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Consiglio Nazionale delle Ricerche

Institute of Nanotechnology – CNR (CNR-NANOTEC)

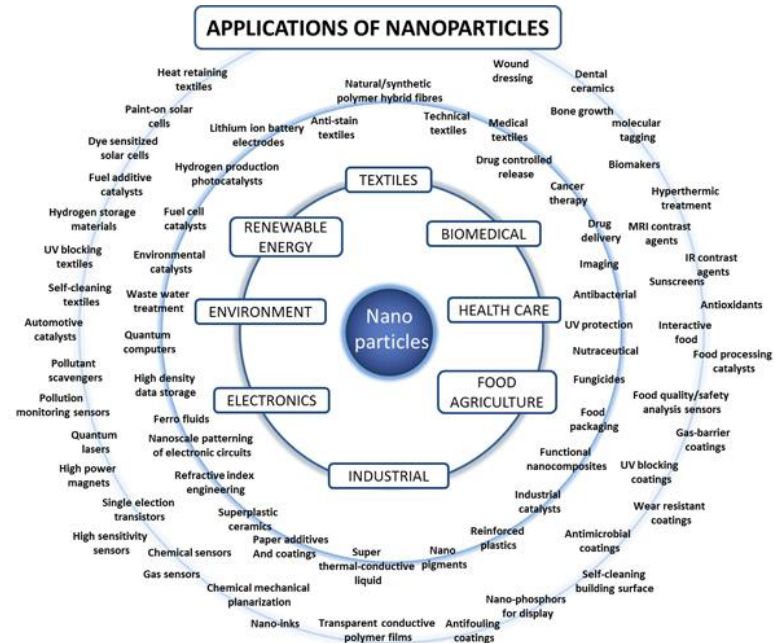
Via Monteroni, 73100 Lecce- Italy

**Di.S.Te.B.A. Department of biological and Environmental
Science and Technology
Via Monteroni 73100 Lecce - Italy**

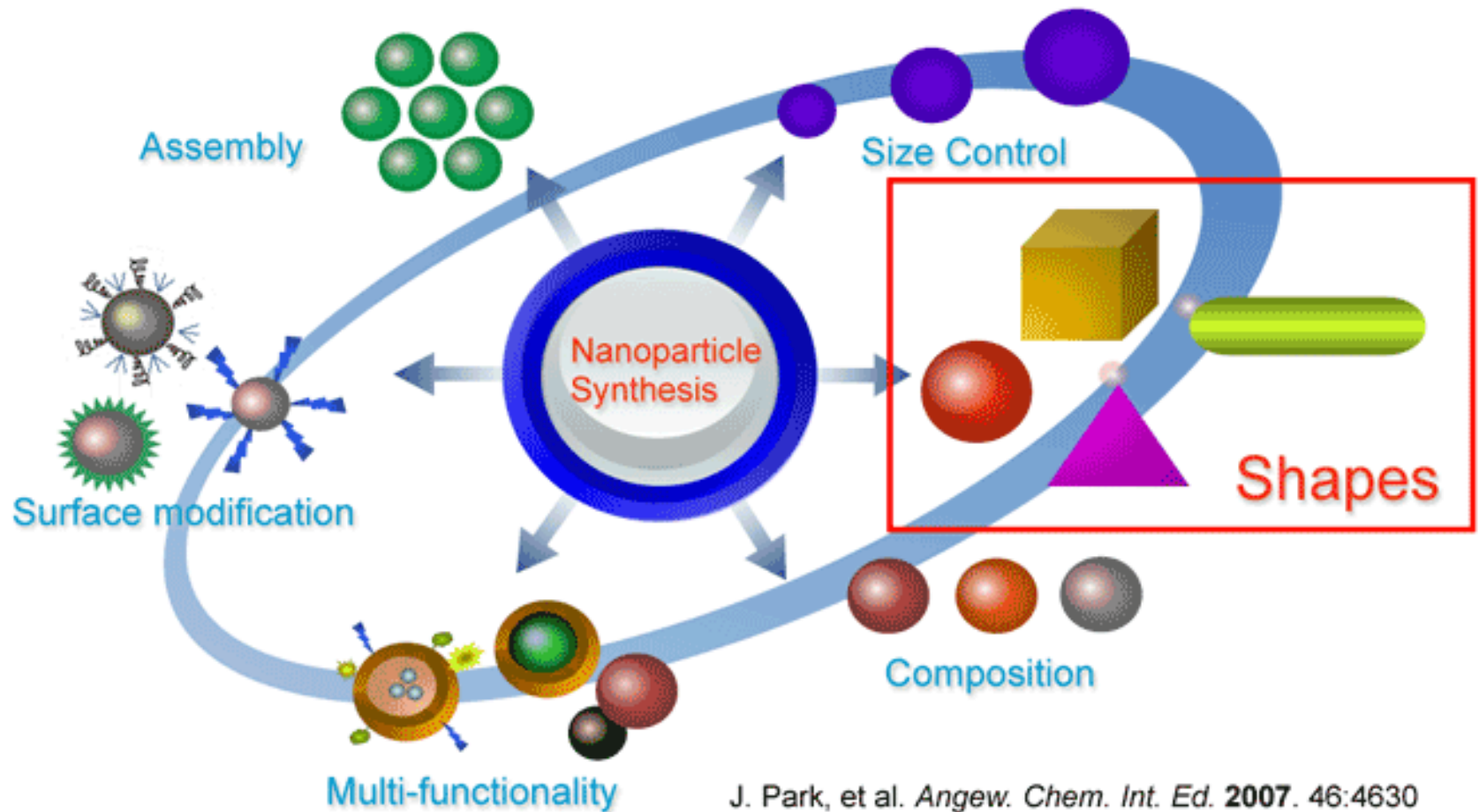
Glycans-based silver nanoparticles green synthesis: risks and benefits for human and environmental safety

Luciana Dini

*University of Salento (Lecce), Department of Biological and Environmental Sciences and Technologies (Di.S.Te.B.A.)
CNR Nantec*

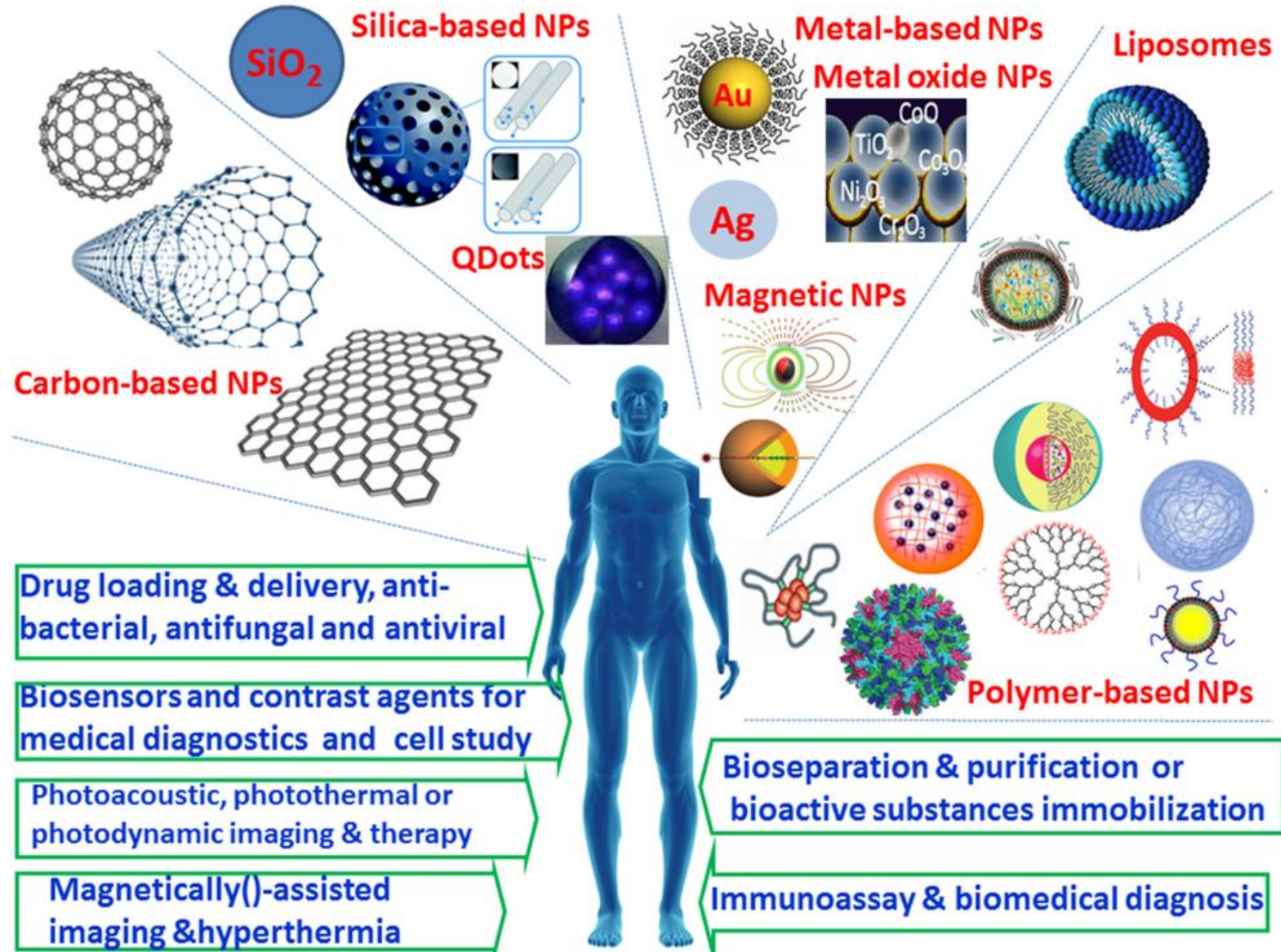


Nanoparticle Properties



J. Park, et al. *Angew. Chem. Int. Ed.* **2007**, 46:4630
S. Kwon & T. Hyeon *Acc. Chem. Res.* **2008**, 41:1696

Nanoparticles in medicine



Silver nanoparticles in commercialized products



Nano silver beauty soap



Nano silver hair shampoo



Nano silver body cleanser



Nano silver toothpaste



Nano silver hand sanitizer



Nano silver facial mask sheet



Nano silver skin care line



Nano silver makeup line



Nano silver wet wipes



Nano silver disinfectant spray



Nano silver toothbrush



Nanosilver hair conditioner



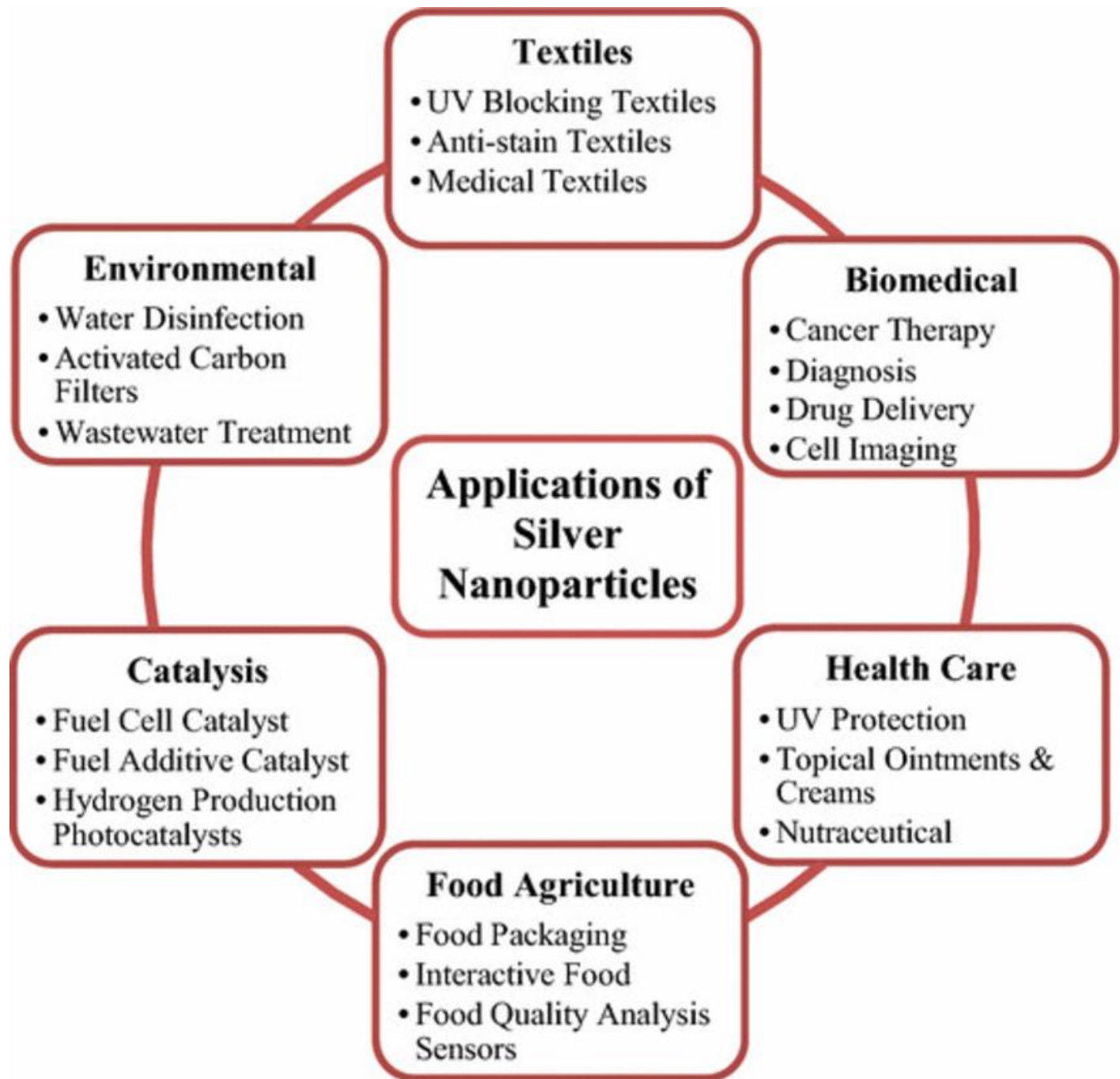
Nano silver wash dish & laundry detergent

