

Nanobiotechnological Applications of Functionalised Carbon Nanotubes

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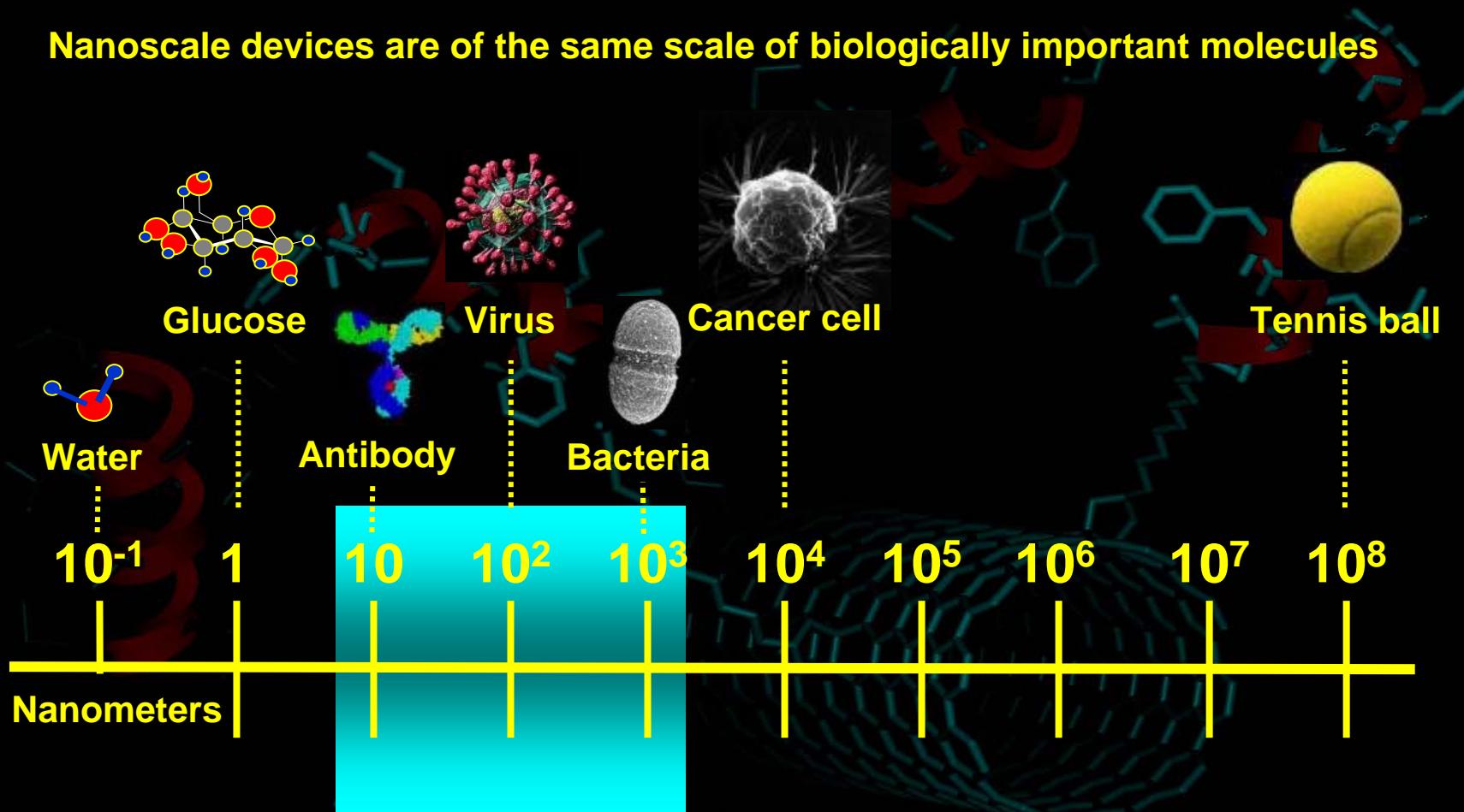


Outline

- *Functionalisation of carbon nanotubes*
- *Capacity of functionalised carbon nanotubes (f-CNT) to penetrate into the cells*
- *Cytotoxicity, impact on cell functionality and biodistribution of f-CNT*
- *Delivery of therapeutic molecules (peptides, genes, drugs) by f-CNT*
- *Conclusions and perspectives*

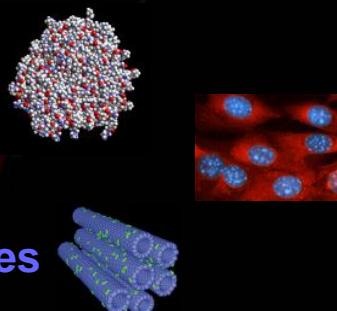
The Right Size of Nano-objects

Nanoscale devices are of the same scale of biologically important molecules

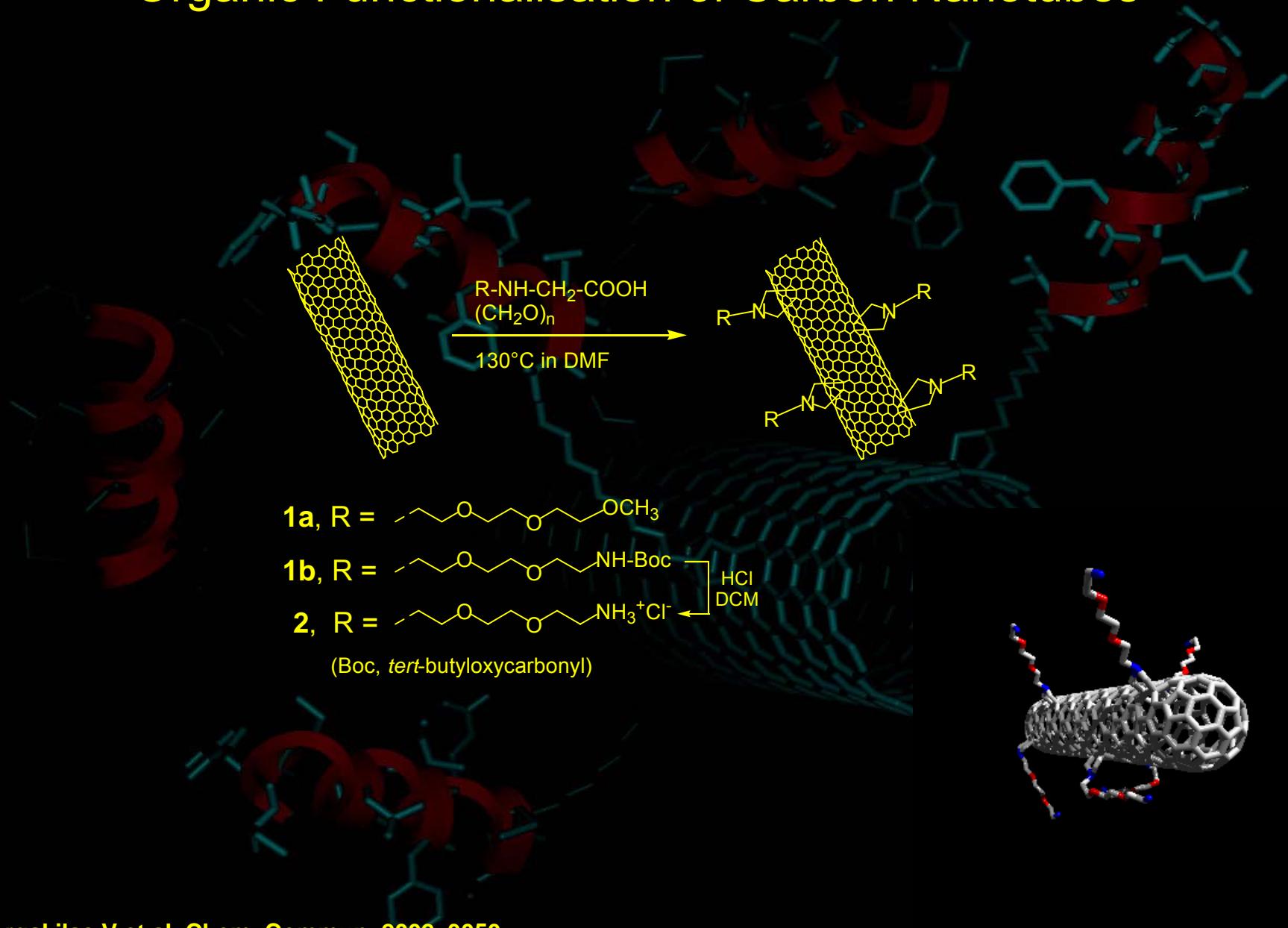


Nanodevices:

