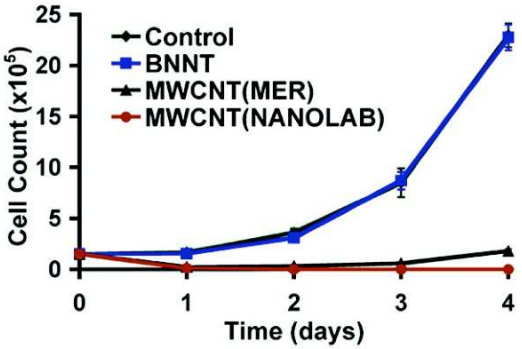
JACS
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY

Boron Nitride Nanotubes Are Noncytotoxic and Can Be Functionalized for Interaction with Proteins and Cells



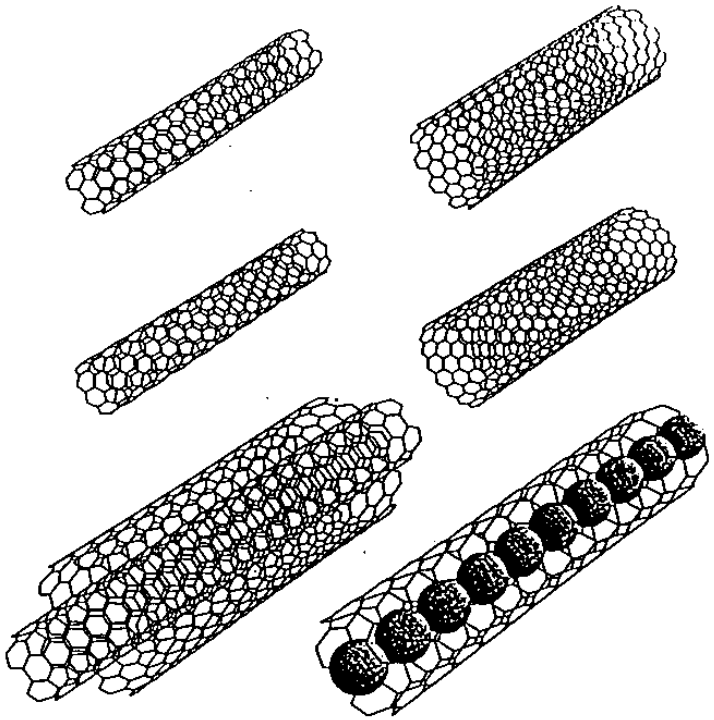
Xing Chen, Peng Wu, Michael Rousseas, David Okawa, Zev Gartner, Alex Zettl, and Carolyn R. Bertozzi

J. Am. Chem. Soc., **2009**, 131 (3), 890-891

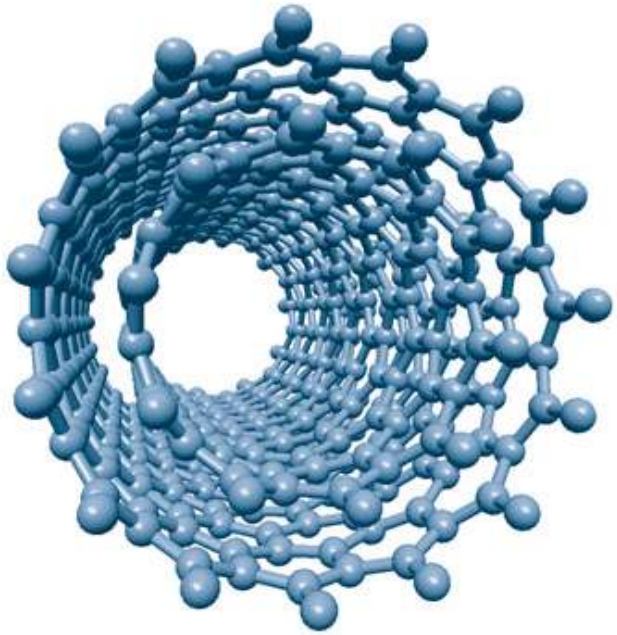
Presentation By Nora Jameson
Current Lit 08/30/2008