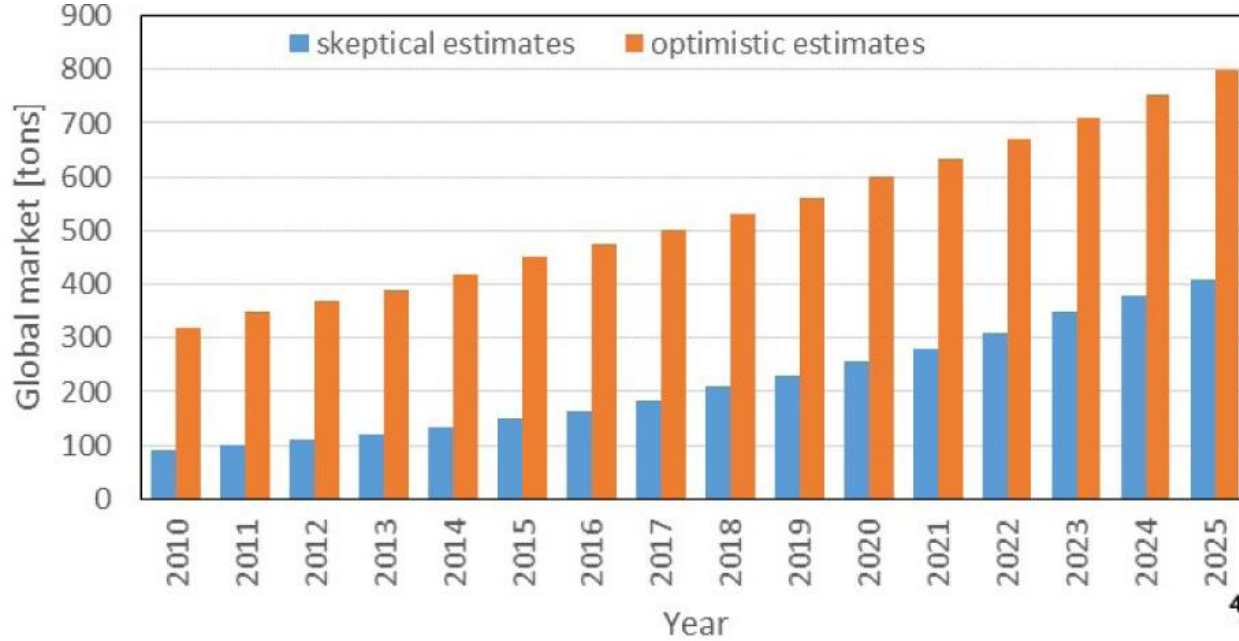


Nano silver colloid

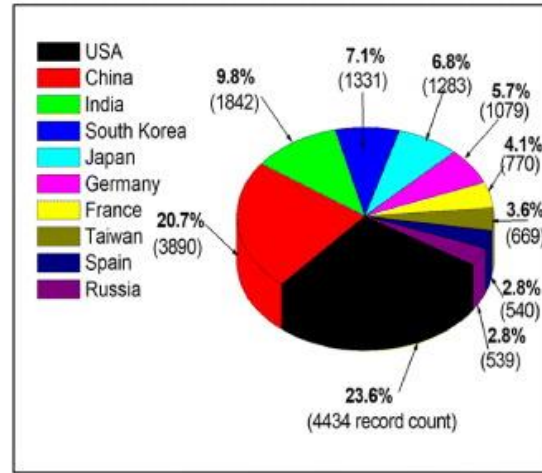
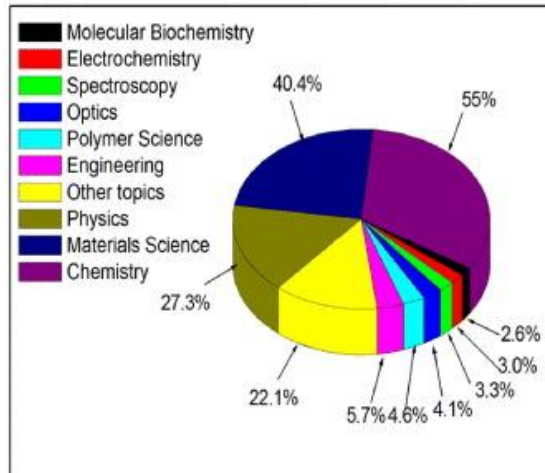
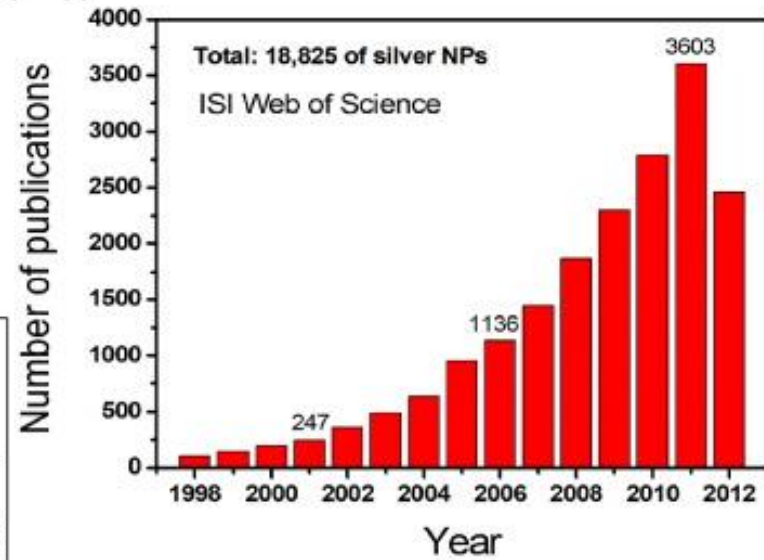


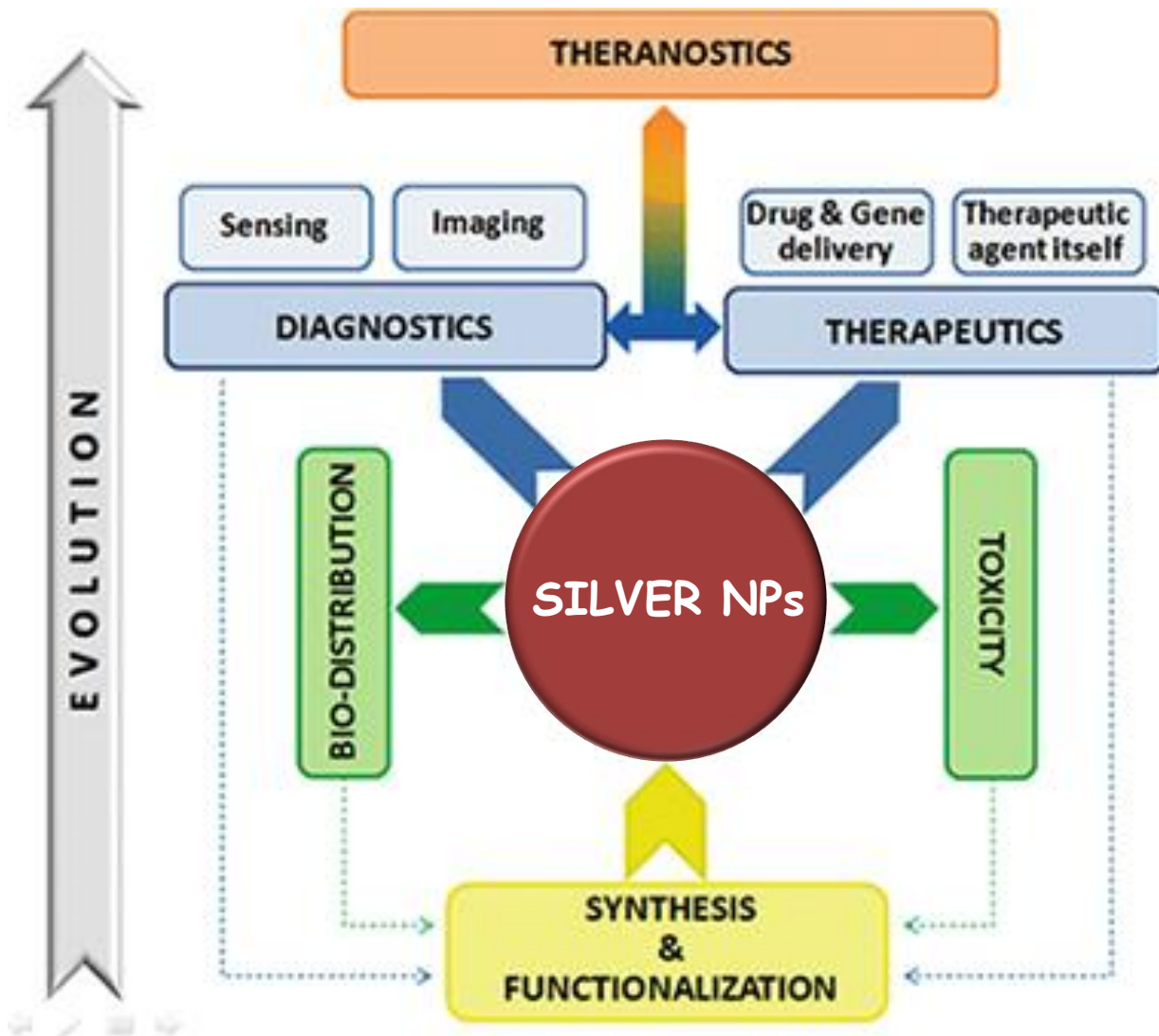
Nano silver antimicrobial masterbatch



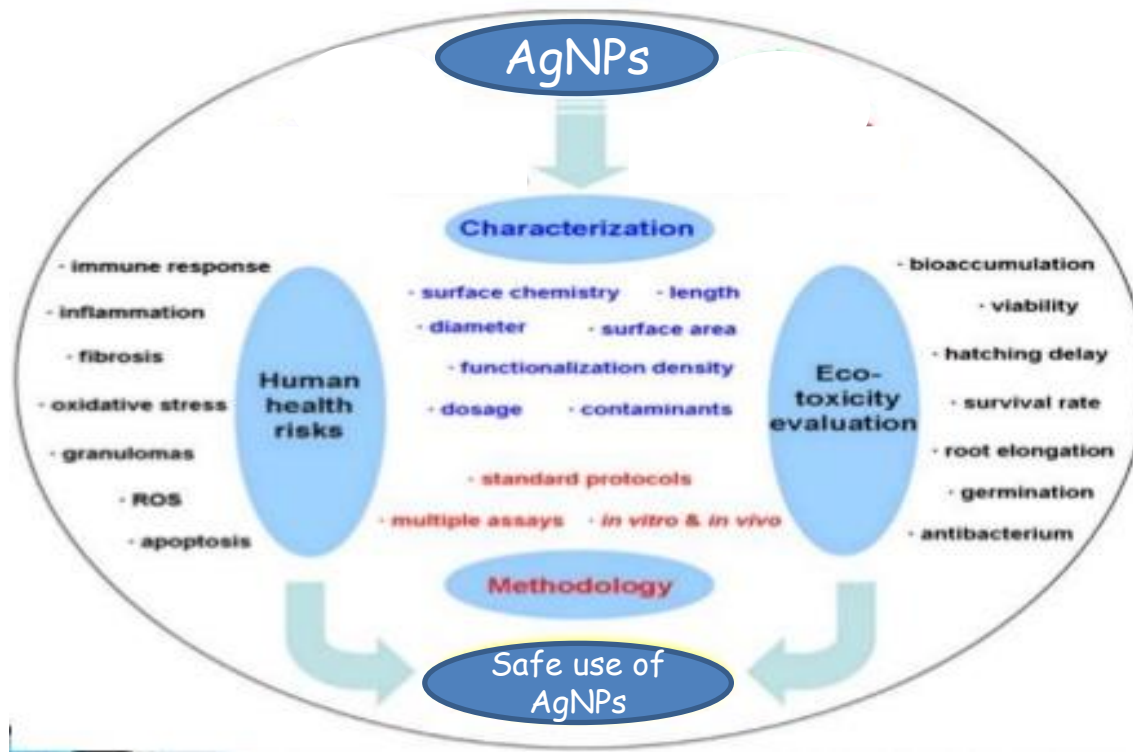


Silver nanoparticles papers





The Potential Hazards



There is growing attention to produce NPs using environmental friendly method (*green chemistry*)

Green synthesis approaches have advantages over conventional methods involving chemical agents associated with environmental toxicity.

AgNPs synthesis

Physical method



Ultrasonication
Irradiation
Laser ablation
Electrochemical
Microwave

Chemical method



Chemical reduction
Sol gel method
Inert condensation
method

Biological method



Microrganisms

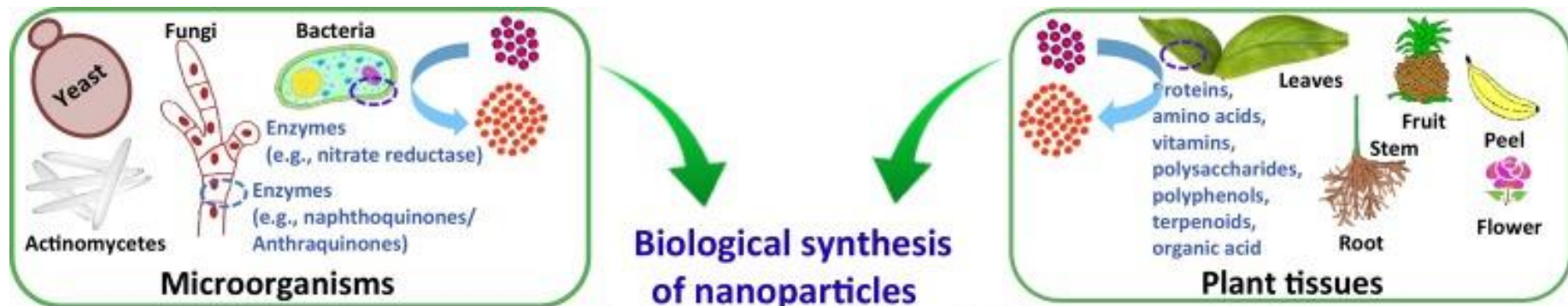


Plants

Green synthesis

Advantages: pure and well-defined AgNPs
Disadvantages: expensive, energy consuming,
potentially toxic