- Nanoparticles
- Dendrimers
- Quantum Dots
- Carbon nanotubes

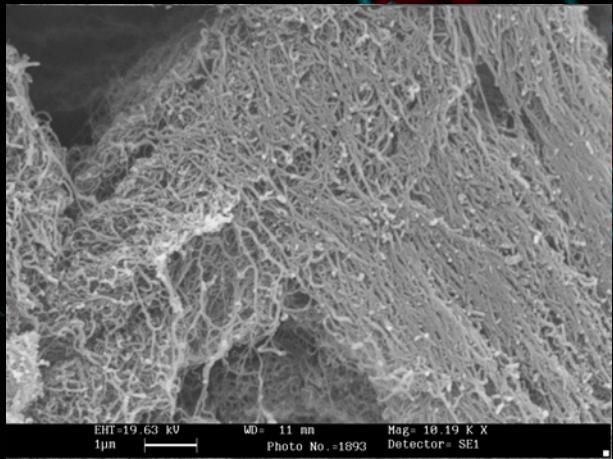


Organic Functionalisation of Carbon Nanotubes

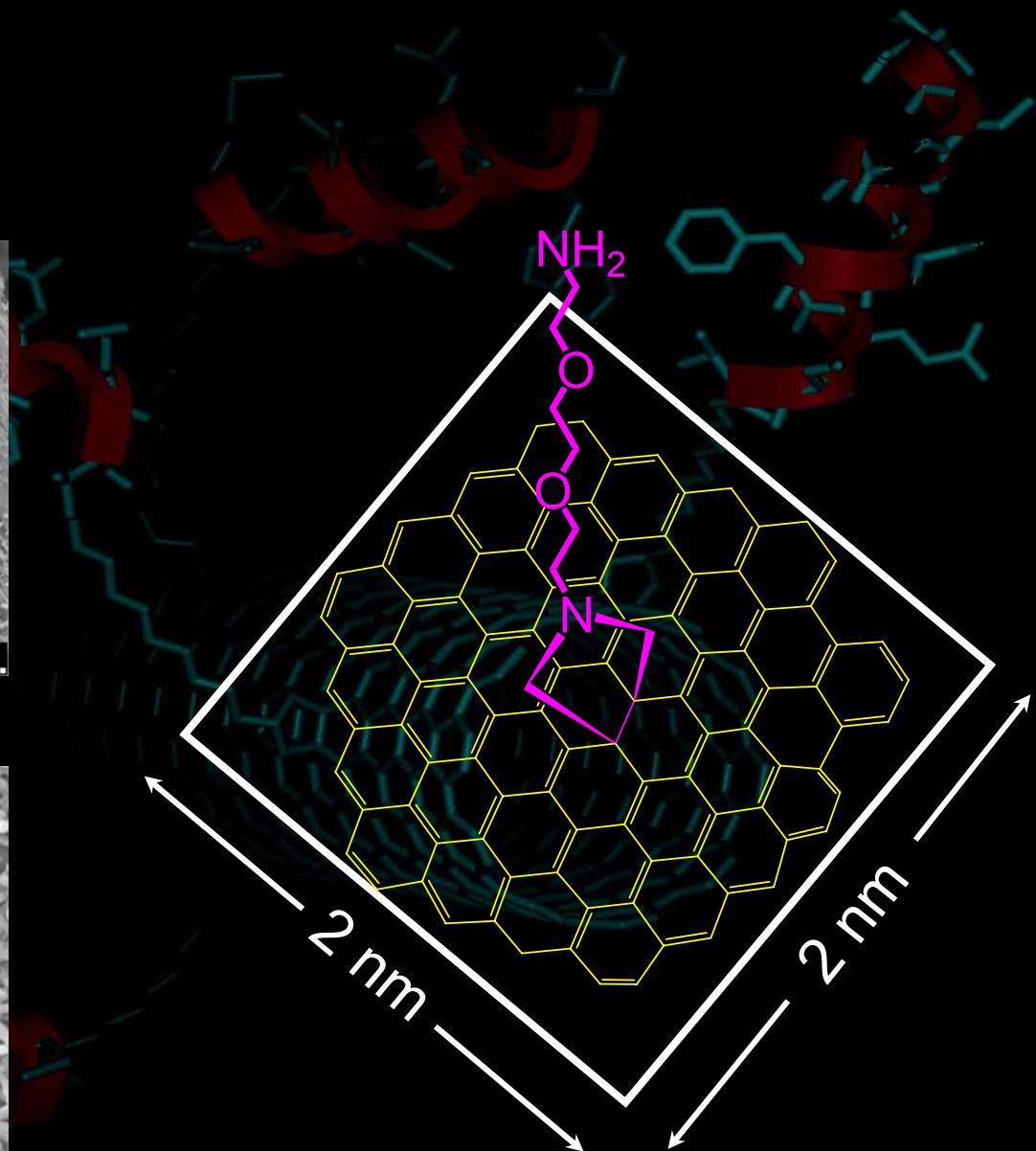
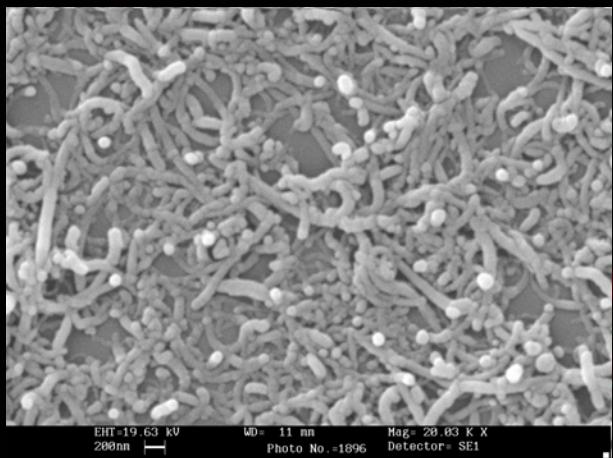