Carbon Nanotubes (CNTs)

- Single-Walled Nanotubes (SWNT)
- Multi-Walled Nanotubes (MWNT)
- Polymerized single-walled nanotubes (P-SWNT)

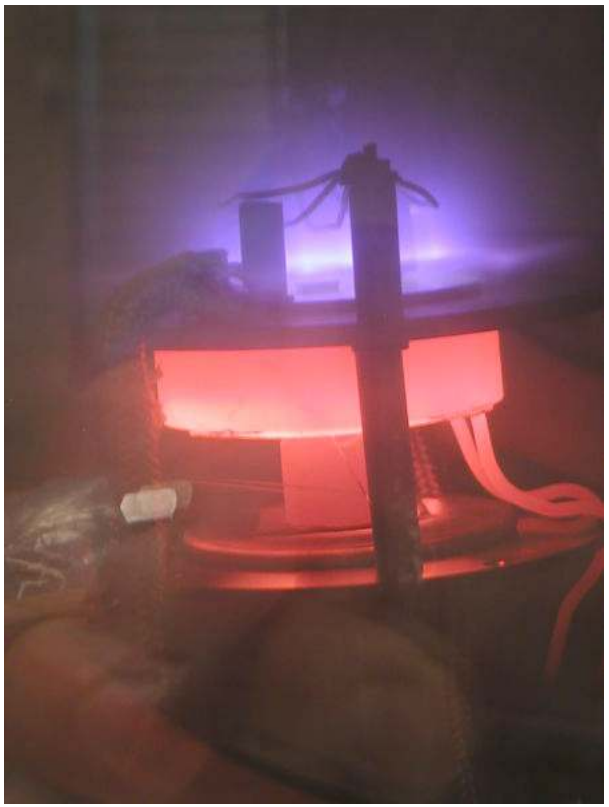


Carbon Nanotubes (CNTs)



- exhibit extraordinary strength
- unique electrical properties
- efficient conductors of heat
- composed entirely of sp2 bonds

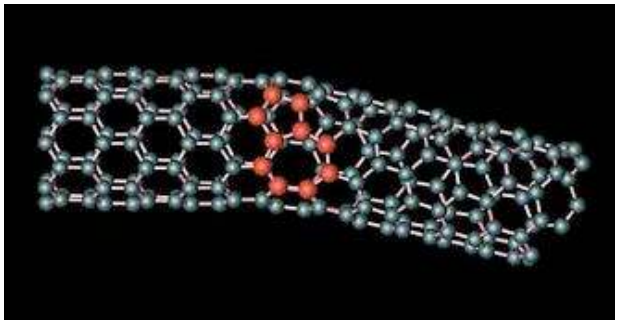
Carbon Nanotubes (CNTs)



- arc discharge
- laser ablation
- chemical vapor deposition (CVD)
- natural, incidental, and controlled flame environments

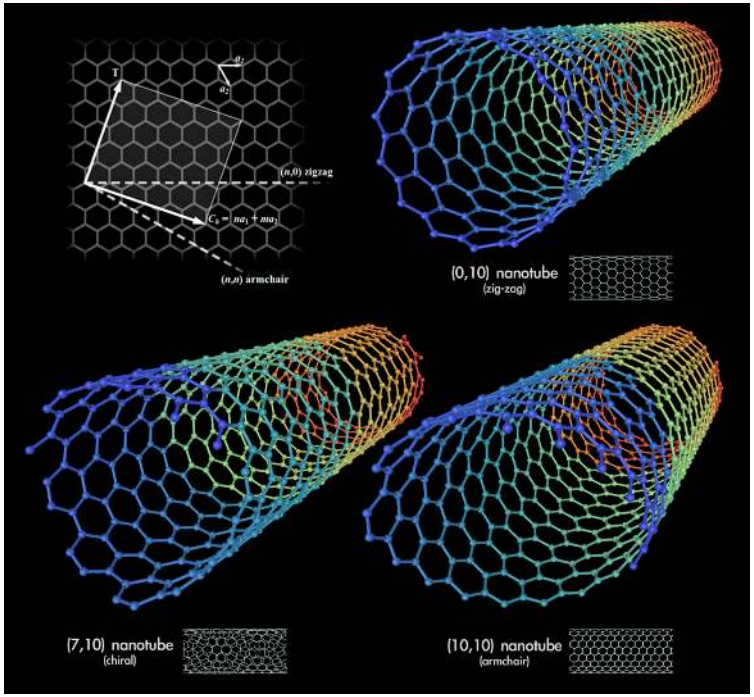
Carbon Nanotubes (CNTs)