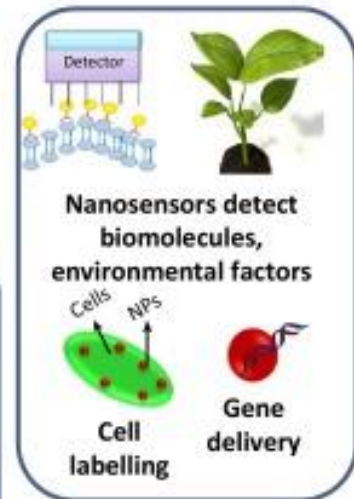
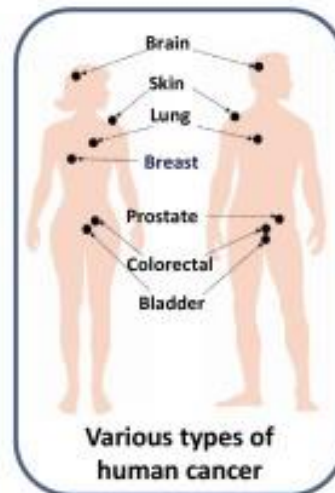
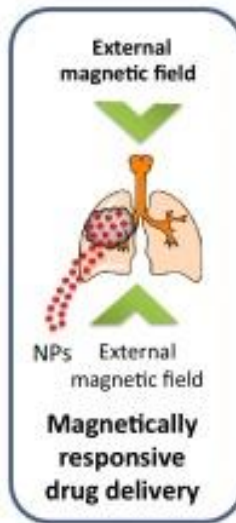
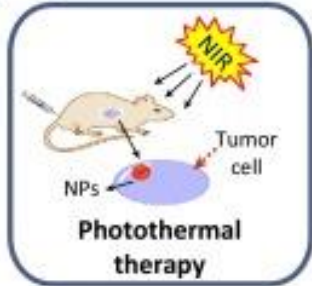
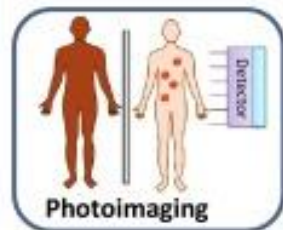
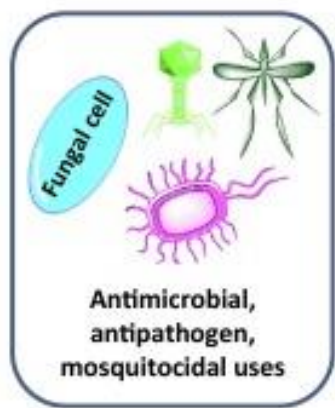
Advantages: free of toxic
contaminants AgNPs solution



- Metal salts
- Metal nanoparticles (NPs)



Applications



- █ Most applicable area
- ▬ Second most-applicable area
- ⋯ Applications under clinical trial

Silver nanoparticles and human health

In vitro toxicity

Toxicity in mammalian cells derived from skin, lung, liver, kidney, brain, vascular system and reproductive organs

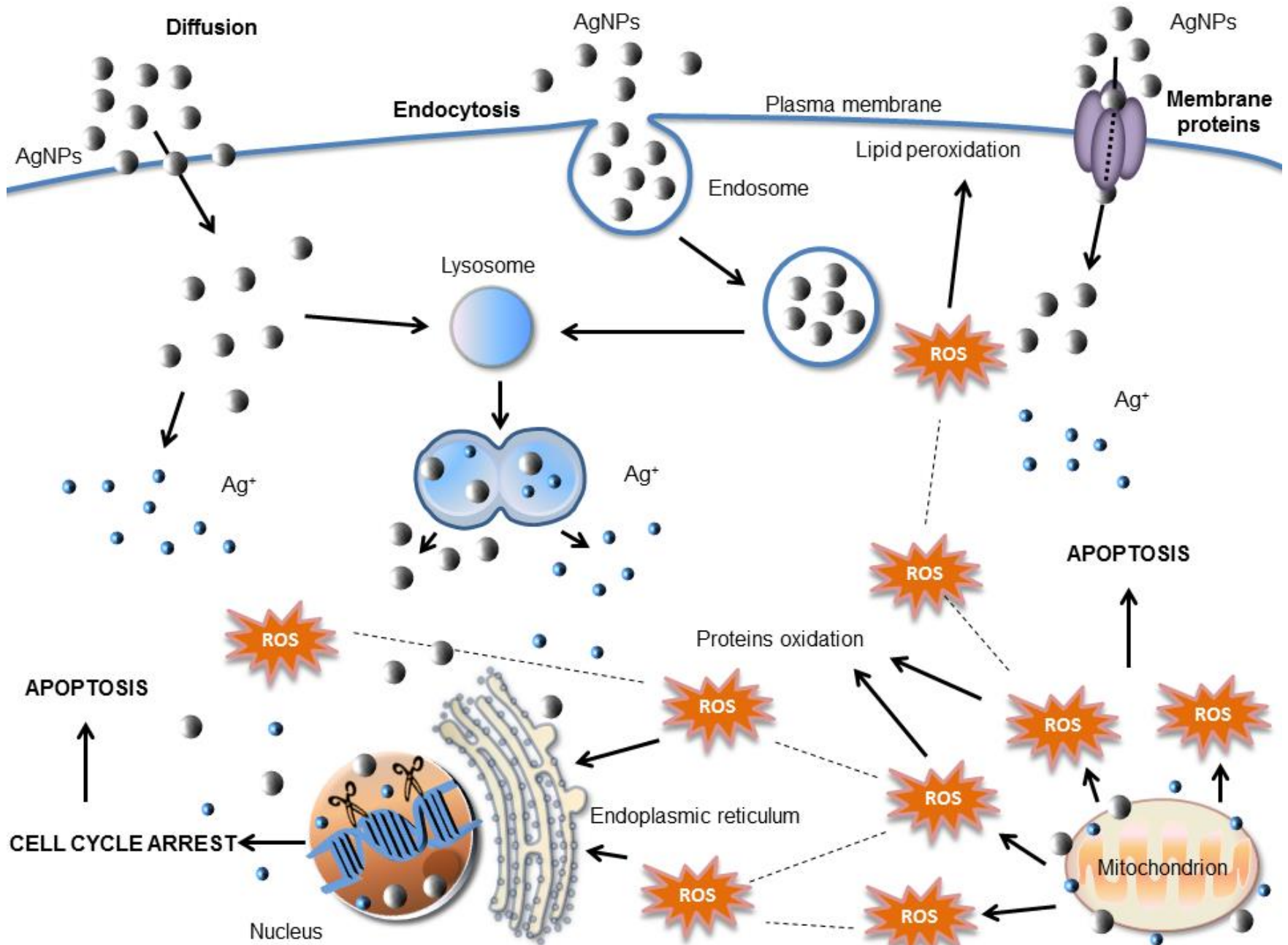
In vivo mammal toxicity

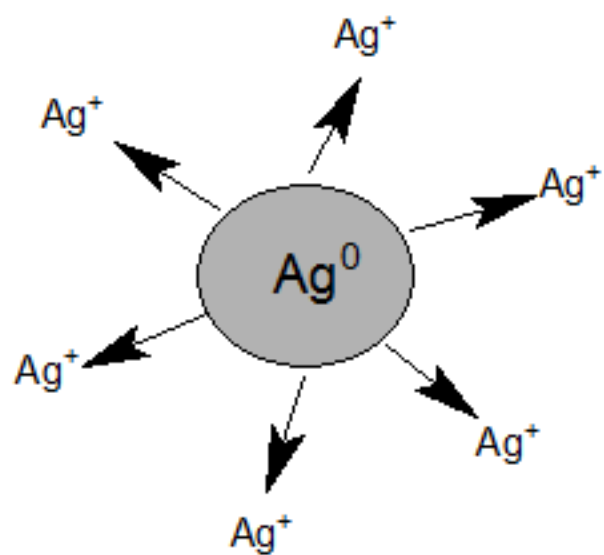
Systematic biodistribution and toxicity to different organs including lung, liver, and brain of mice and rats

In vivo non-mammal toxicity

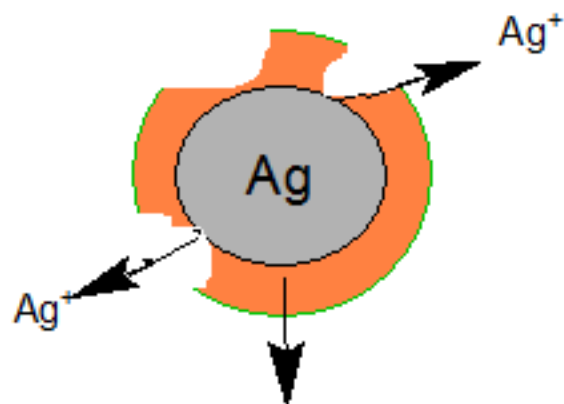
Produce developmental and structural malformations in zebrafish, drosophila and fish

Mechanism of toxicity of AgNPs on cells

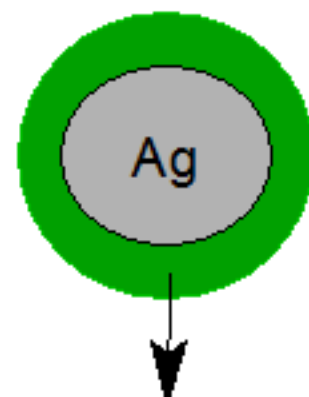




No surface coating
High dissolution

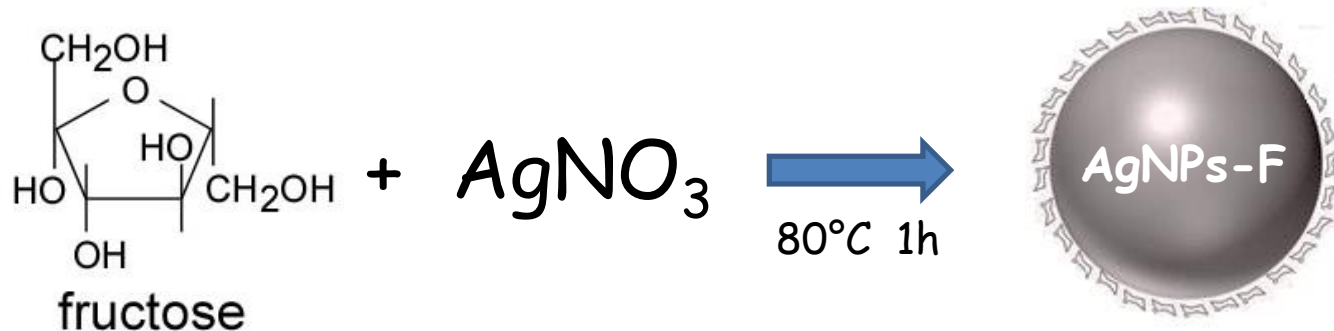
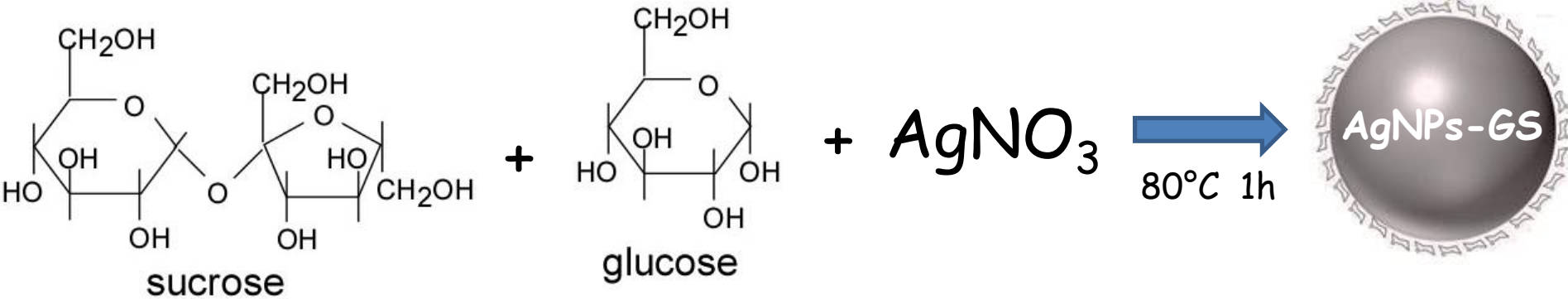
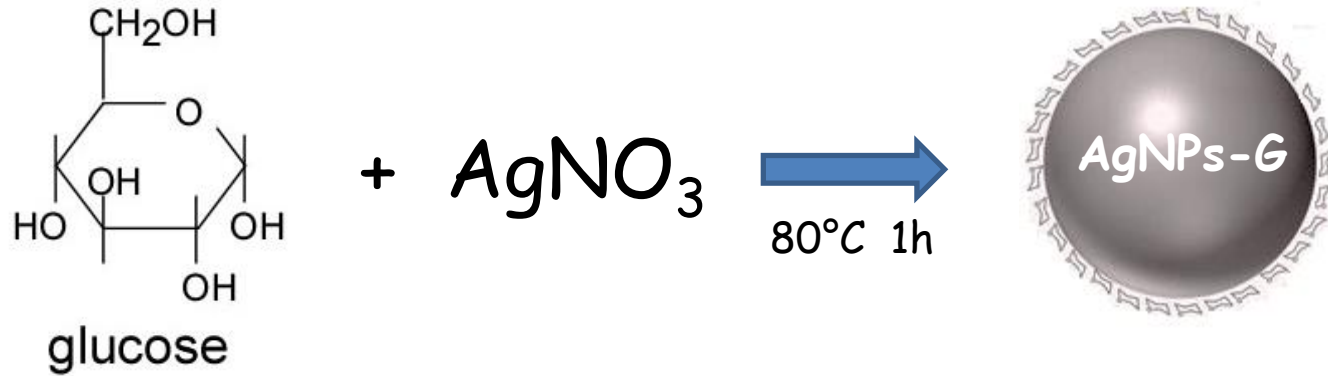


