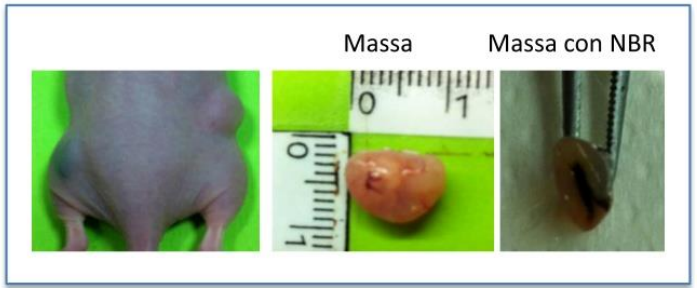
Preliminary studies: in-vivo hyperthermia

In-vivo efficiency test on xenograft model of pancreatic cancer PDAC cells

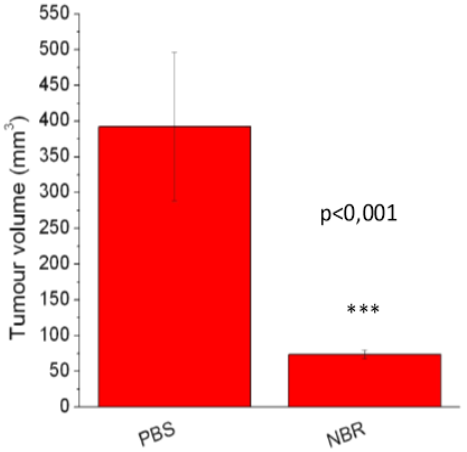


NBR "nude" particles 0,1%

Irraggiamento
Inoculo NBR

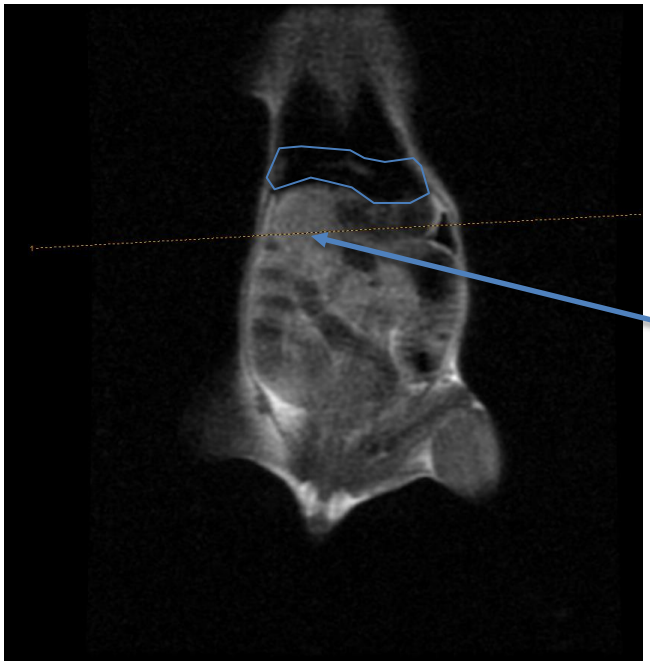


Efficacia irraggiamento

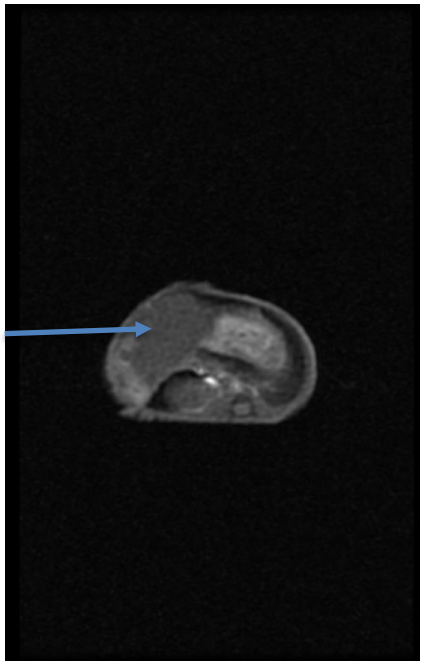


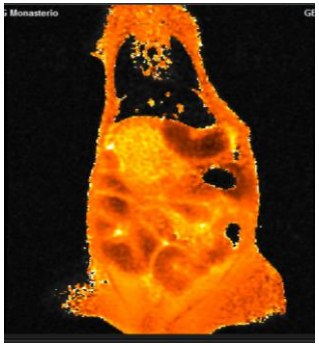
Steps towards theranostic: In vivo MRI

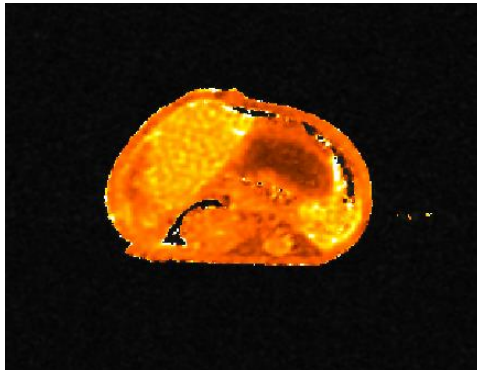
T2 weighted images of pancreatic tumours



Lesione







Tumour bearing mouse :
injected animal (mouse 6)
T2 weighted images of axial (right) and coronal (upper) sections

T2 mapping of the axial section (ms) *Yellow*

Conclusioni

Con la nanotecnologia si riesce a progettare un materiale a livello degli atomi e degli elettroni. In questa maniera possiamo sviluppare prodotti con caratteristiche nuove e peculiari.

La convergenza tecnologica in aree di ricerca strategica permette la creazione di catene del valore verso prodotti che integrano in maniera ottimale le nanotecnologie e KET. (Medicale-food-ICT)

In nanomedicina emerge con sempre maggior forza la necessità di sviluppare sistemi nano teranostici per la cura di patologie complesse (cancro, malattie neurologiche)

Come in tutti i settori della ricerca che studiano nuovi materiali e tecniche si deve porre la massima attenzione ad uno sviluppo sostenibile che tenga conto di principi etici di comportamento

Grazie per l'attenzione

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