- electrical circuits
- solar cells
- ultracapacitors
- mechanical memory elements
- nanoscale electric motors
- nanoradios
- electricity storage



Carbon Nanotubes (CNTs)

- Useful for a variety of biological functions:
  - biosensing
  - imaging
  - intracellular delivery
  - cancer cell targeting



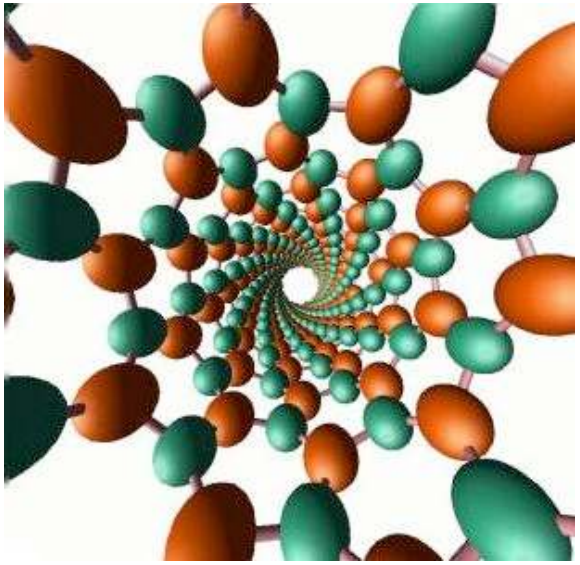
Star, A.; Tu, E.; Niemann, J.; Gabriel, J. C. P.; Joiner, C. S.; Valcke, C. *Proc. Natl. Acad. Sci. U.S.A.* **2006**, *103*, 921.
Wong, S. S.; Joselevich, E.; Woolley, A. T.; Cheung, C. L.; Lieber, C. M. *Nature* **1998**, *394*, 52.
Chen, X.; Kis, A.; Zettl, A.; Bertozzi, C. R. *Proc. Natl. Acad. Sci. U.S.A.* **2007**, *104*, 8218
Kostarelos, K.; Lacerda, L.; Pastorin, G.; Wu, W.; Wieckowski, S.; Luangsivilay, J.; Godefroy, S.; Pantarotto, D.; Briand, J. P.; Muller, S.; Prato, M.; Bianco, A. *Nat. Nanotechnol.* **2007**, *2*, 108.
Kam, N. W. S.; O'Connell, M.; Wisdom, J. A.; Dai, H. J. *Proc. Natl. Acad. Sci. U.S.A.* **2005**, *102*, 11600.

Carbon Nanotubes (CNTs)

- cytotoxic to cells with different phenotypes
  - accumulate in the cytoplasm and cause cell death
- functional modifications can alter these cytotoxic responses
- possibility of *in situ* desorption brings considerable risk to their use in living organisms

Kam, N. W. S.; O'Connell, M.; Wisdom, J. A.; Dai, H. J. *Proc. Natl. Acad. Sci. U.S.A.* **2005**, *102*, 11600.
Chen, X.; Tam, U. C.; Czlapinski, J. L.; Lee, G. S.; Rabuka, D.; Zettl, A.; Bertozzi, C. R. *J. Am. Chem. Soc.* **2006**, *128*, 6292.
Sayes, C. M.; Liang, F.; Hudson, J. L.; Mendez, J.; Guo, W. H.; Beach, J. M.; Moore, V. C.; Doyle, C. D.; West, J. L.; Billups, W. E.; Ausman, K. D.; Colvin, V. L. *Toxicol. Lett.* **2006**, *161*, 135.
Dumortier, H.; Lacotte, S.; Pastorin, G.; Marega, R.; Wu, W.; Bonifazi, D.; Briand, J. P.; Prato, M.; Muller, S.; Bianco, A. *Nano Lett.* **2006**, *6*, 1522.