Surface Functionalised Carbon Nanotube

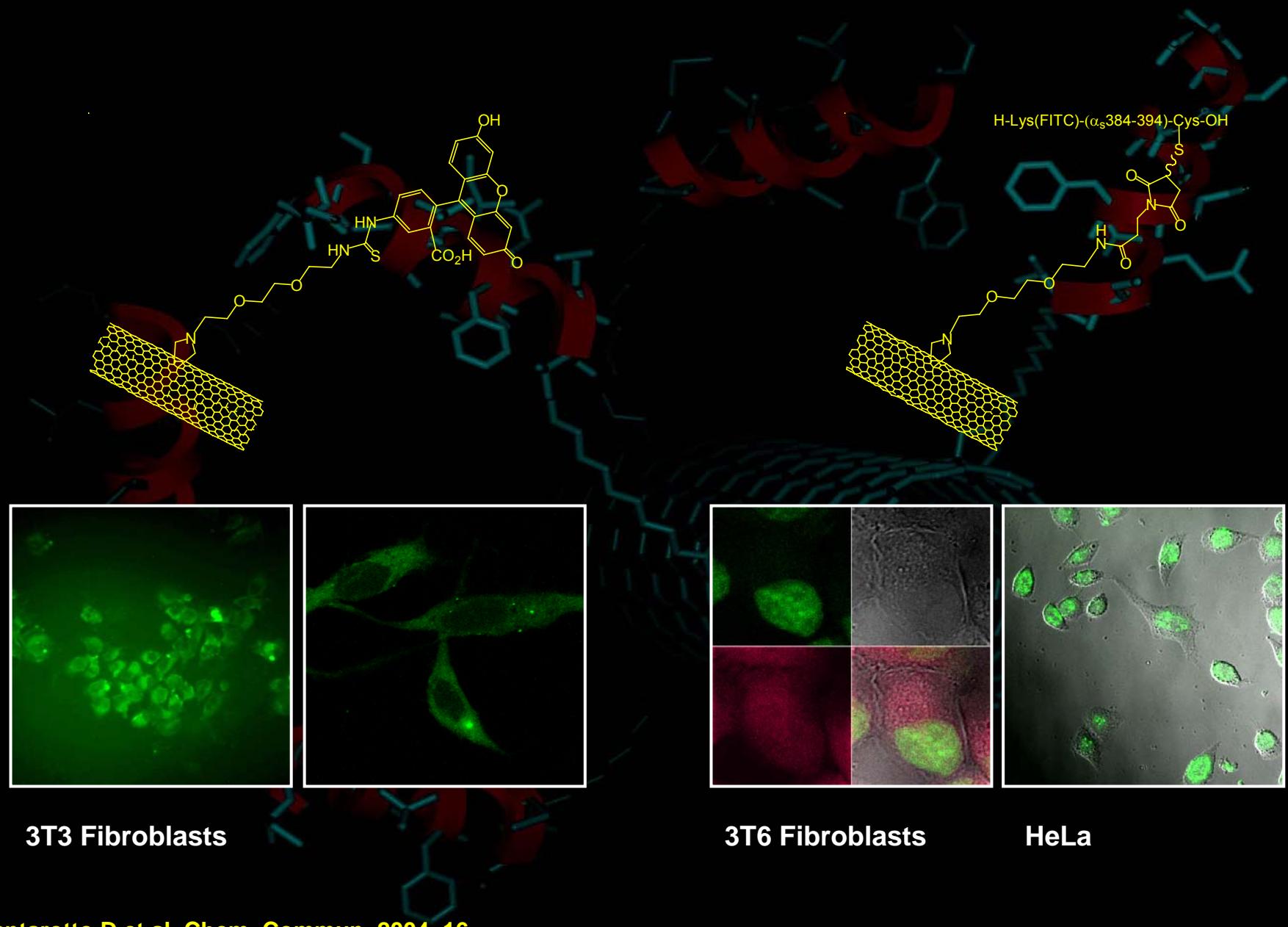
SWNT-NH₃⁺



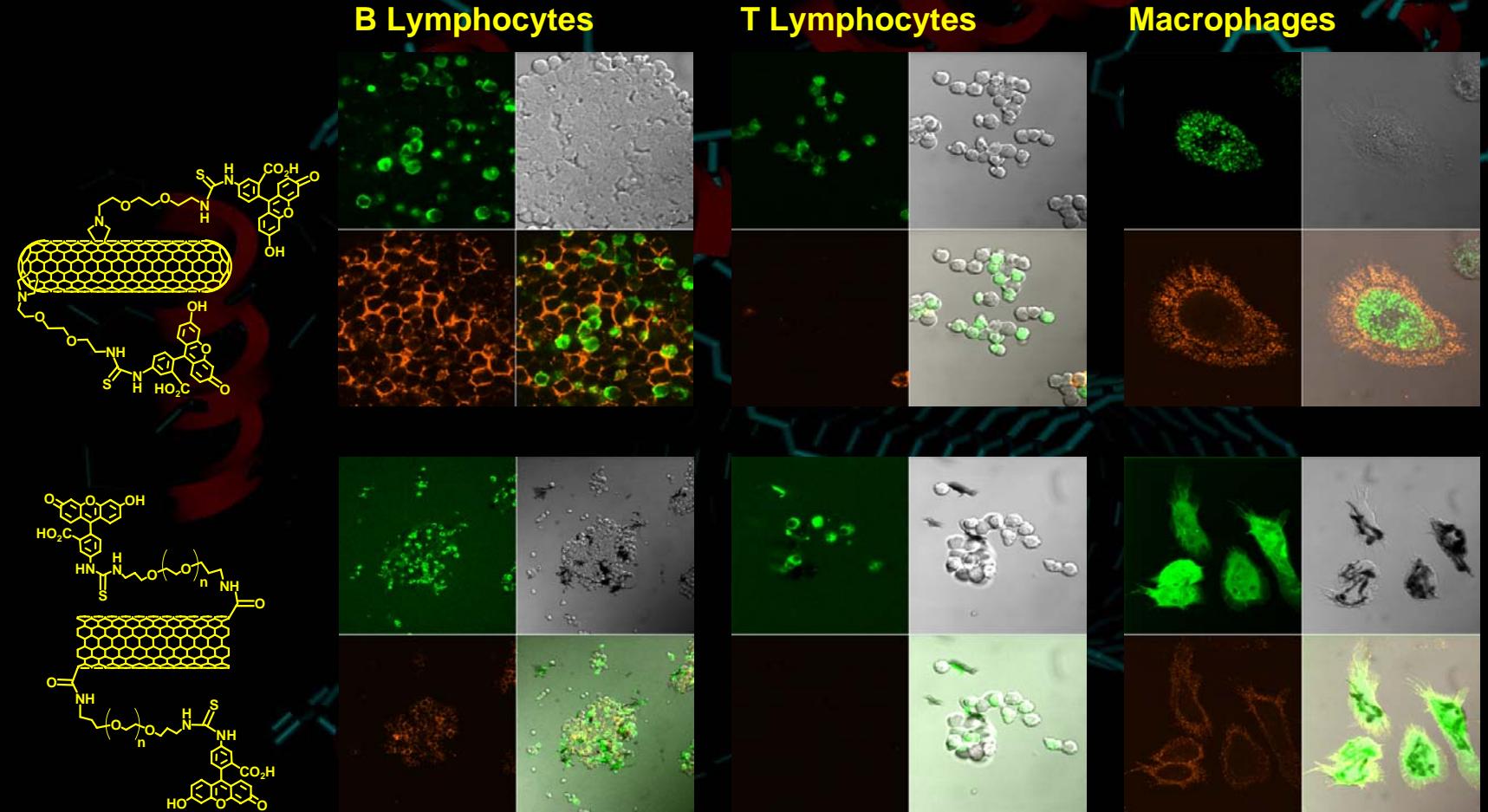
MWNT-NH₃⁺



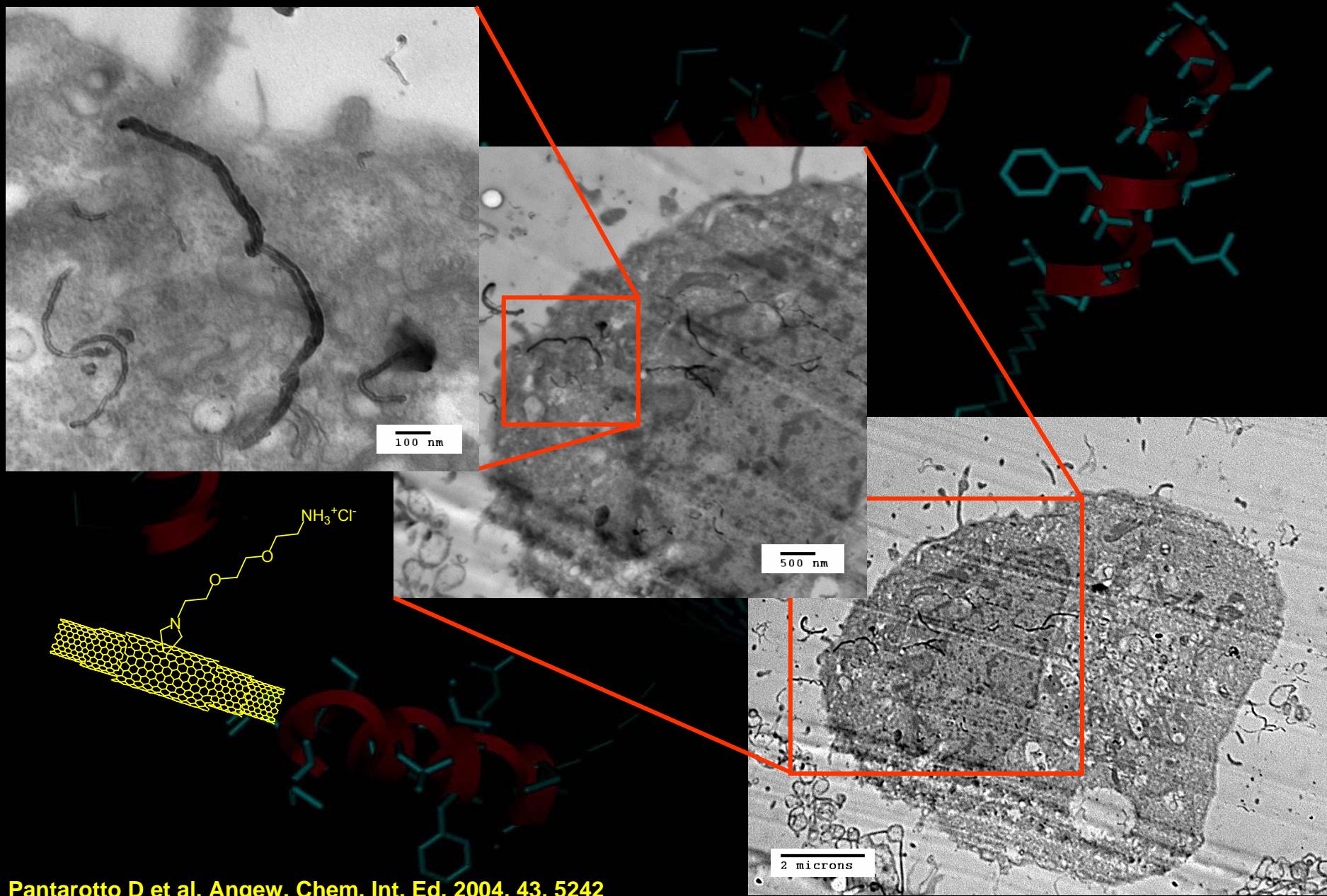
Do Functionalised Carbon Nanotubes Penetrate into the Cells?



Cell Uptake of Functionalised Carbon Nanotubes by Immunocompetent Cells

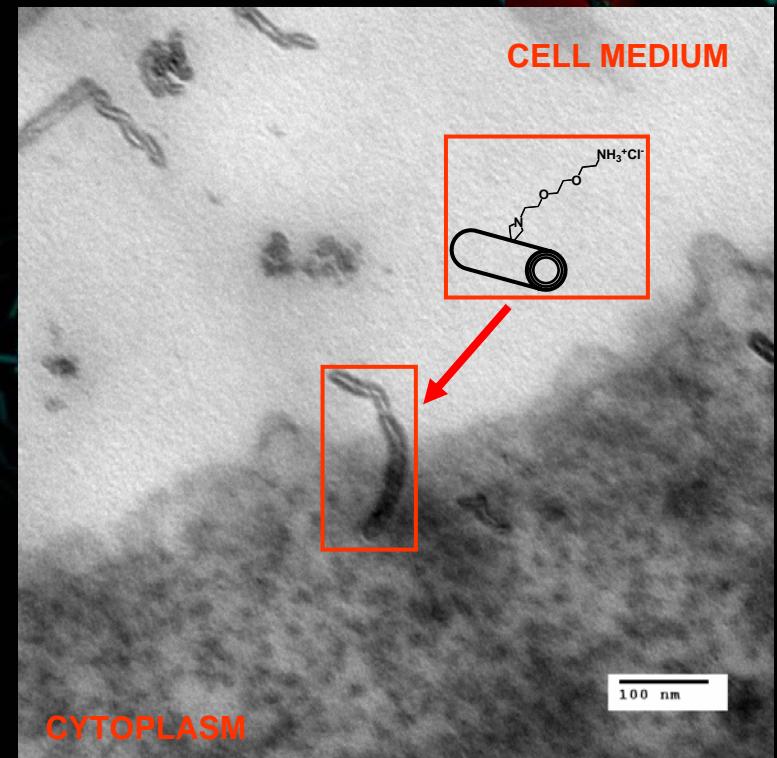
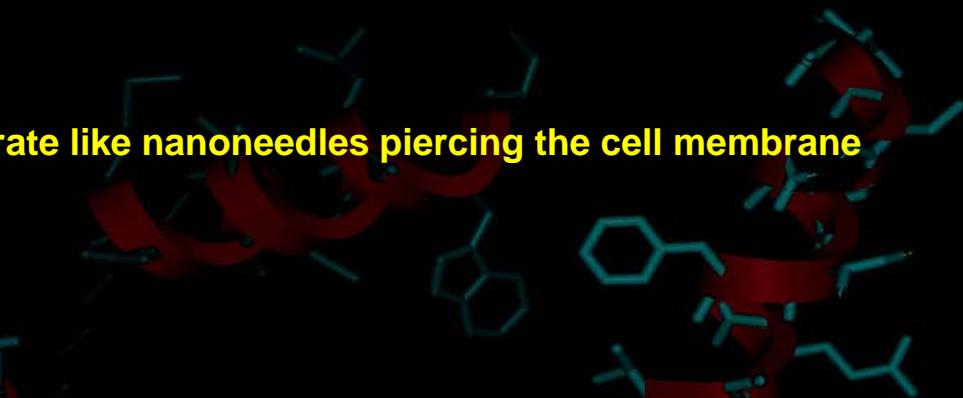
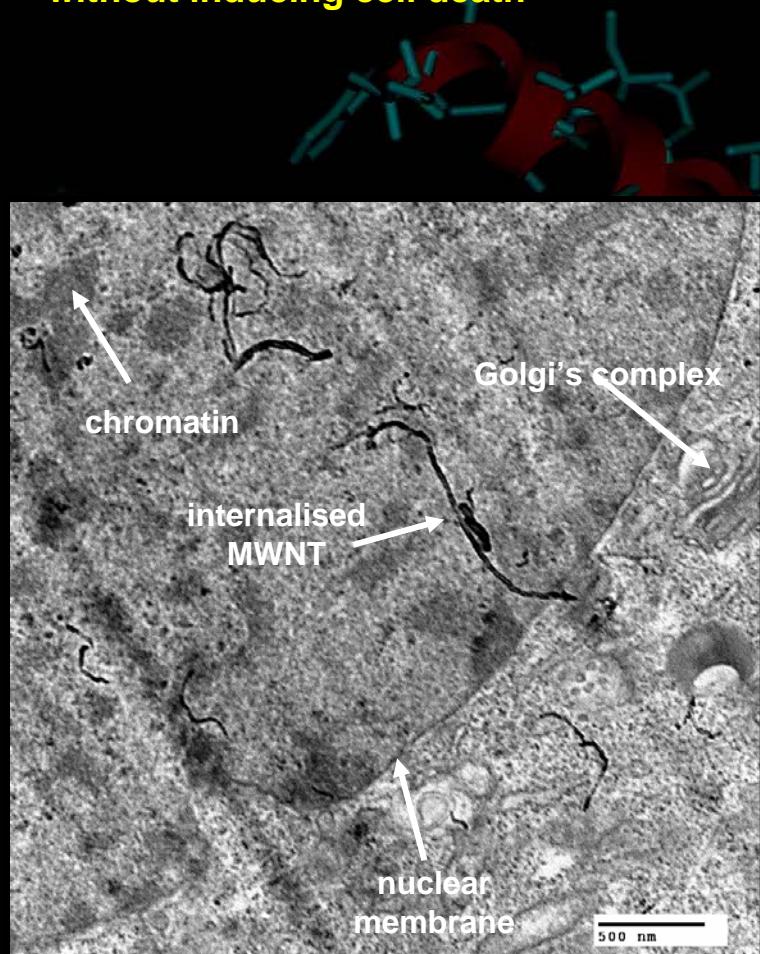