Weak surface coating
Low dissolution

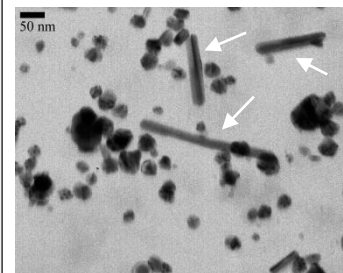
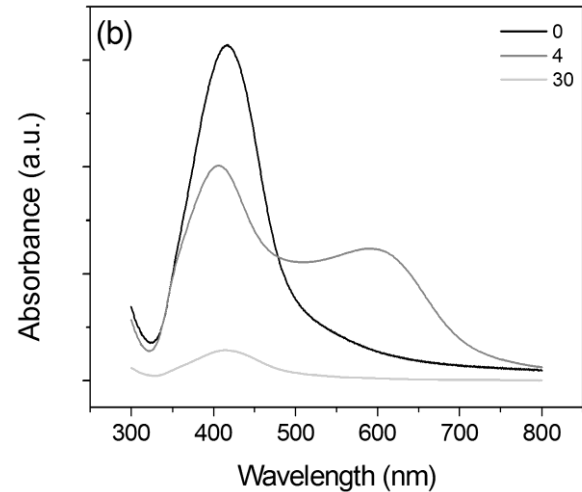
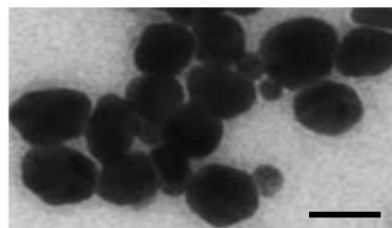
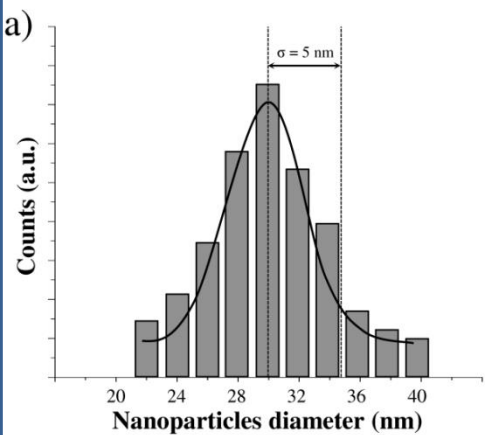


Robust surface coating
No dissolution

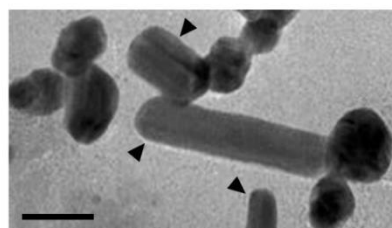
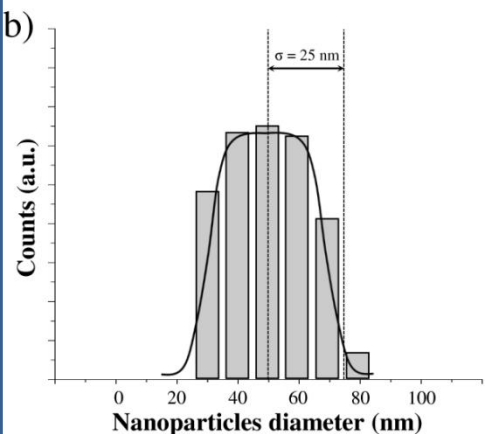
Synthesis of AgNPs



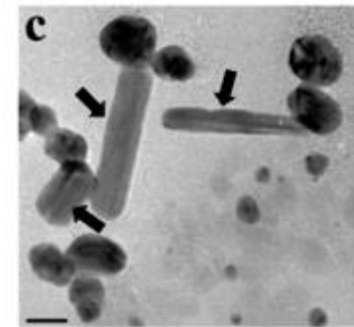
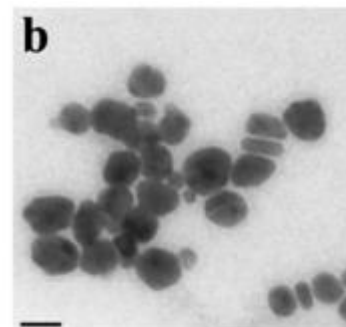
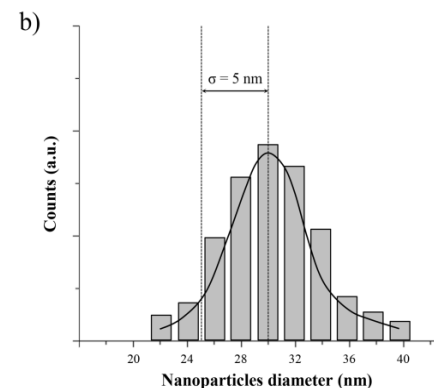
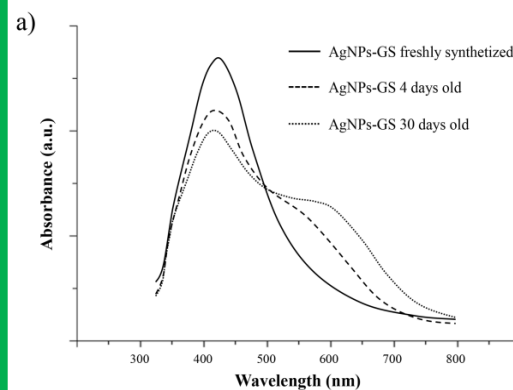
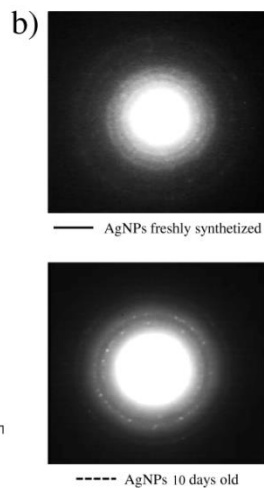
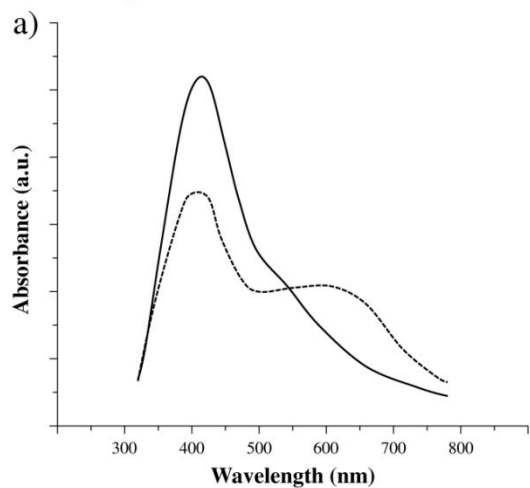
AgNPs-G



AgNPs-F

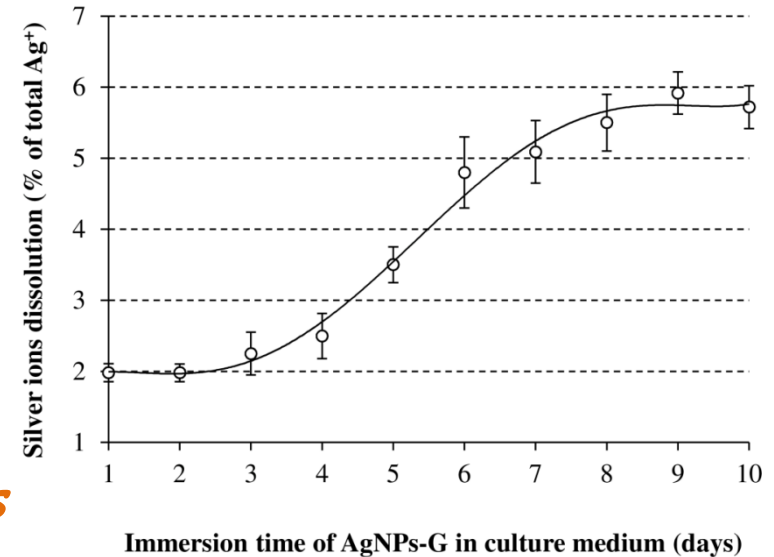
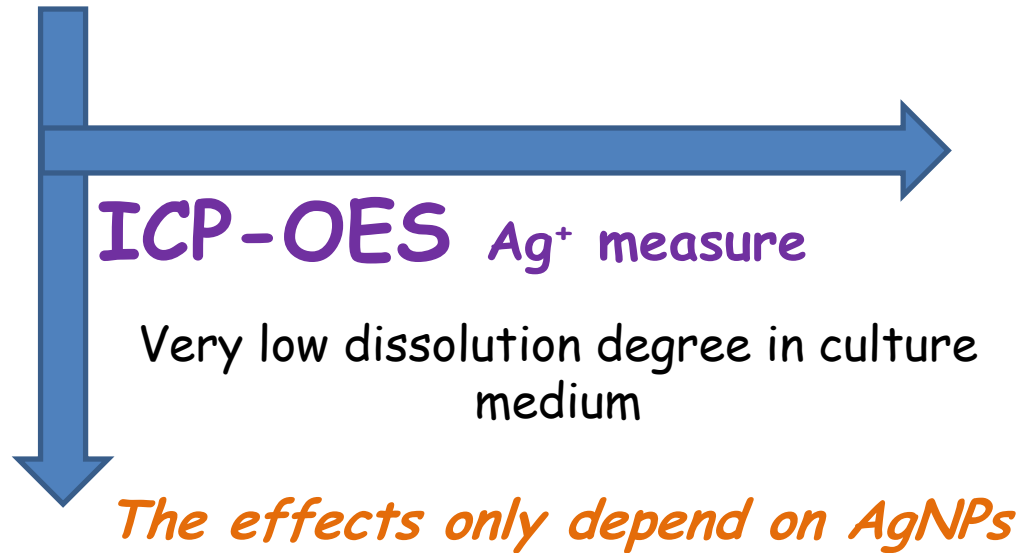


AgNPs-GS

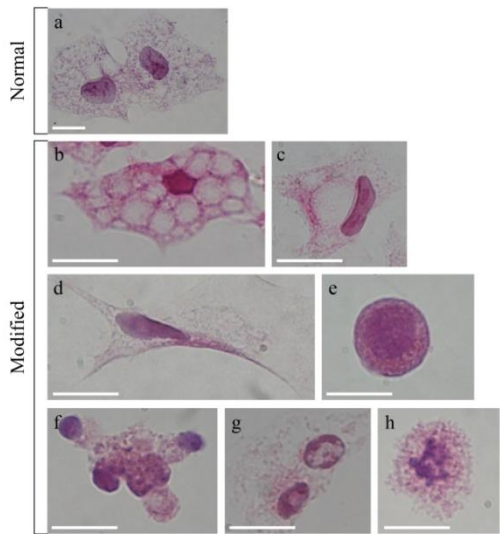
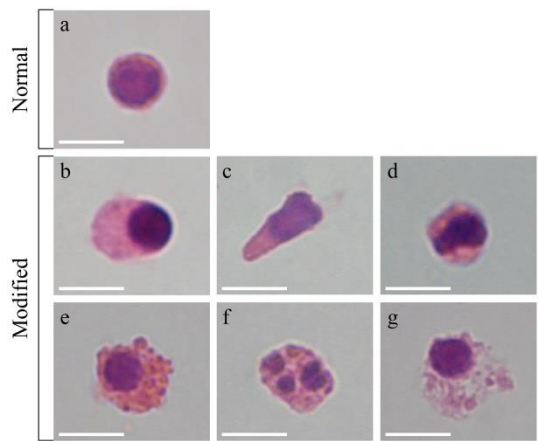
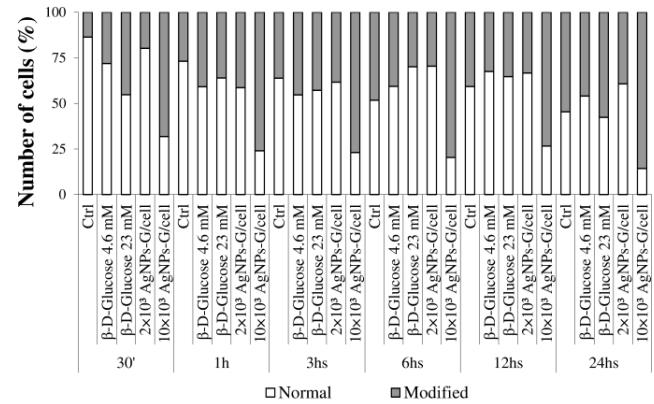
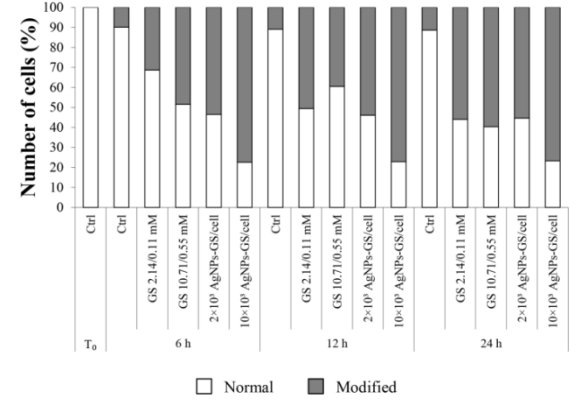
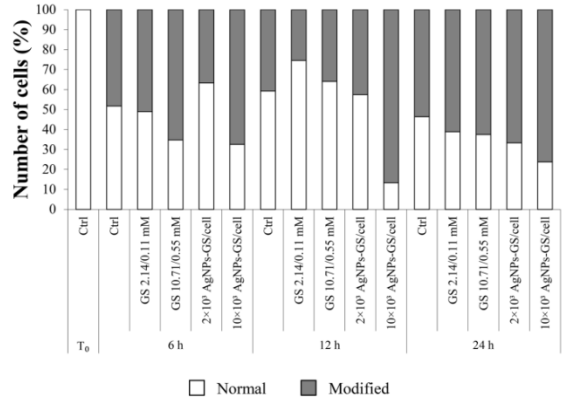
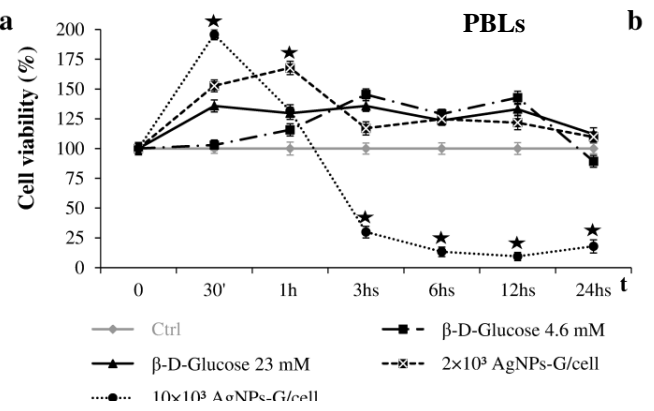
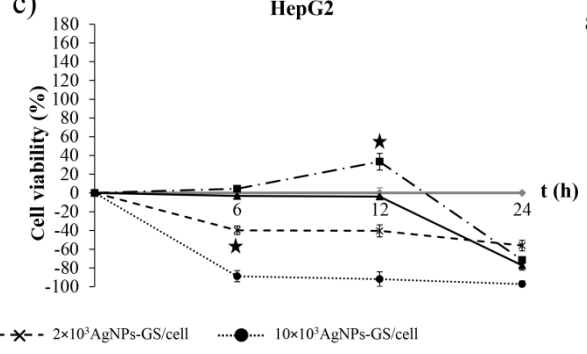
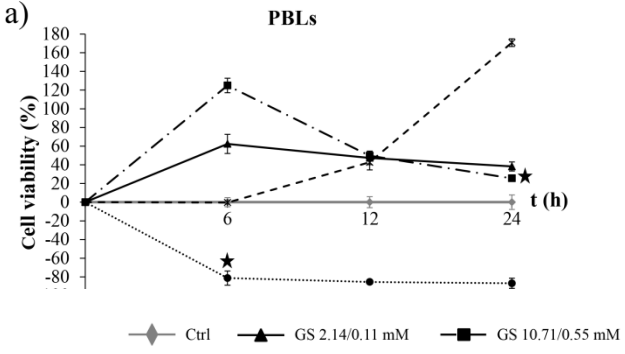