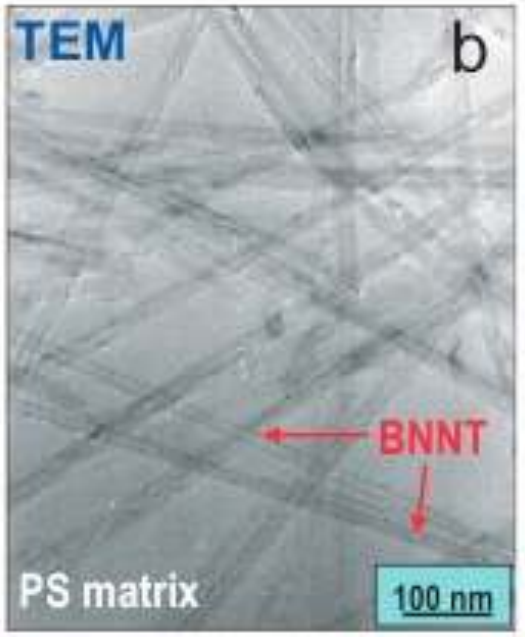
Boron Nitride Nanotubes (BNNTs)



- inherently noncytotoxic
- wide band gap semiconductors whose electrical properties are independent of geometry
- more chemically inert and structurally stable than CNTs

Boron Nitride Nanotubes (BNNTs)

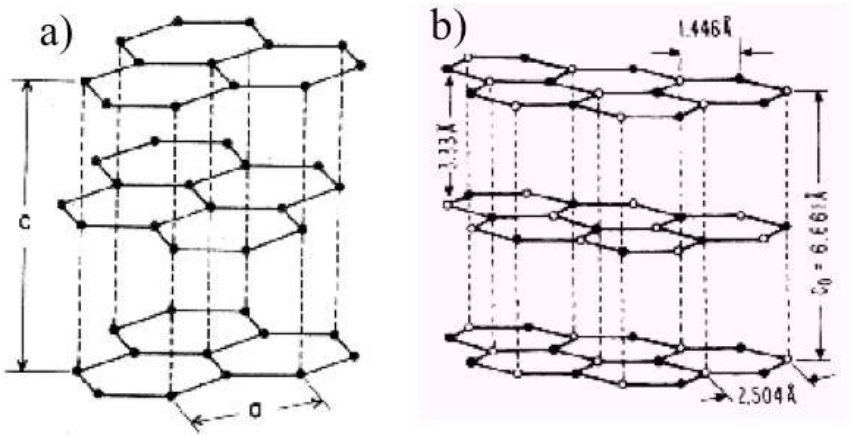
- aerospace technology
- medical and nanobiological technology
- ultraviolet lasers
- field-emitting devices
- electrical nano-insulators
- gas adsorption
- polymeric composites



Golberg D., Y. Bando, C. Tang, and C. Zhi *Adv. Mater.* **2007**, 19, 2413–2432

CNTs vs. BNNTs

- boron atoms in one layer are located directly on top of nitrogen atoms in neighboring layers and vise versa
- In graphite hexagons are offset and do not lie on top of each other



Graphite a: 2.456 Å
c: 6.696Å

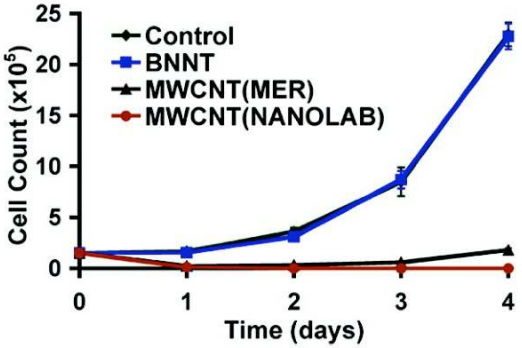
a: 2.504 Å Boron Nitride
c: 6.661 Å

Tatar, R. C., and Rabii, S., *Physical Review B* **25,** 4126-41 (1982).