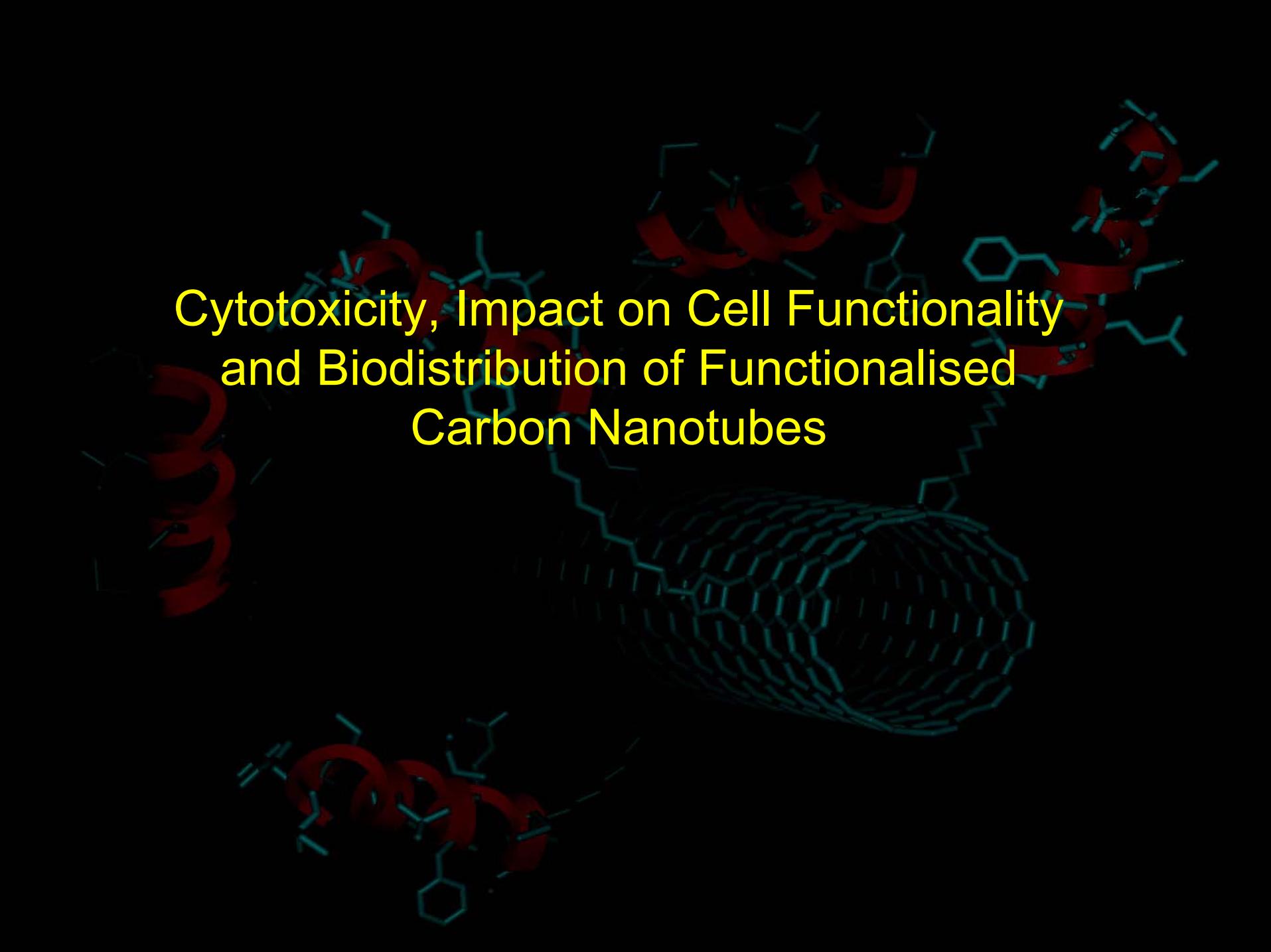
Cell Uptake of Functionalised Carbon Nanotubes



Nanoneedle Cell Penetration of Carbon Nanotubes

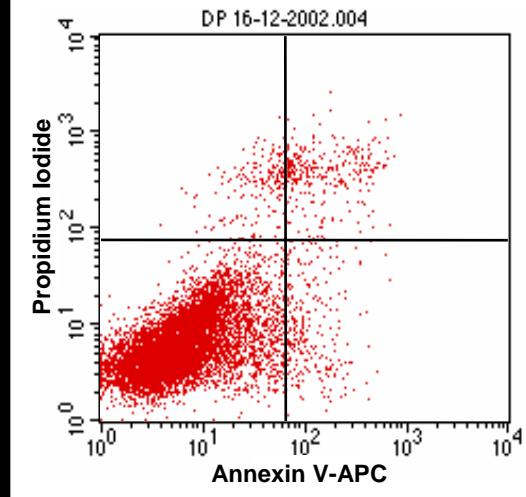
Functionalised carbon nanotubes penetrate like nanoneedles piercing the cell membrane without inducing cell death



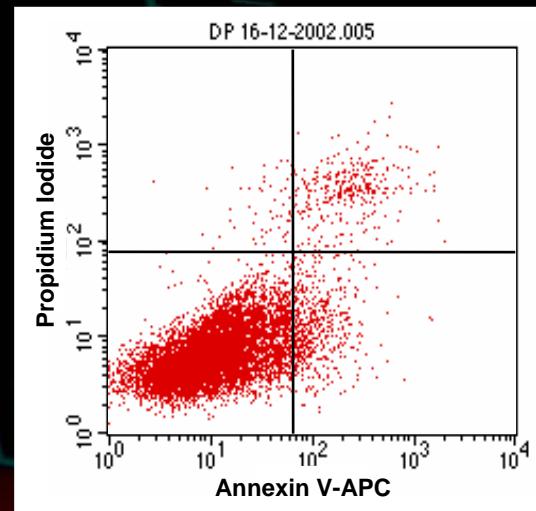


Cytotoxicity, Impact on Cell Functionality and Biodistribution of Functionalised Carbon Nanotubes

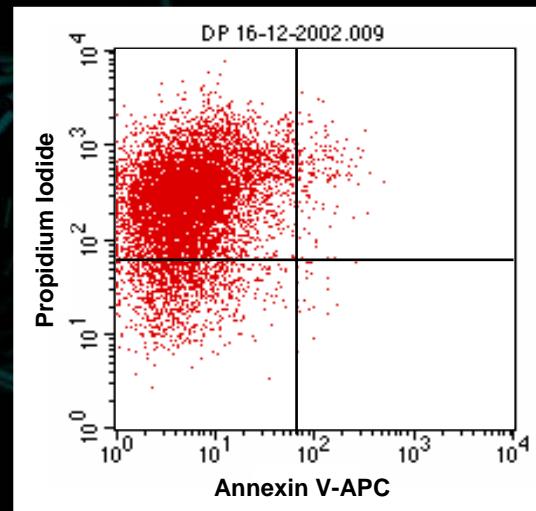
Cell Viability after Treatment with Fluorescent Carbon Nanotubes



DP 16-12-2002.004



DP 16-12-2002.005



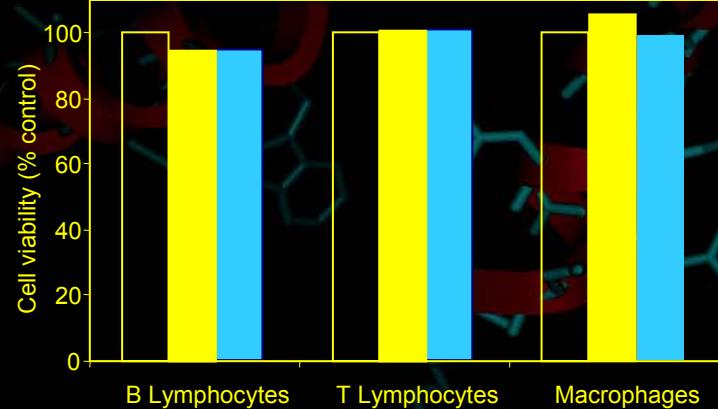
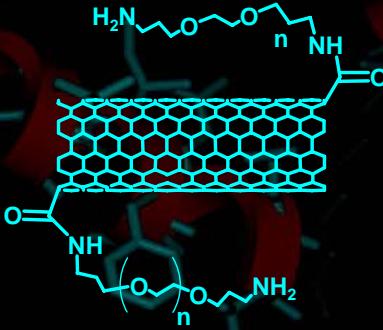
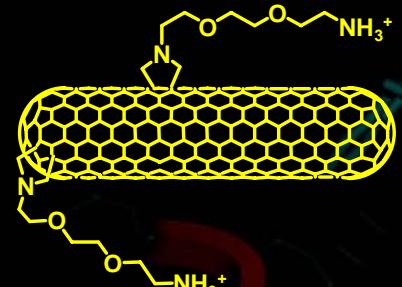
DP 16-12-2002.009