Stability of AgNPs

AgNPs-G > AgNPs-GS > AgNPs-F

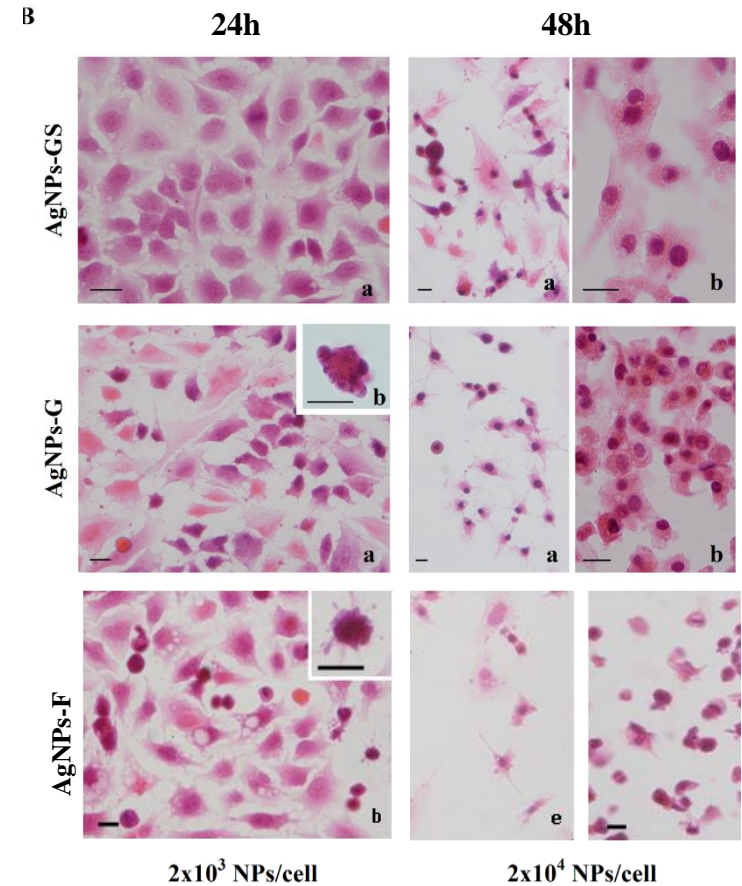
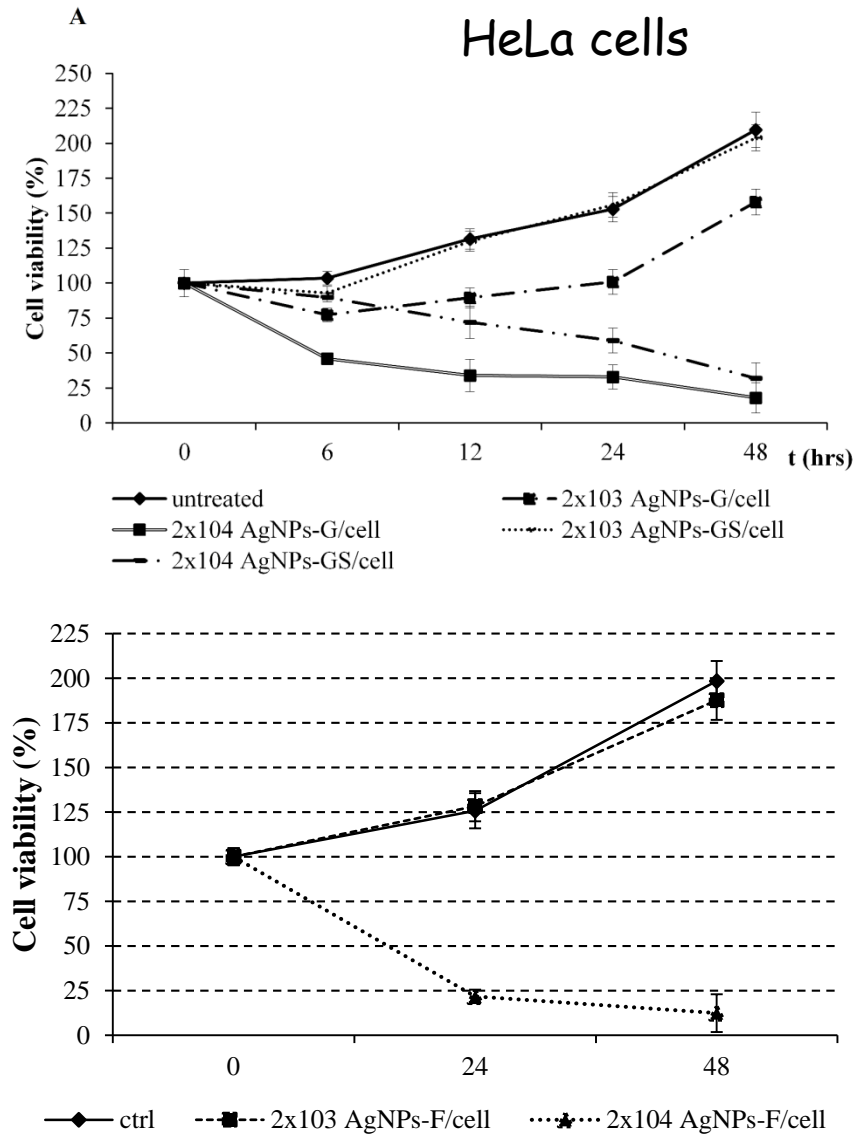


Immersion time (days)	Silver concentration (µg/mL)		Degree of dissolution (%)
	2×10 ³ NPs/cell	2×10 ⁴ NPs/cell	
1	0,026	0,267	1,98
2	0,026	0,267	1,98
3	0,030	0,303	2,25
4	0,034	0,337	2,49
5	0,047	0,472	3,50
6	0,065	0,648	4,79
7	0,069	0,687	5,09
8	0,074	0,742	5,50
9	0,079	0,798	5,91
10	0,077	0,772	5,72



Toxicity:
MTT assay

Toxicity: MTT assay



Stability of AgNPs

AgNPs-G > AgNPs-GS > AgNPs-F

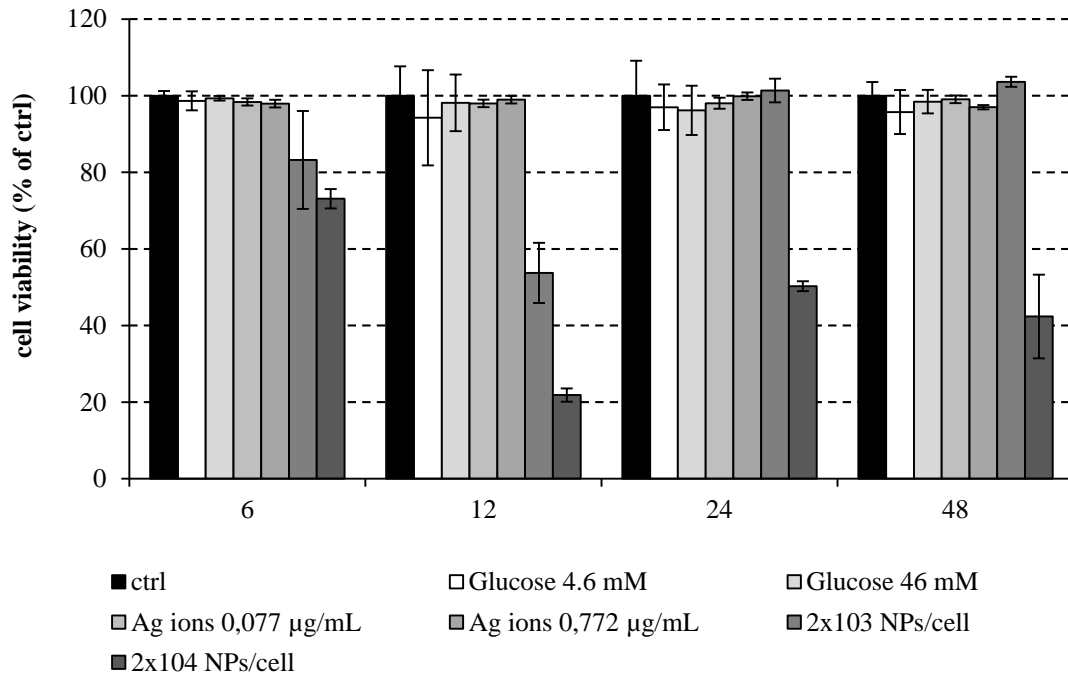
Toxicity

AgNPs-F > AgNPs-G > AgNPs-GS

Sensitivity of cells to AgNPs

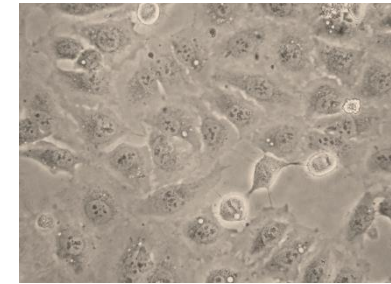
HepG2 > HeLa > PBLs

MTT assay

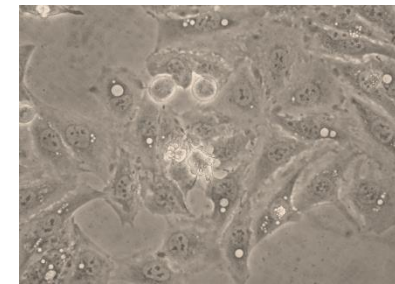


HeLa cells

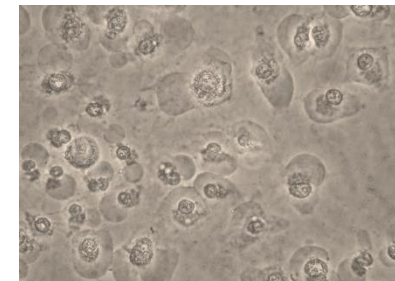
Untreated



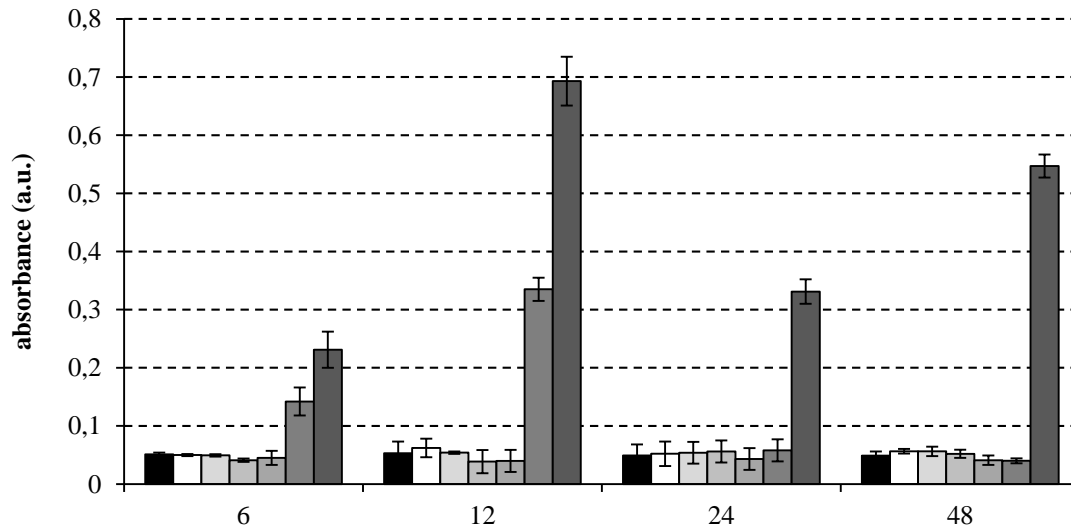
2×10^3 AgNPs/cells

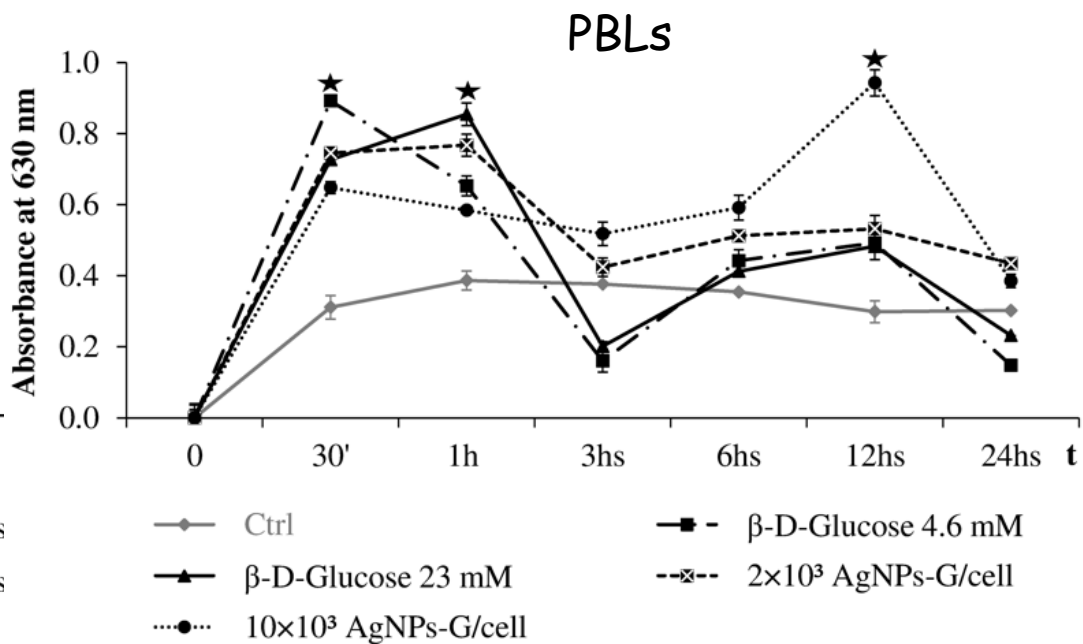
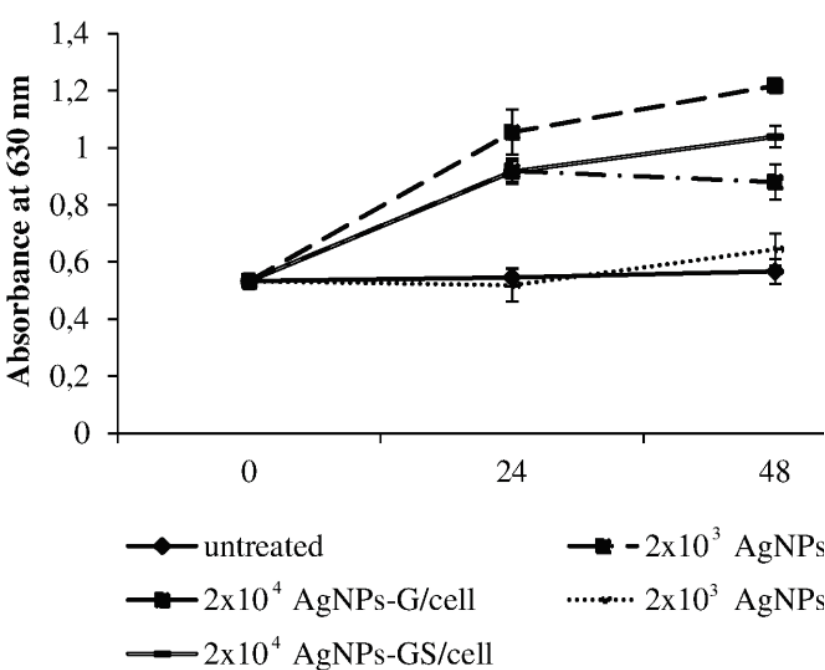