Sichel, E. K., Miller, R. E., Abrahams, M. S., and Buiocchi, C. J., *Physical Review B* **13**, 4607-11 (1976).

JACS
JOURNAL OF THE AMERICAN CHEMICAL SOCIETY

Boron Nitride Nanotubes Are Noncytotoxic and Can Be Functionalized for Interaction with Proteins and Cells

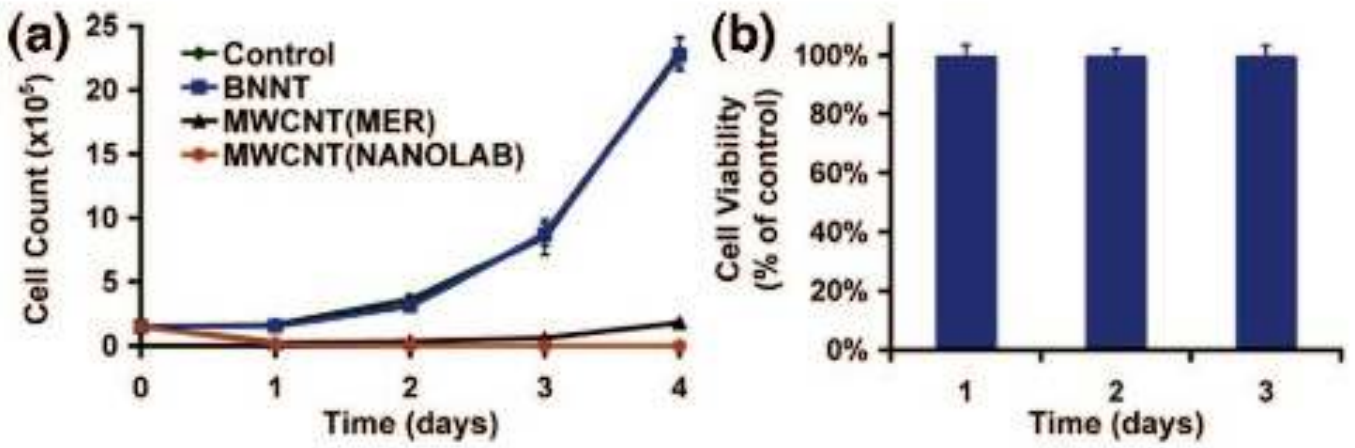


Xing Chen, Peng Wu, Michael Rousseas, David Okawa, Zev Gartner, Alex Zettl, and Carolyn R. Bertozzi