[C] = $\sim 1 \mu\text{g/ml}$

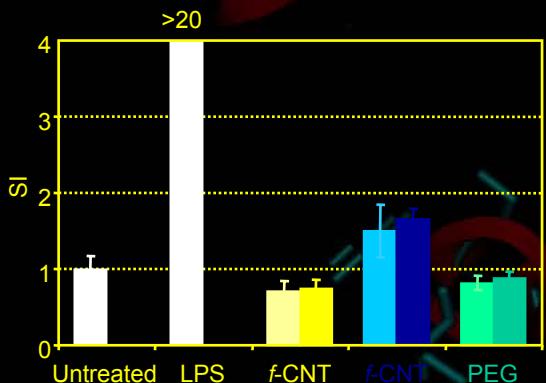
[C] = $\sim 5 \mu\text{g/ml}$

[C] = $\sim 10 \mu\text{g/ml}$

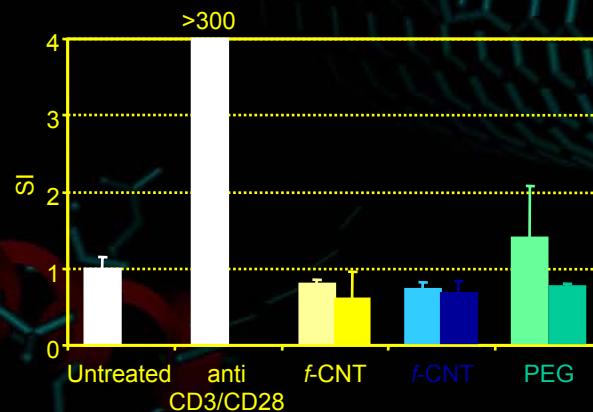
Cell Viability and Functionality after *f*-CNT Uptake



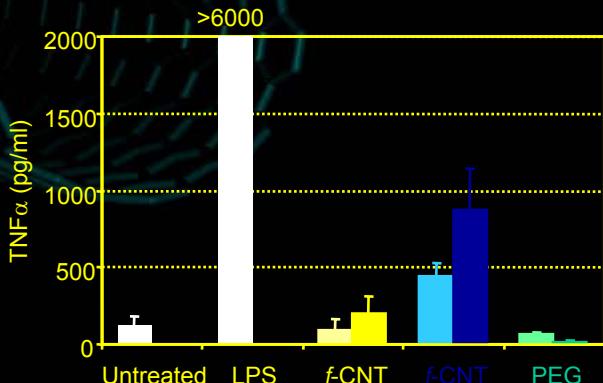
B Lymphocytes



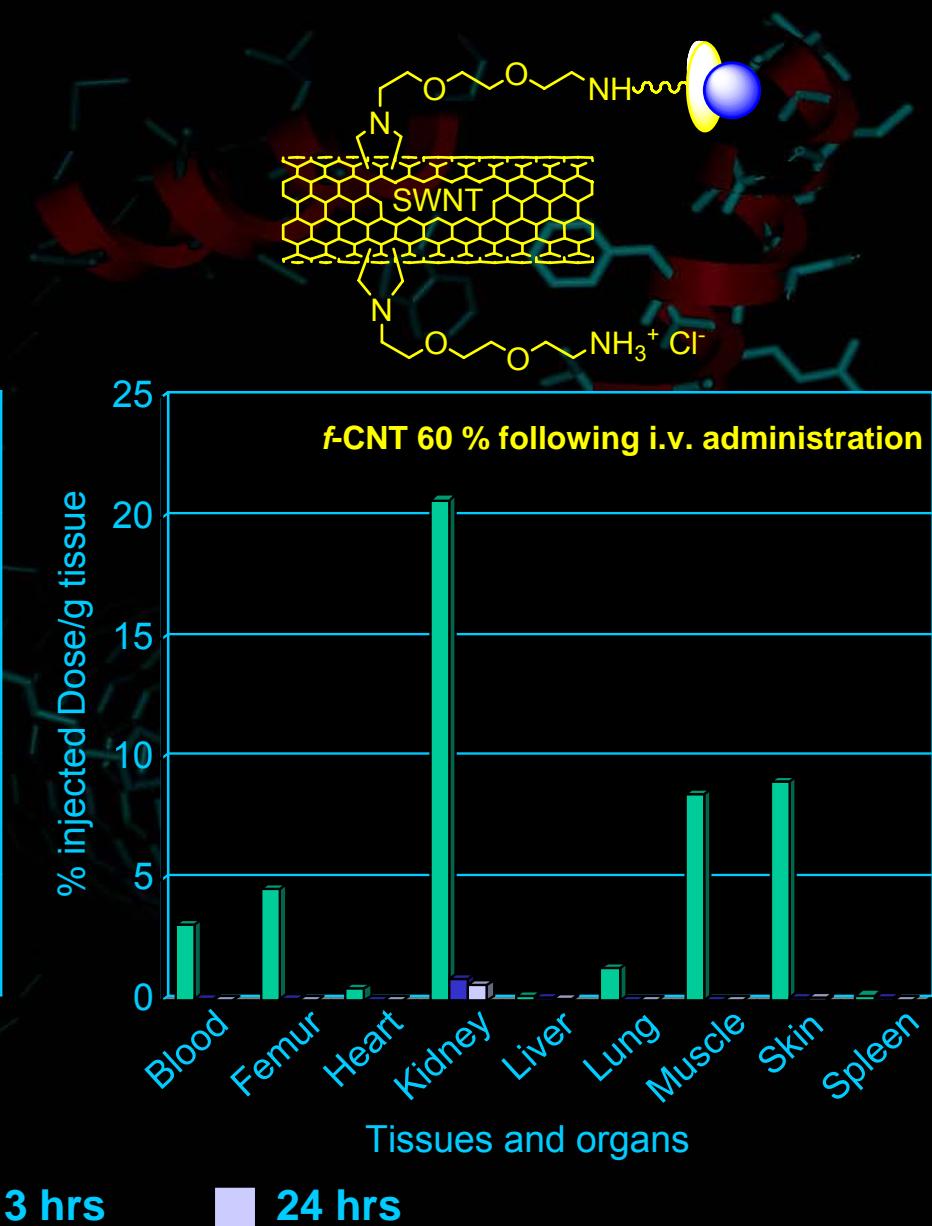
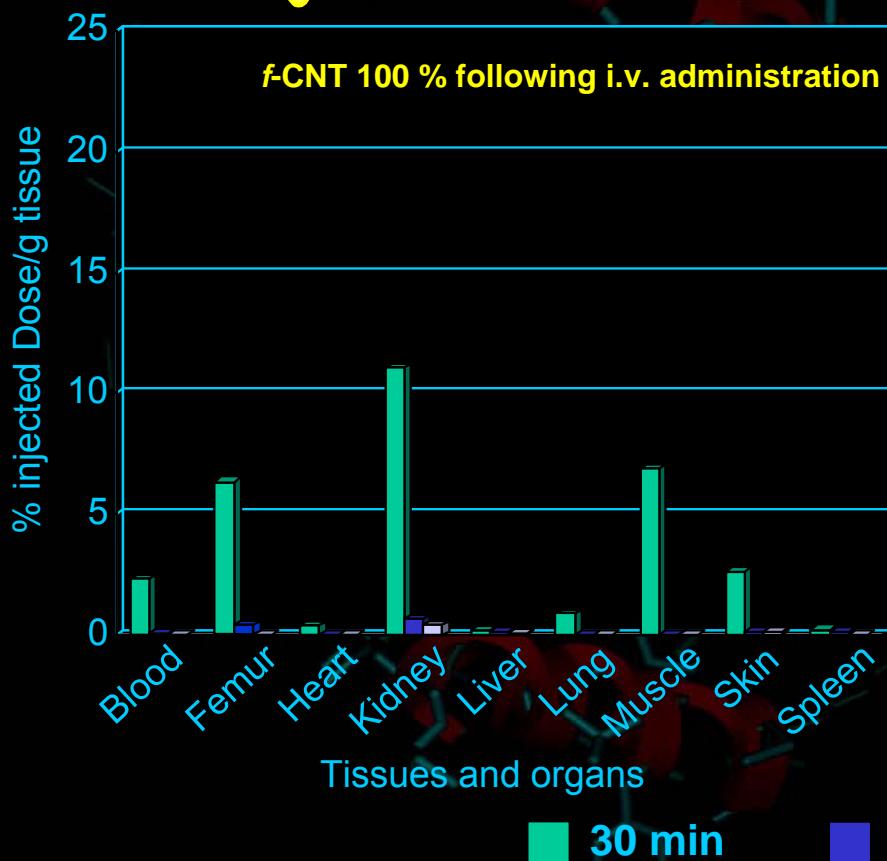
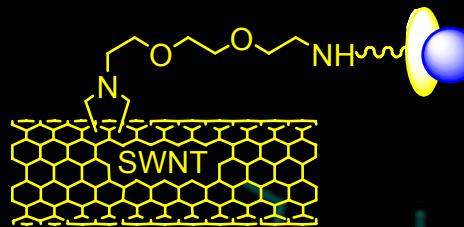
T Lymphocytes