2×10^4 AgNPs/cells

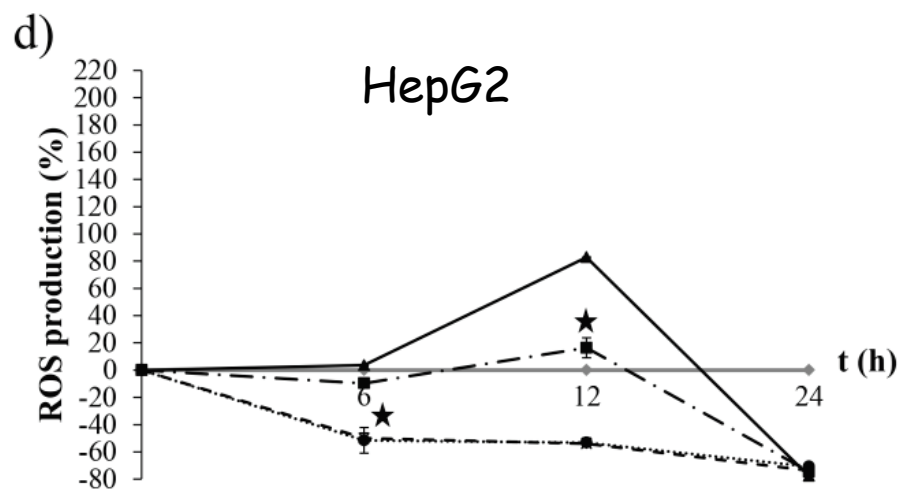
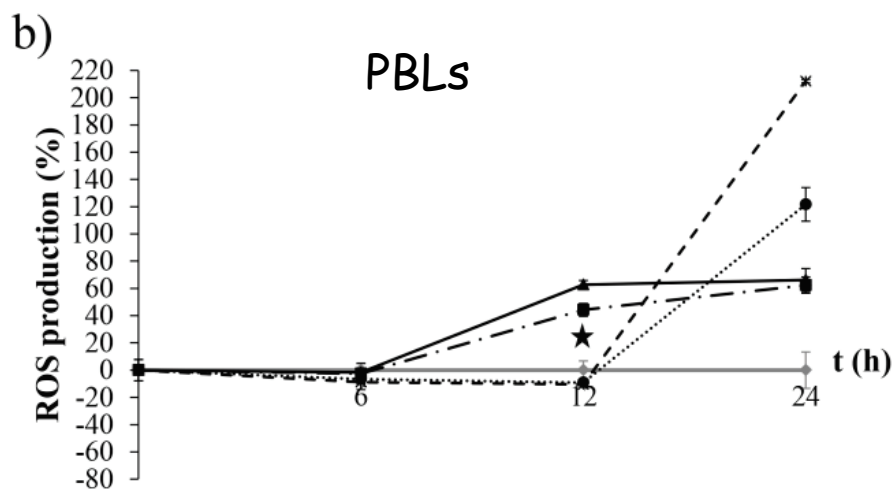
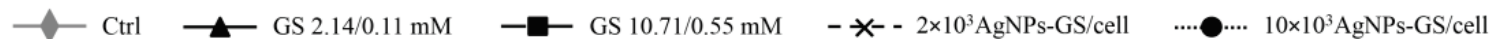


LDH assay

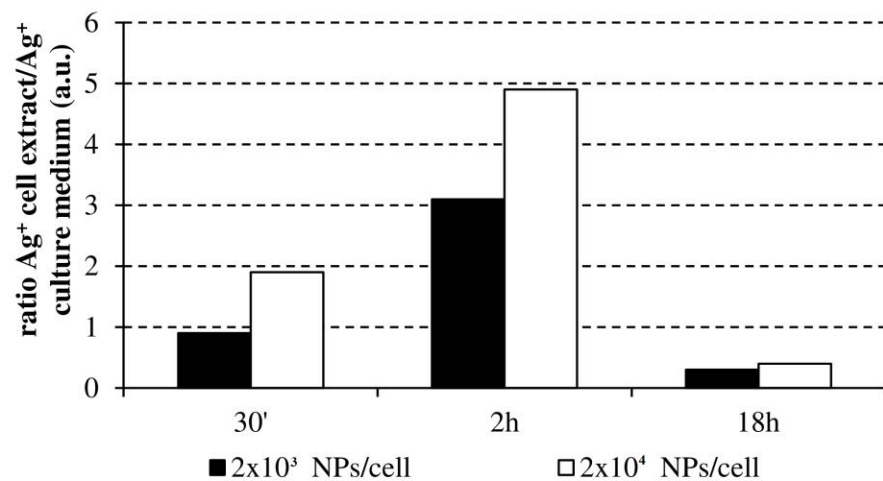
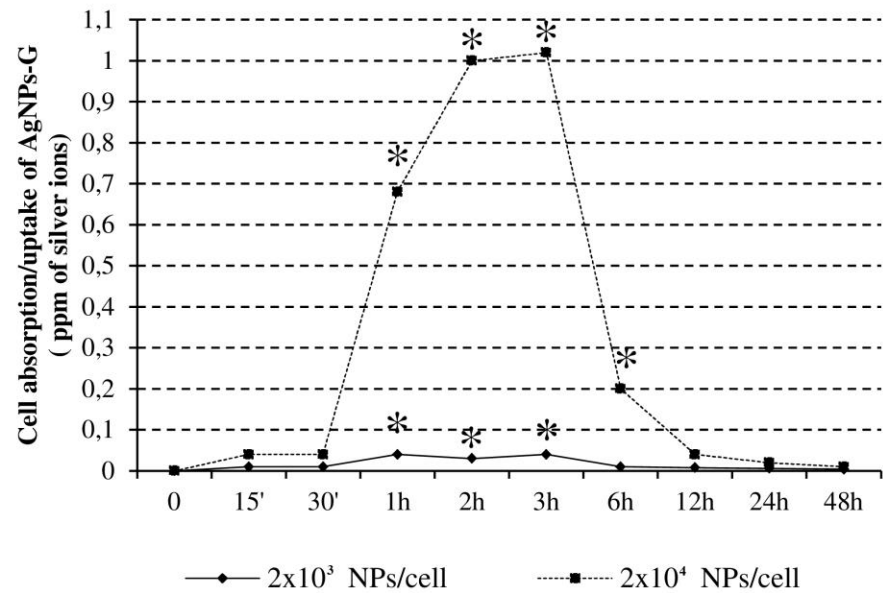




ROS production: NBT assay

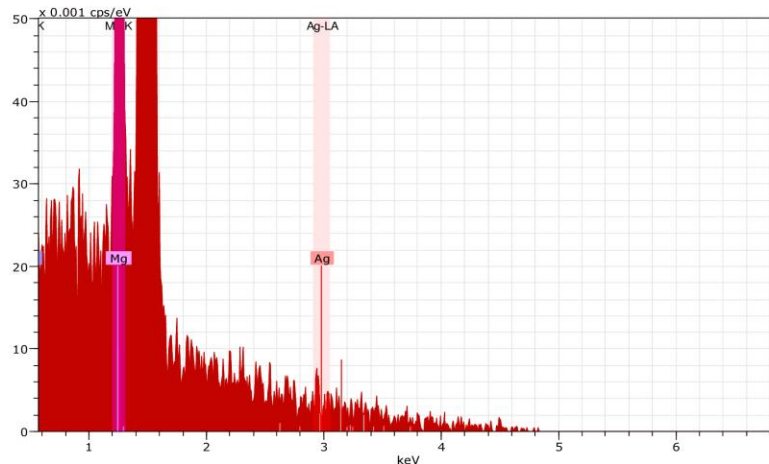
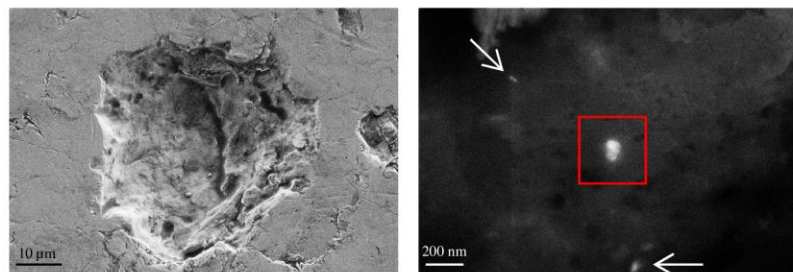