J. Am. Chem. Soc., **2009**, 131 (3), 890-891

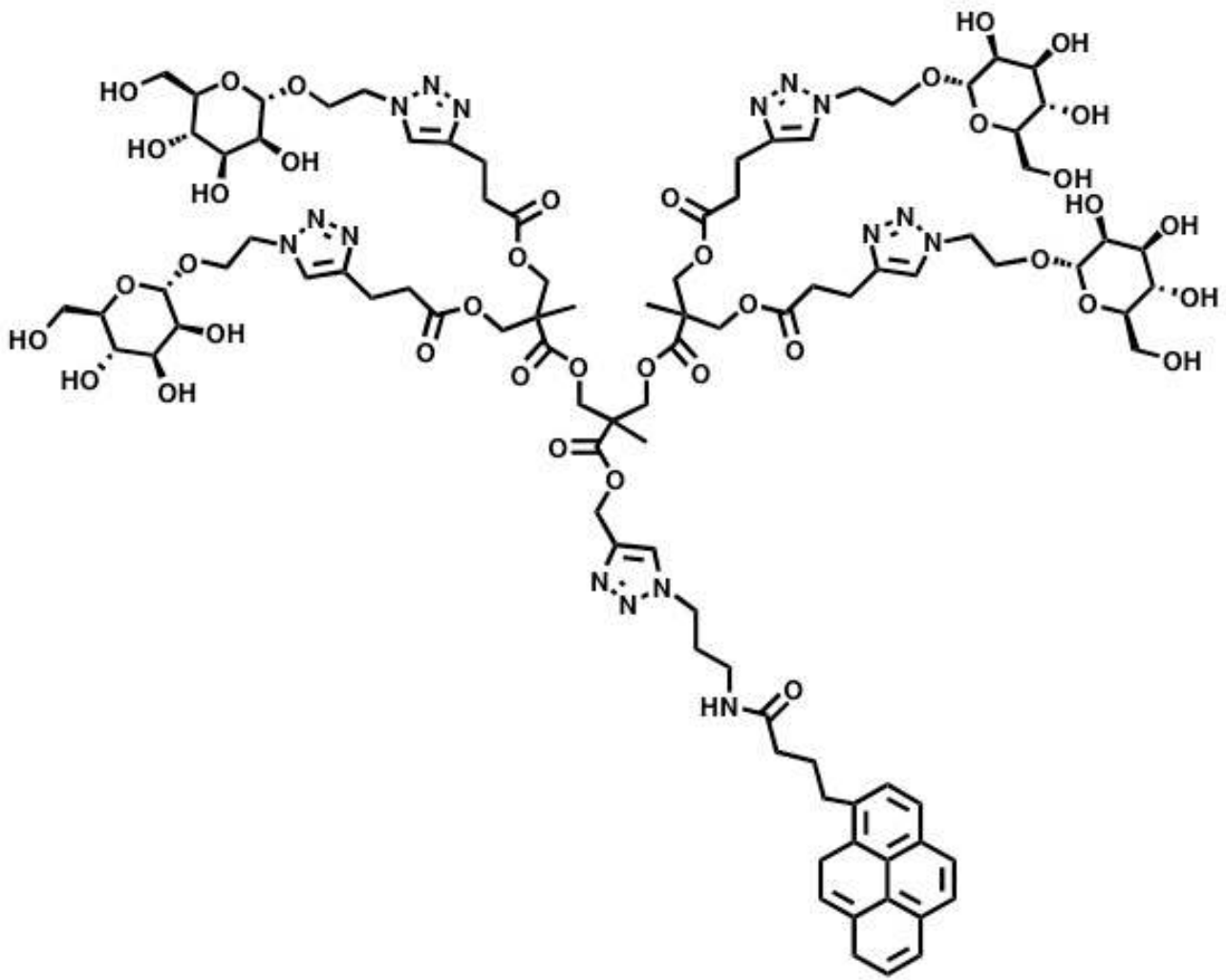
Presentation By Nora Jameson
Current Lit 08/30/2008

BNNTs Cytotoxic?

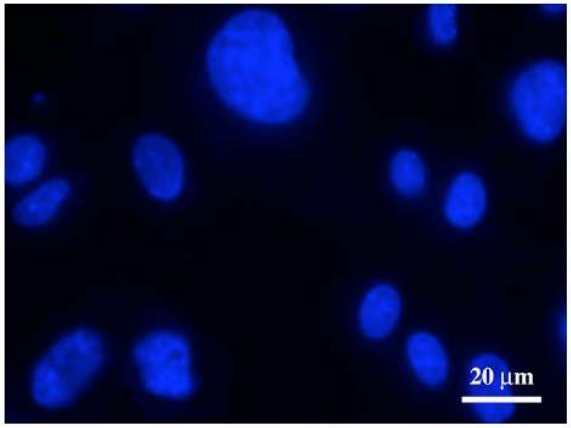


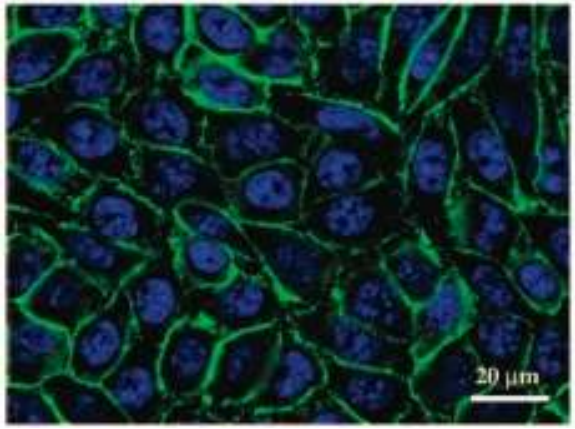
- BNNTs are **not** cytotoxic. (a) BNNTs do not inhibit HEK 293 cell proliferation. (b) BNNTs have no effect on cell viability. HEK 293 cells were cultured with BNNTs or with media alone.