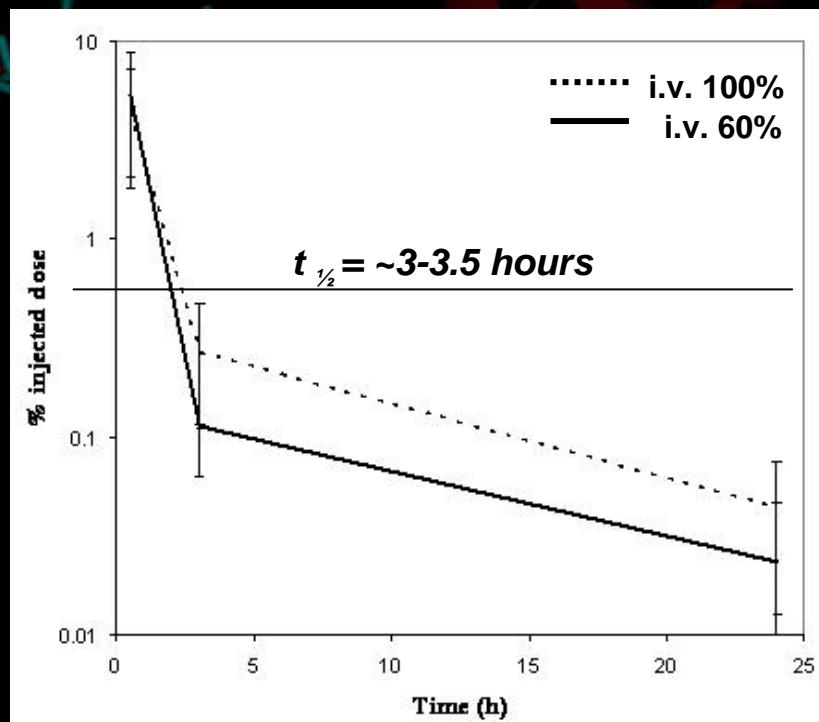
Macrophages



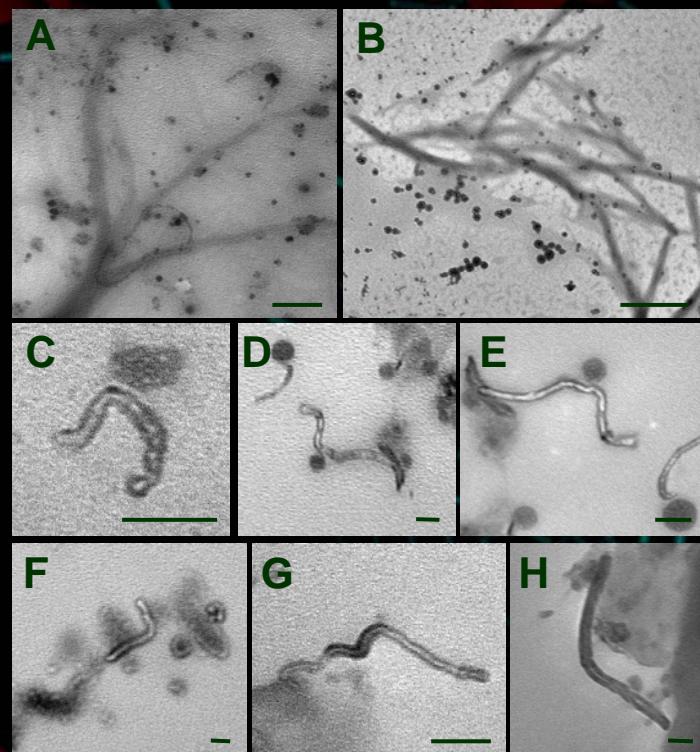
Tissue Biodistribution of Functionalised Carbon Nanotube



Blood Circulation of Functionalised Carbon Nanotubes



Carbon Nanotube Excretion via Urines



SWNT-DTPA

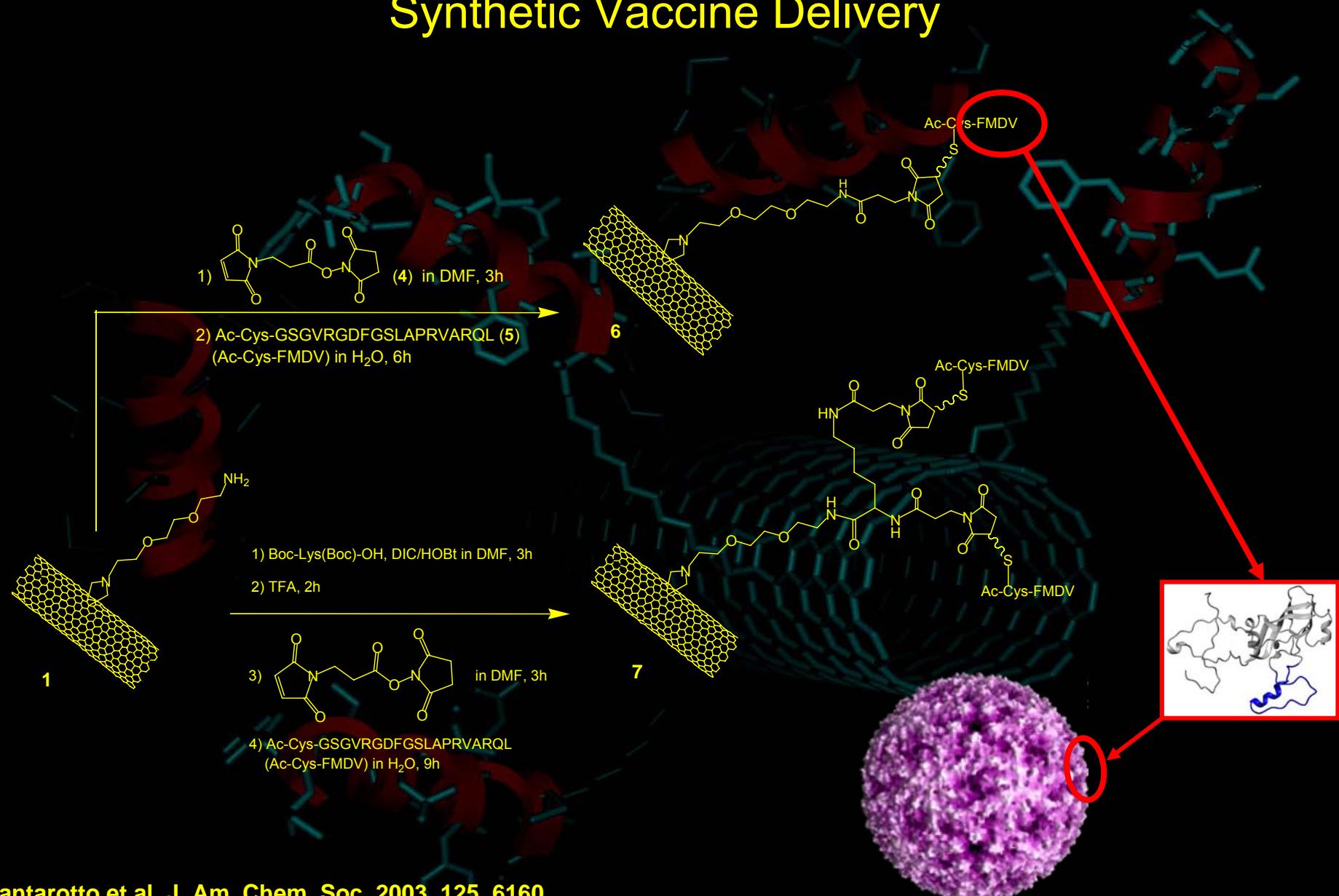
MWNT-DTPA

Scale bar 100 nm

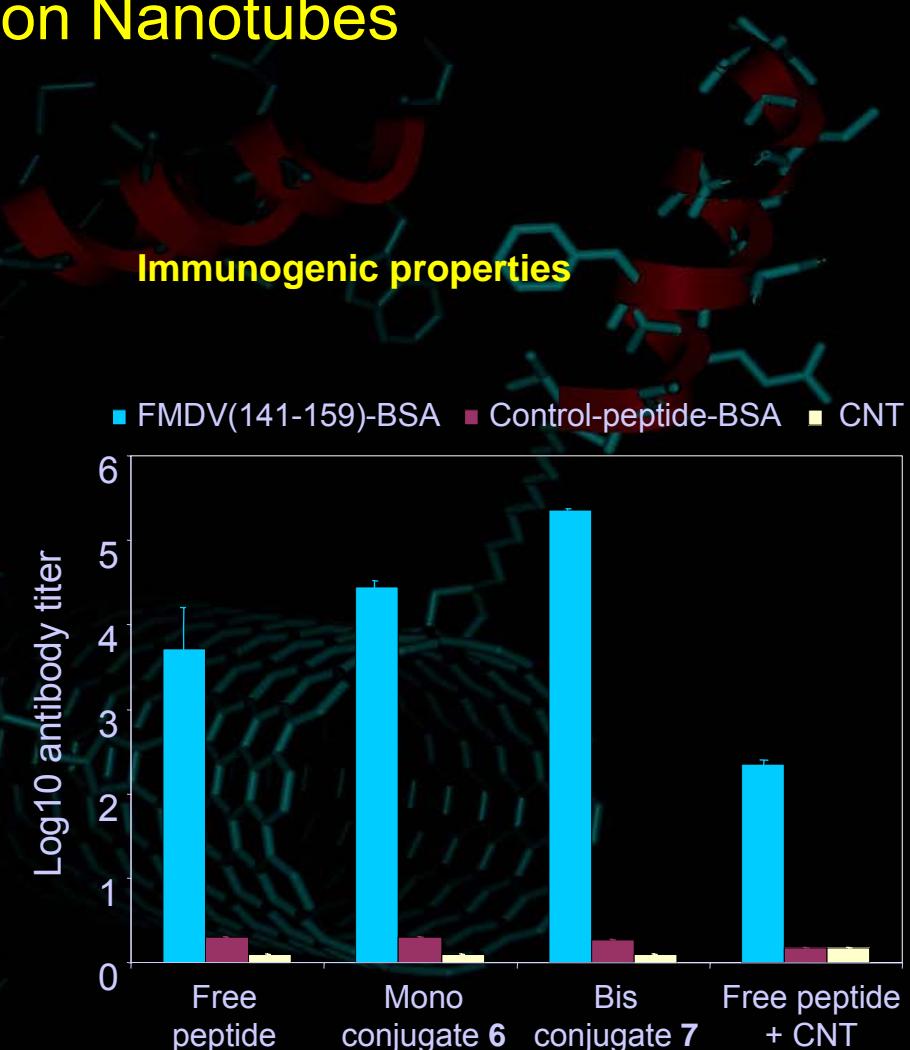
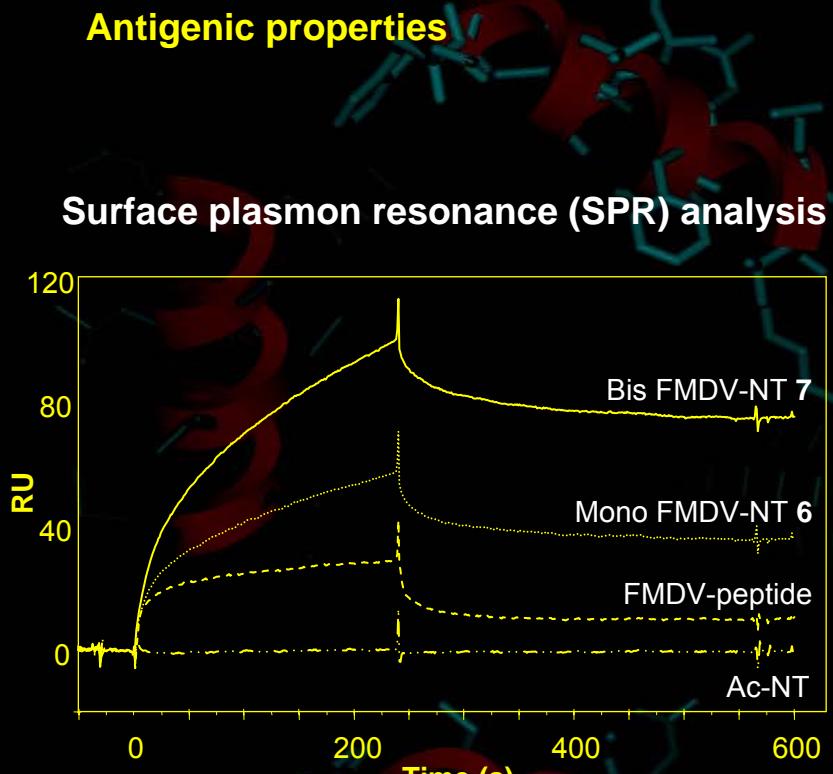
Functionalised Carbon Nanotubes as New Vectors for the Delivery of Therapeutic Molecules