HeLa cells

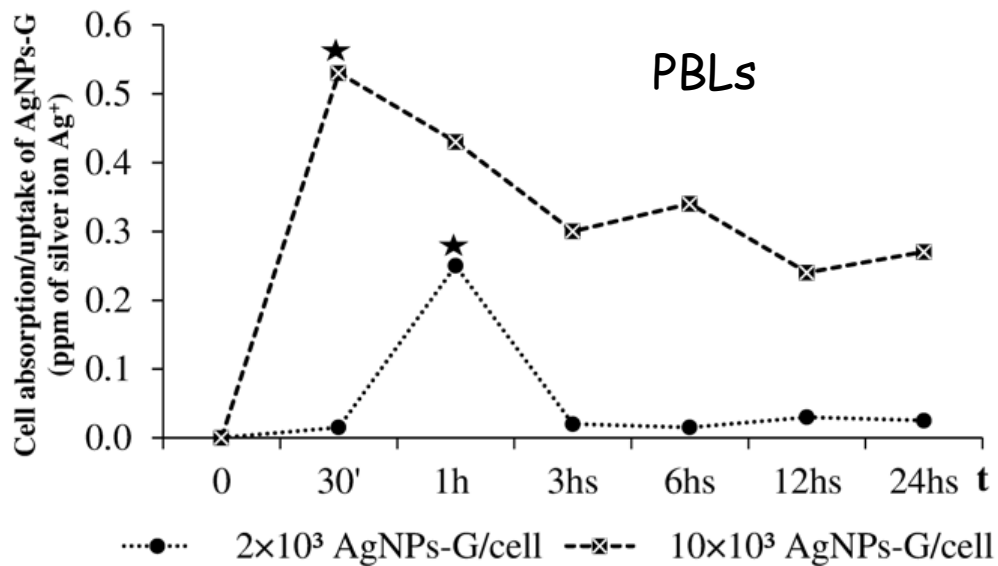


AgNPs-G uptake

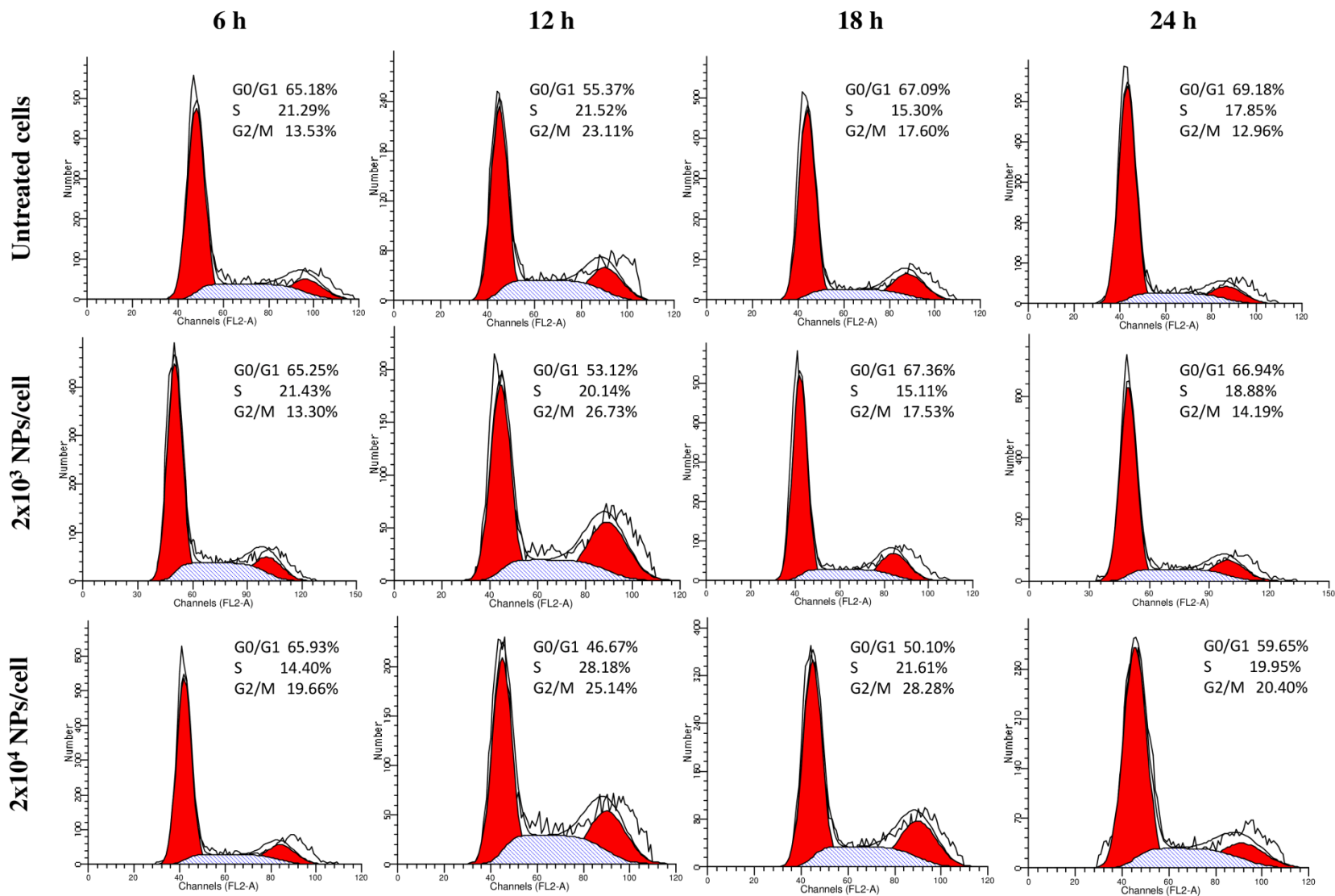
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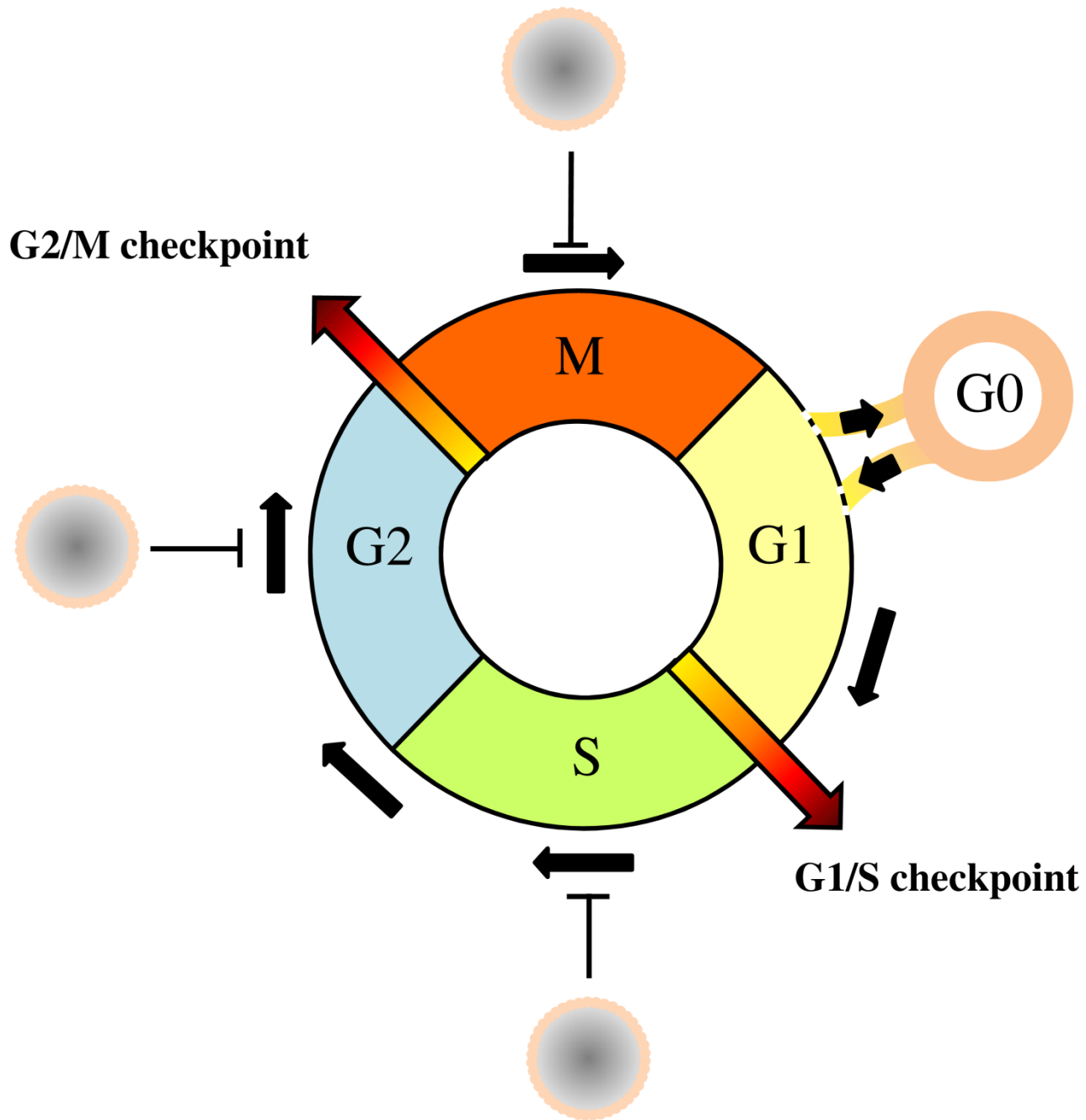


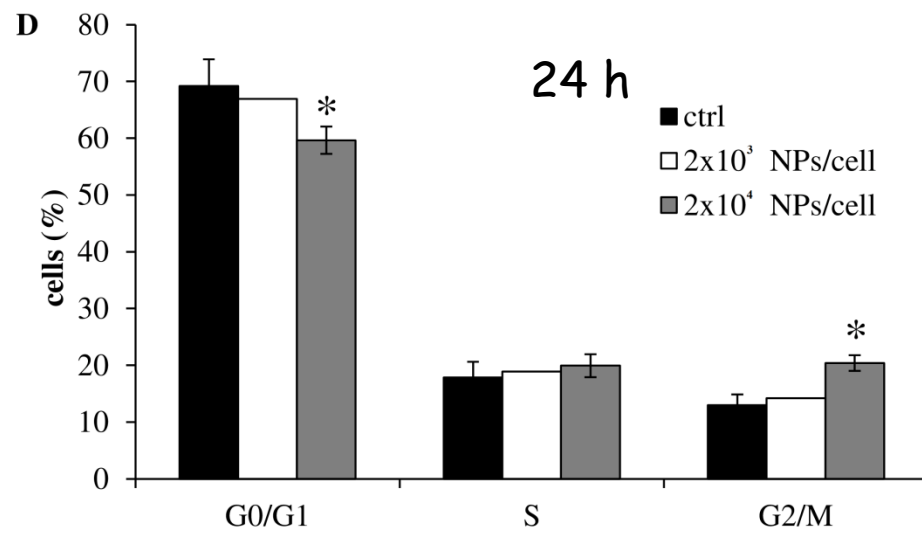
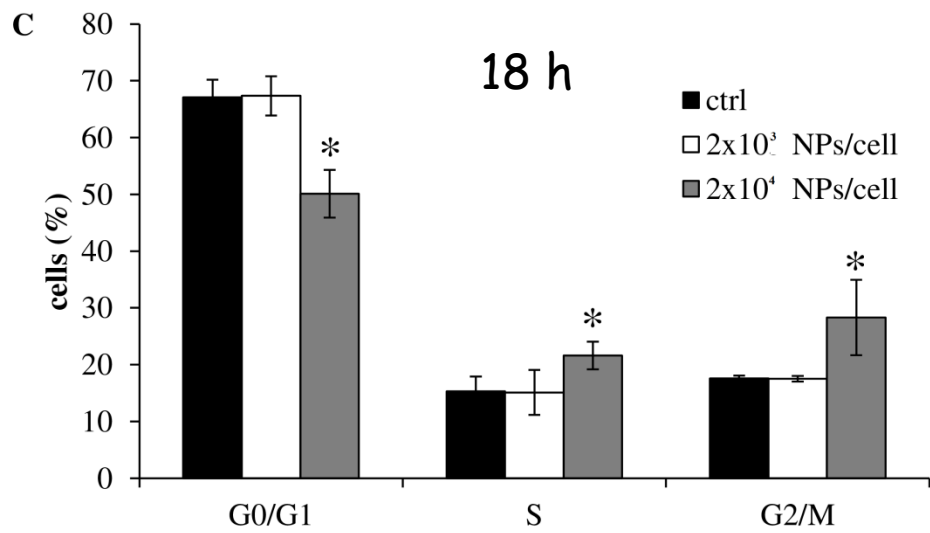
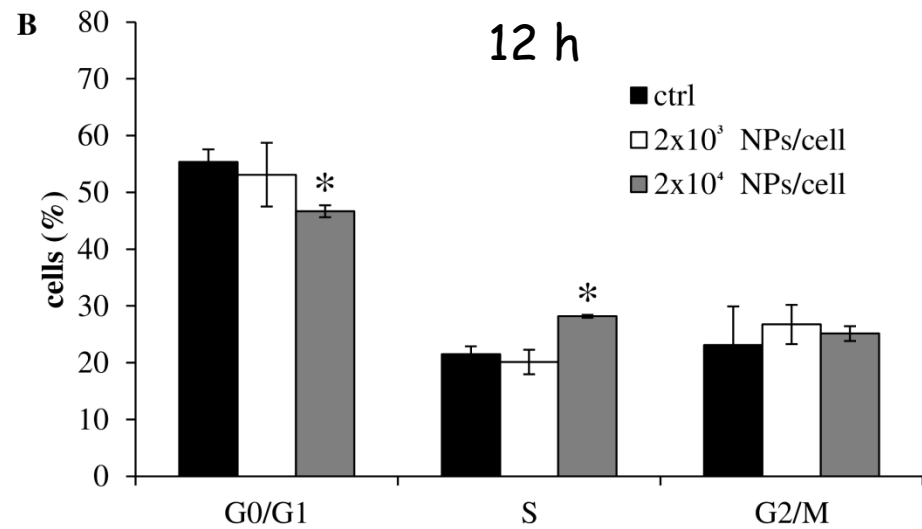
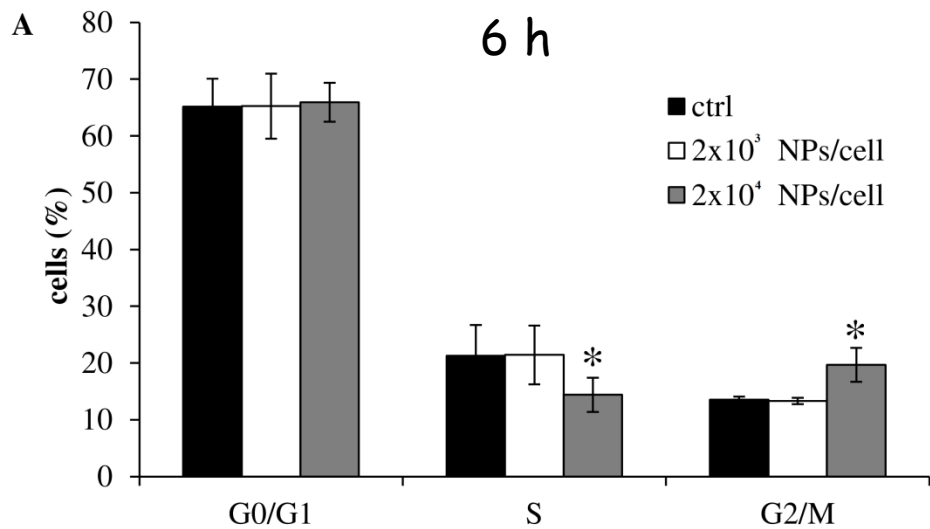
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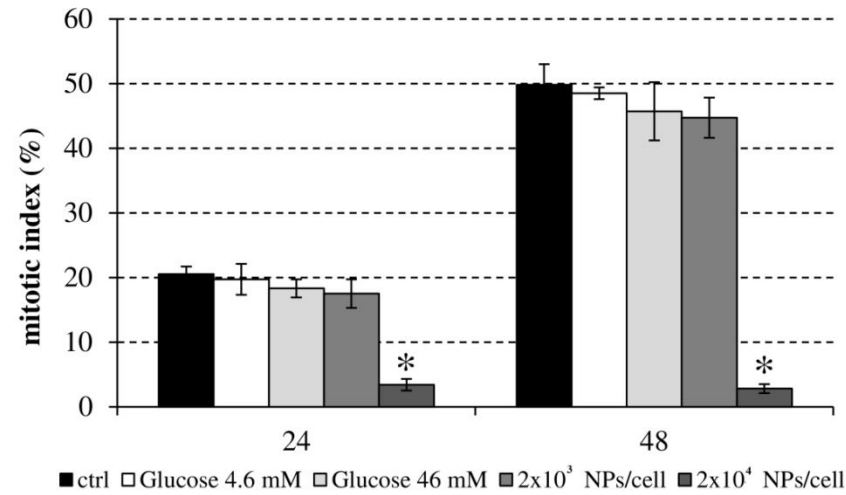
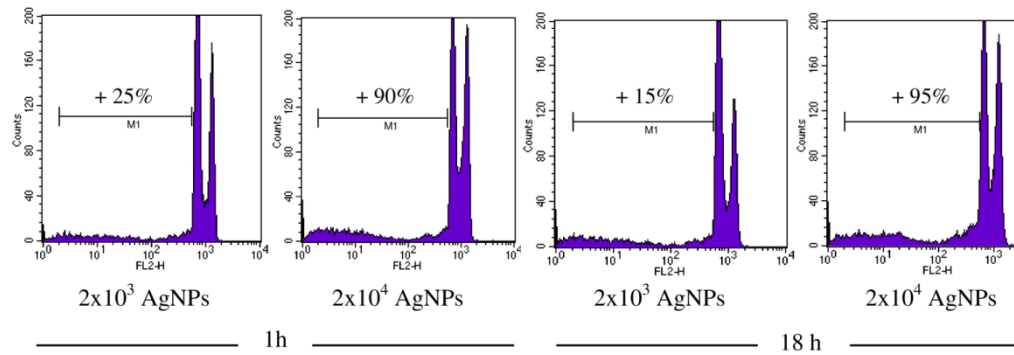
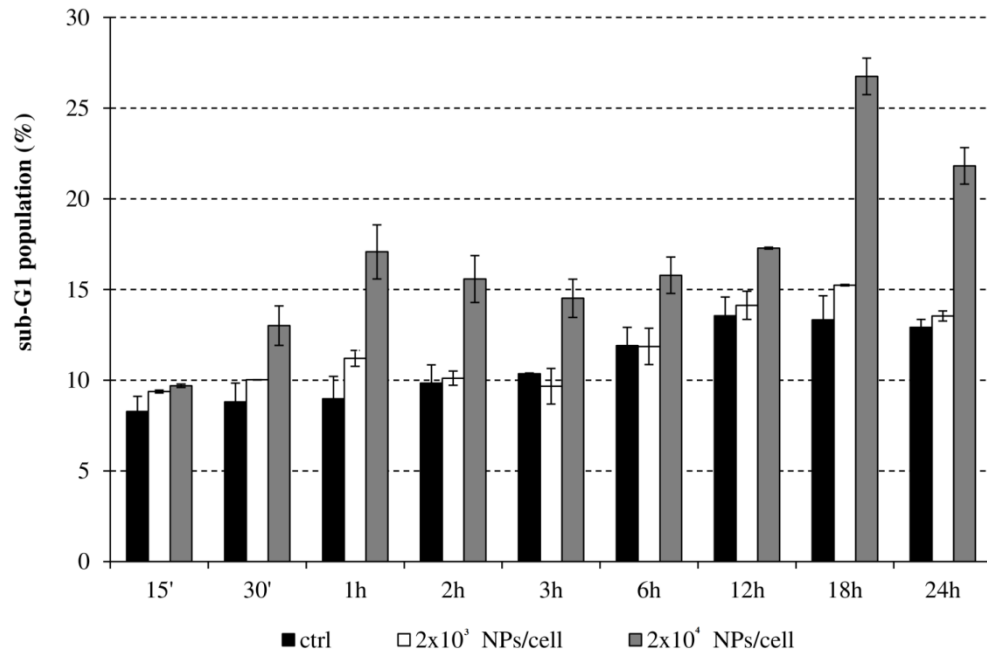
Effect of AgNPs-G on cell cycle of HeLa cells: FACS analysis