Surface Functionalization

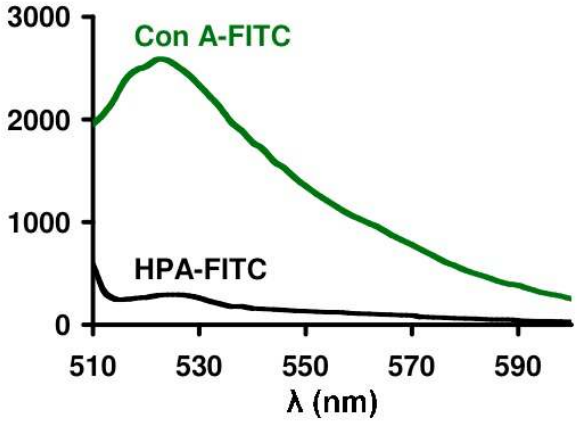


BNNTs can bind to proteins

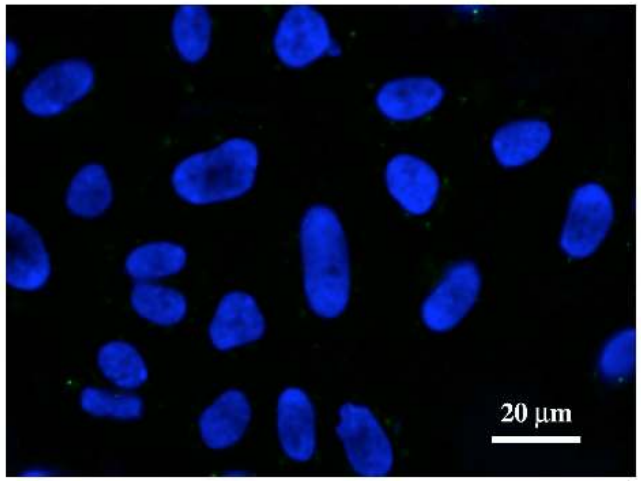


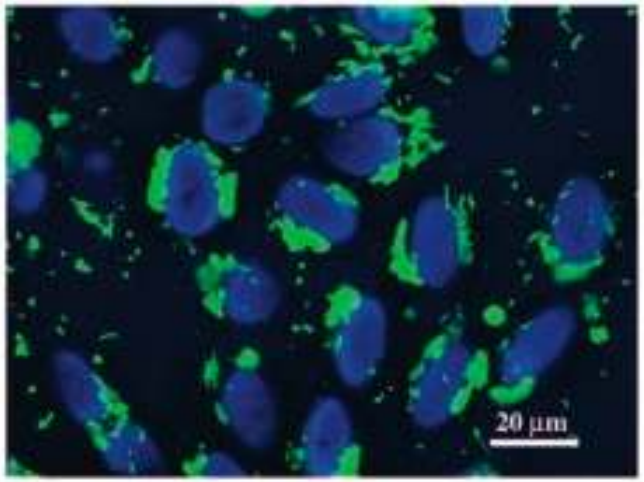


- (left) BNNTs coated with [G-2] Gal, which do not bind to Con A, showed no fluorescent labeling of the surface of CHO cells
- (right) fluorescence associated with Con A-bound [G-2] Man-BNNTs



BNNTs as cell delivery agents





- (left) CHO cells after overnight incubation with FITC-DNA alone, showed no significant cell surface fluorescence.
- (right) CHO cells after internalization of BNNTs coated with FITC-labeled DNA. CHO cells were incubated with FITC-DNA-BNNTs overnight and stained with DAPI prior to microscopy analysis.

Conclusions

- BNNTs are not cytotoxic
- BNNTs can be functionalized
- BNNTs can bind specifically to proteins
- BNNTs can act as cell delivery agents
- Future therapeutic/pharmaceutical uses