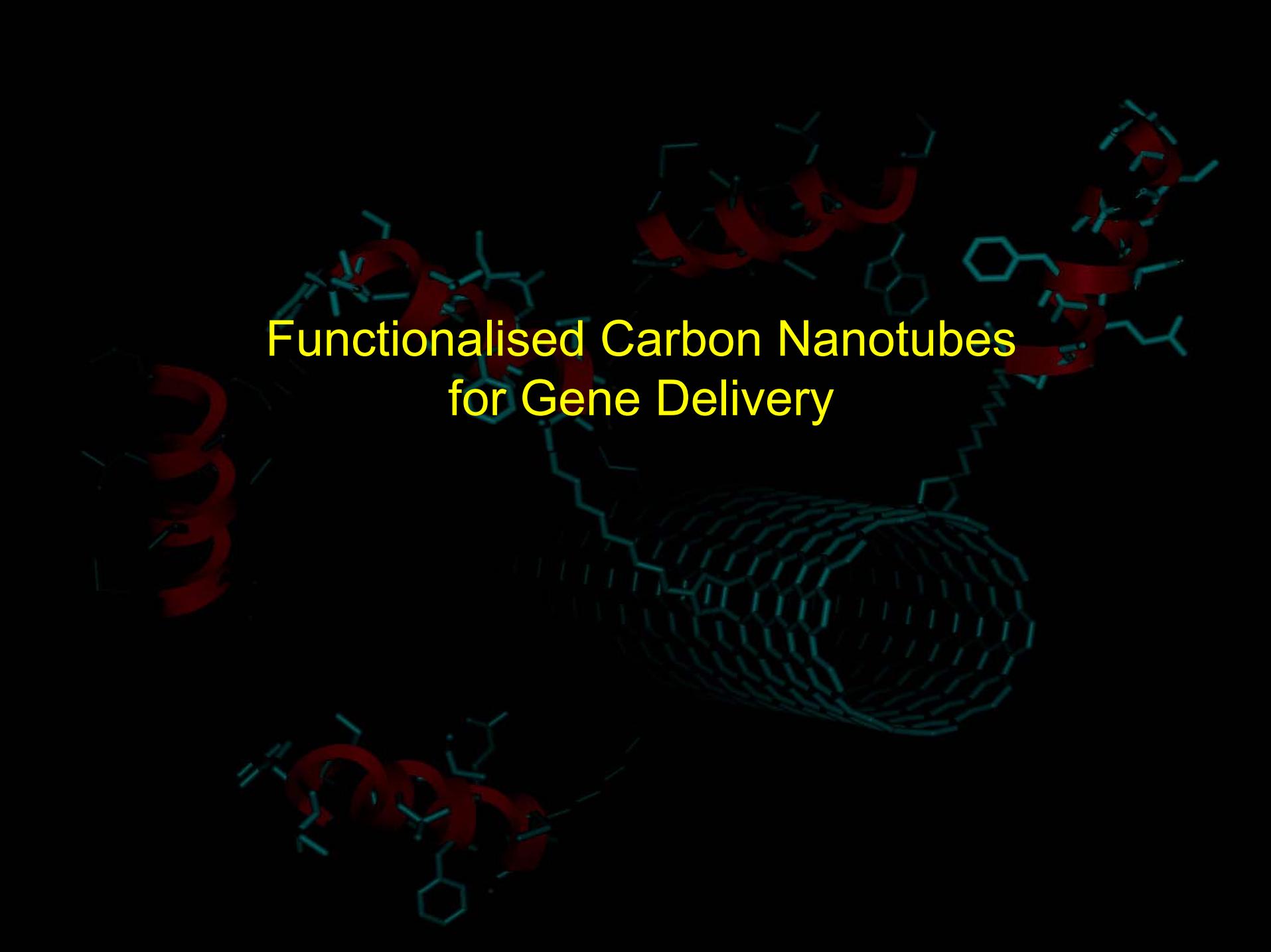
- Functionalisation of carbon nanotubes with bioactive peptides
 - Application on vaccine delivery
- Formation of supramolecular complexes based on charge interactions
 - Application on gene delivery
- Functionalisation of carbon nanotubes with therapeutic molecules
 - Application on drug delivery

Peptide Antigens Conjugated to Carbon Nanotubes for Synthetic Vaccine Delivery



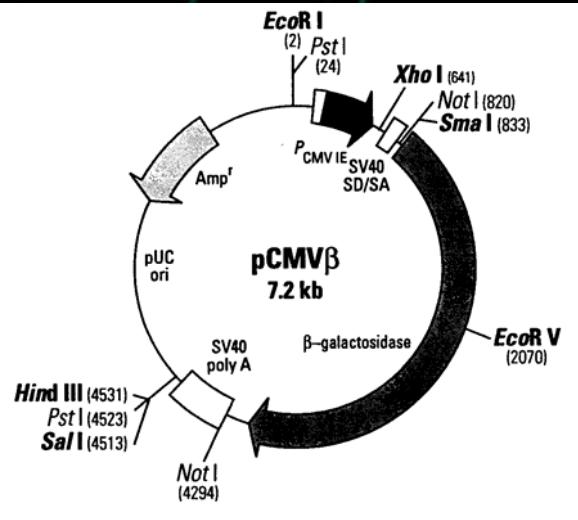
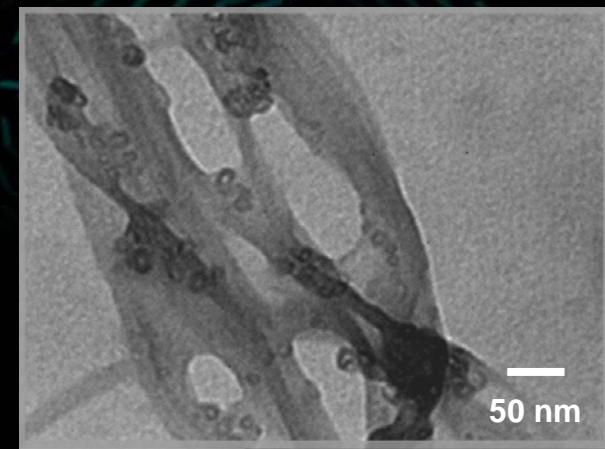
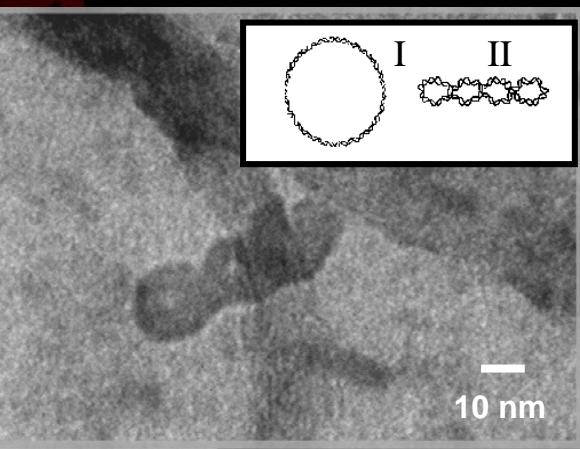
Antigenic and Immunogenic Characterisation of Peptide-Carbon Nanotubes