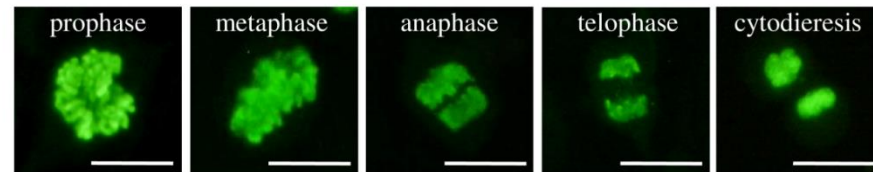




Sub G1 phase



M phase



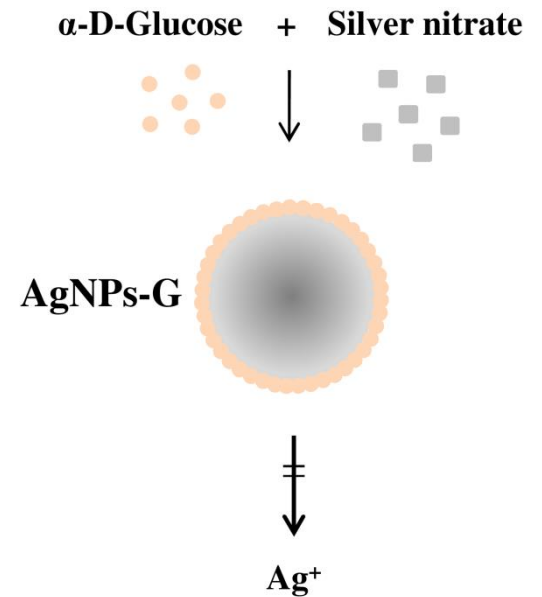
The effects of AgNPs depend on

surface coating

dose of NPs/cell

time of treatment

cell type

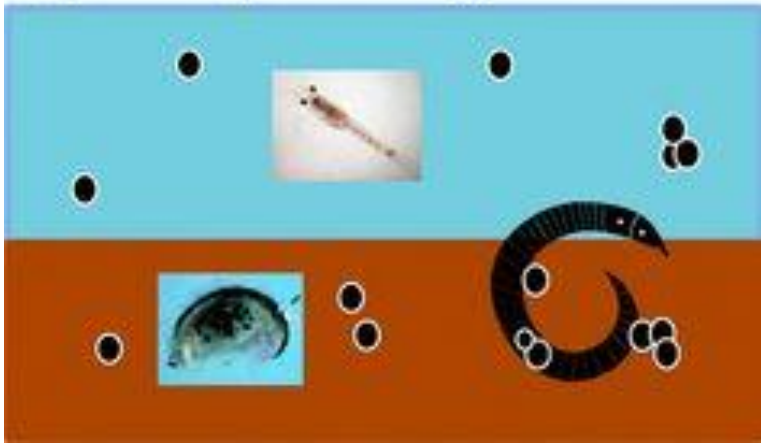


What happens when NPs enter the marine environment?

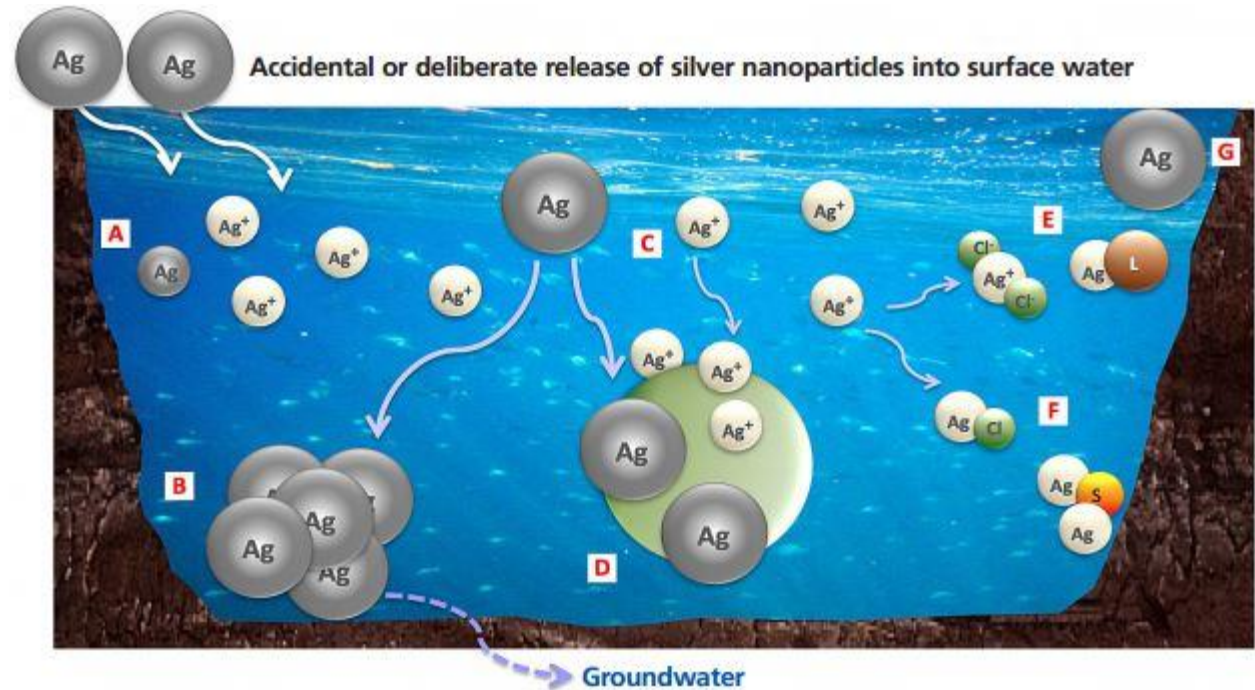
Toxicity?

Bioaccumulation?

Biotransformation?



AgNPs into the marine environment



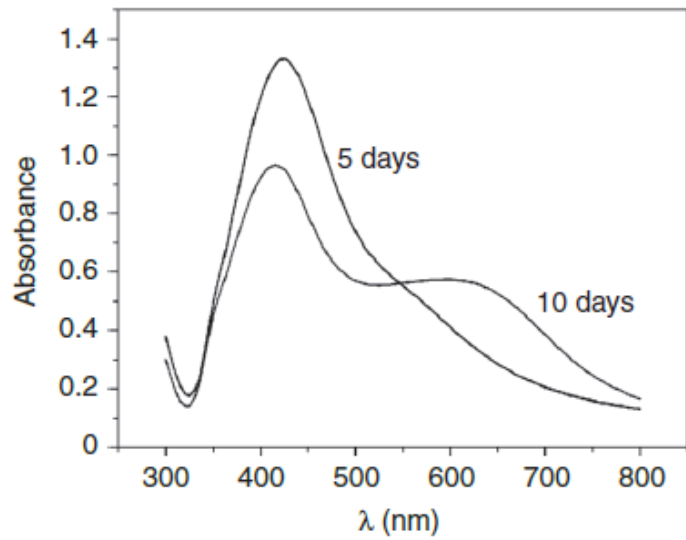


Figure 4 Stability of the highest concentration of AgNPs in MFSW up to 10 days. UV-visible spectra of 15×10^{13} AgNPs diluted in 500 cm^3 of MFSW.

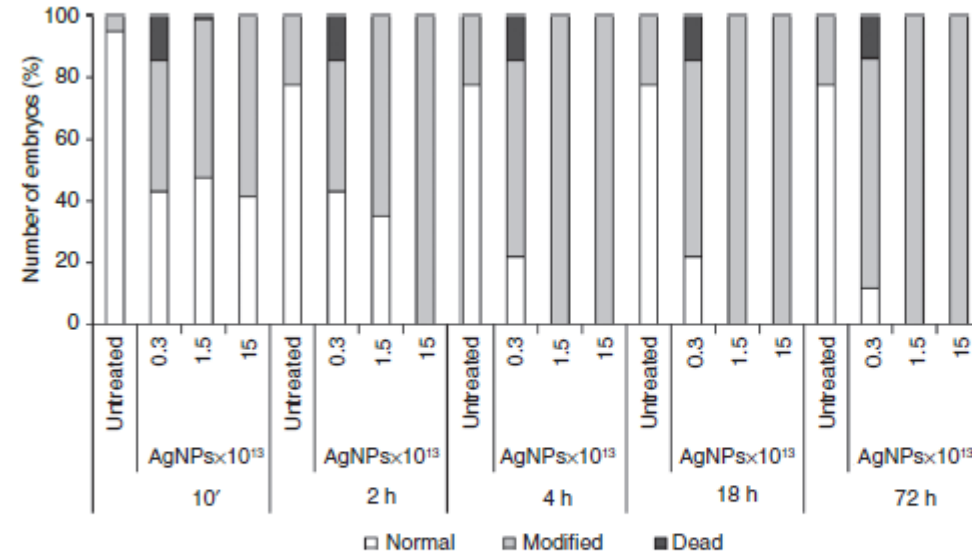
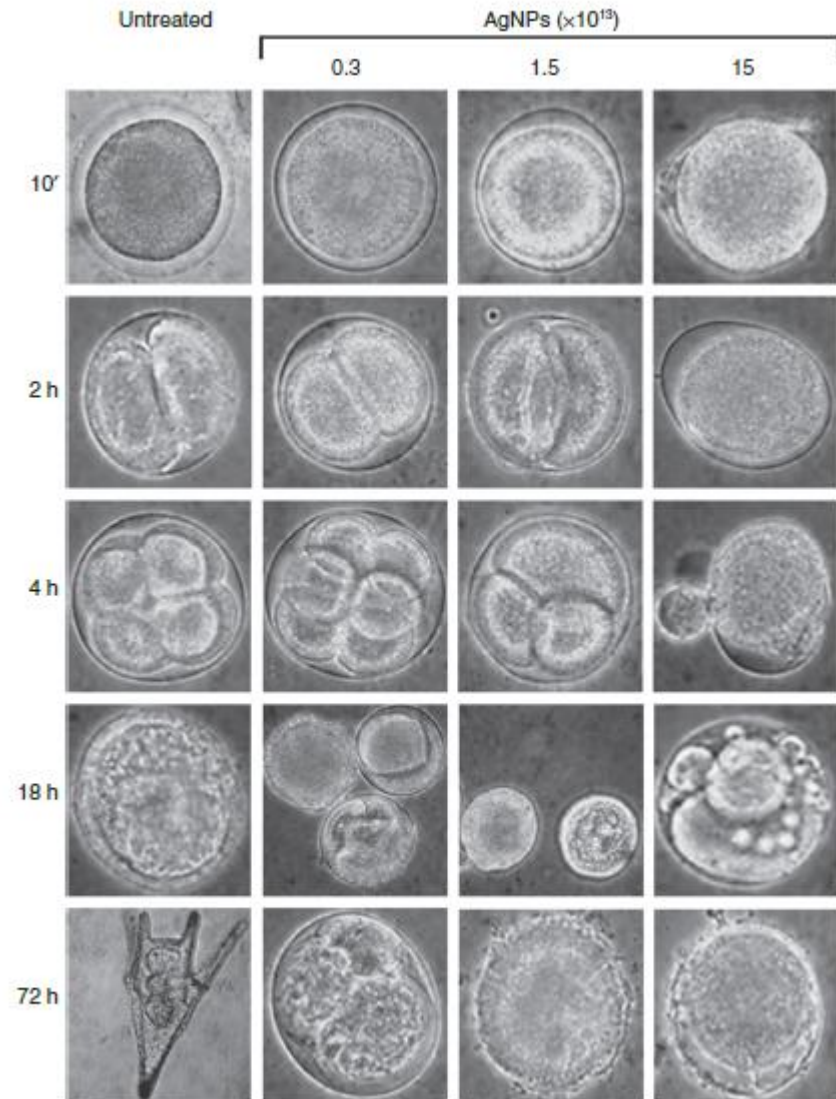


Figure 10 Percentages of abnormal *P. lividus* embryos induced by AgNPs. Percentage of LM-based scorings of abnormal sea urchin *P. lividus* embryos developed for up to 72 h with 0.3, 1.5 and 15×10^{13} AgNPs in 500 cm^3 of MFSW. The errors measured as SEs never exceeded the 3%.



University of Salento- Lecce
Laboratory of Comparative Anatomy
and Cytology



CNIS-University of Sapienza- Roma

Letzere Spellenzeri Roma