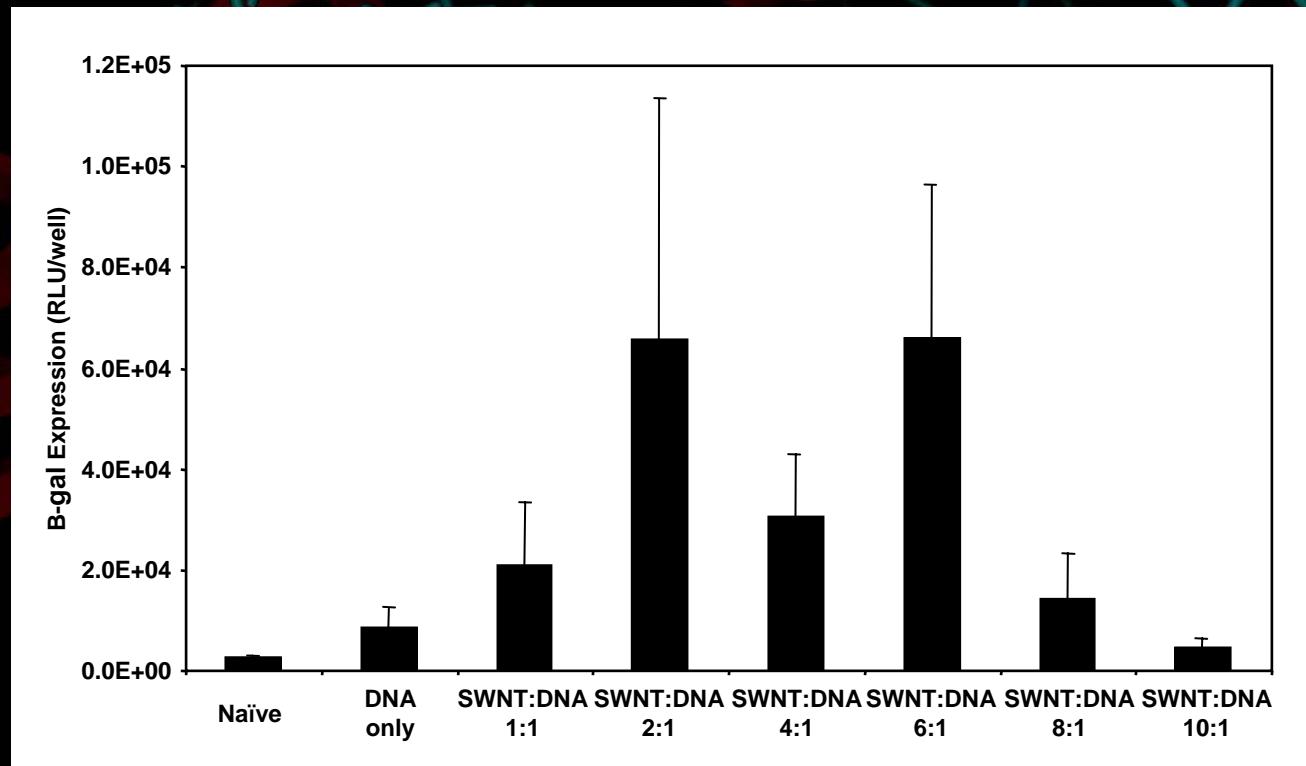


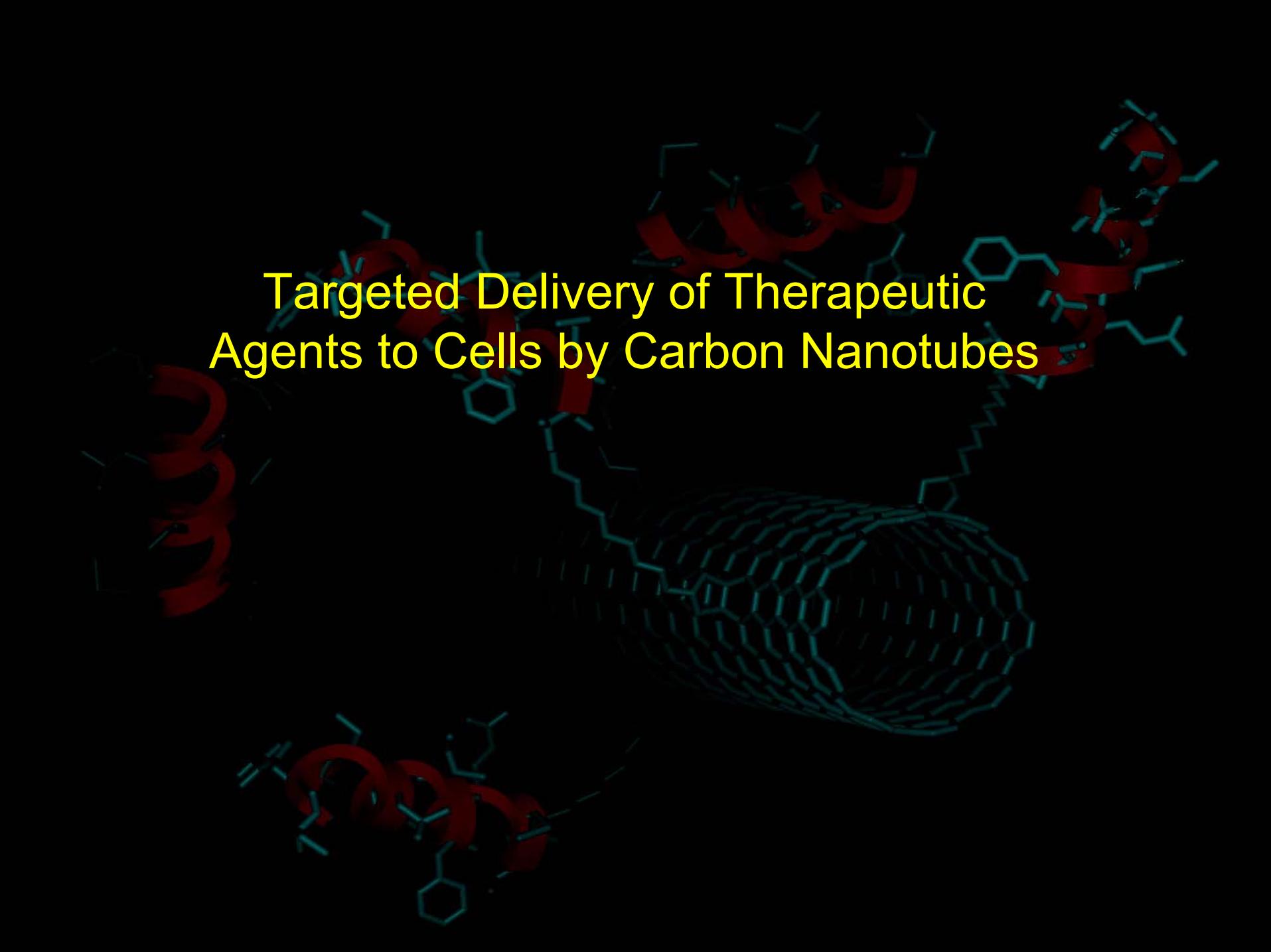
Functionalised Carbon Nanotubes for Gene Delivery

Potential of Carbon Nanotubes on Gene Delivery



Delivery and Expression of Plasmid DNA by *f*-CNT





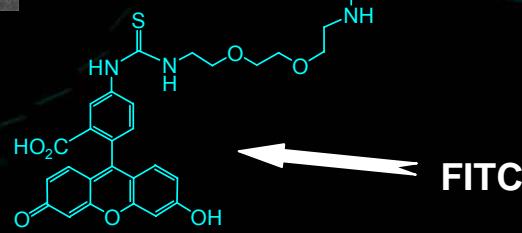
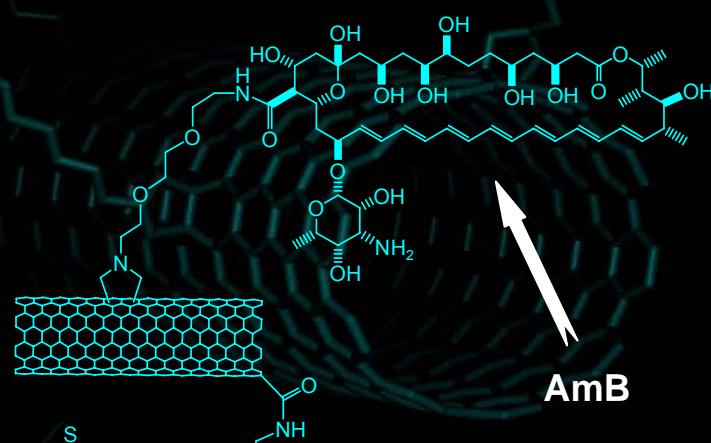
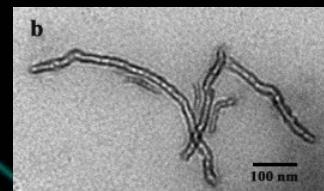
Targeted Delivery of Therapeutic Agents to Cells by Carbon Nanotubes

Delivery of Antibiotics by Carbon Nanotubes

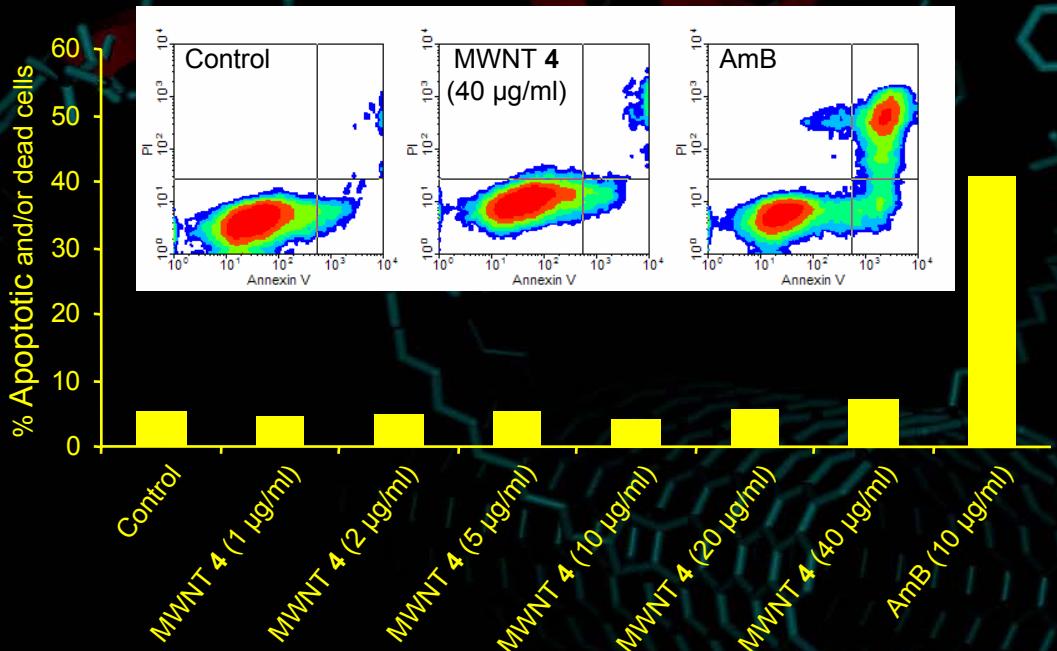
Amphotericin B (AmB) is a potent antifungal agent for the treatment of chronic fungal infections
AmB is highly toxic for mammalian cells (likely because of the formation of aggregates which reduce the solubility in water)

New approach to carbon nanotube functionalisation: preparation of nanotubes carrying one or more active molecule with:

- i) Optical signal for imaging
- ii) Specific targeting



Effect of AmB Conjugated to Carbon Nanotubes



The conjugation of AmB to carbon nanotubes clearly reduces the toxic affect of the antifungal agent on mammalian cells

Conclusions and Perspectives

Advantages of Functionalised Carbon Nanotubes

- Control of the functionalization
- Lack of immunogenicity
- Reduced toxicity
- No apparent tissue/organ accumulation

Factors to be Carefully Addressed

- Quality of the starting material (carbon nanotubes)
- Control of the preparations
- Long-term toxicity

Acknowledgements

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