

# **Panel 10: How exposure changes as NP are transformed in the environment**

**R. David Holbrook**

**Surface and Microanalysis Science Division  
National Institute of Standards and Technology**

**NNI Workshop on Nanomaterials & the Environment and  
Instrumentation, Metrology, and Analytical Methods**

**Arlington, VA  
October 7, 2009**

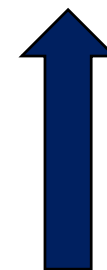
---

***Understanding how exposures may change as nanomaterials are transformed in the environment.***

***Evaluate abiotic, and ecosystem-wide, effects***

- 1. What is the state of research at the current time?***
- 2. Are research needs provided by NNI complete?***
- 3. Which research needs should be addressed in near-, medium-, and longer-term?***

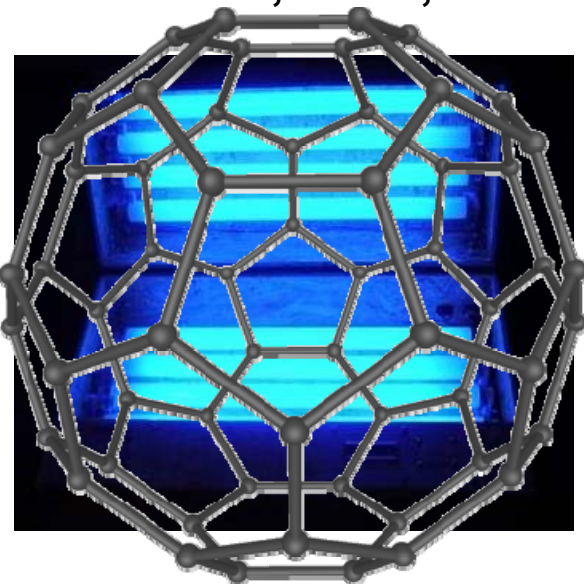
**How does the Nanoparticle  
effect the Environment?**



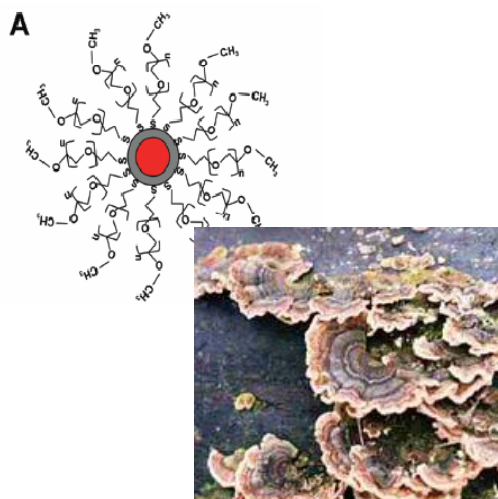
**How does the Environment  
effect the Nanoparticle?**

# Abiotic Effects on Nanoparticles

Lee et al., ES&T, 2009



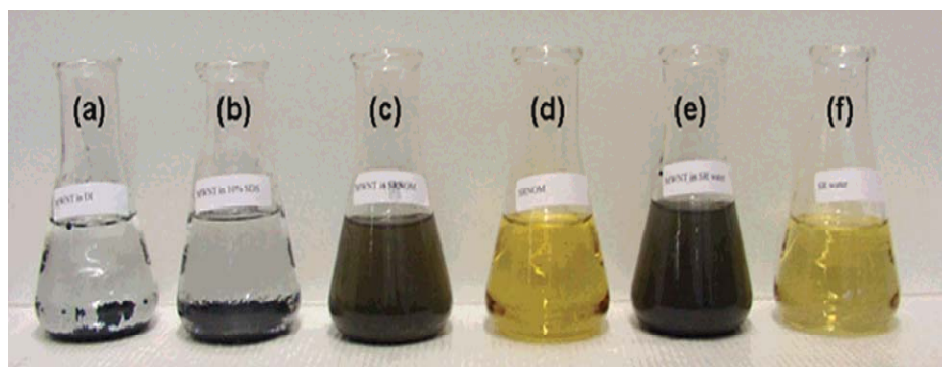
Menz et al., ES&T, 2009



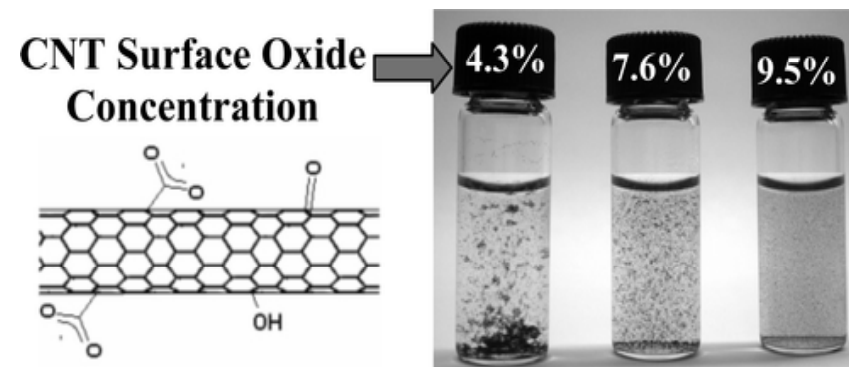
Klaine et al., ET&C, 2008



Hyung et al., ES&T, 2007



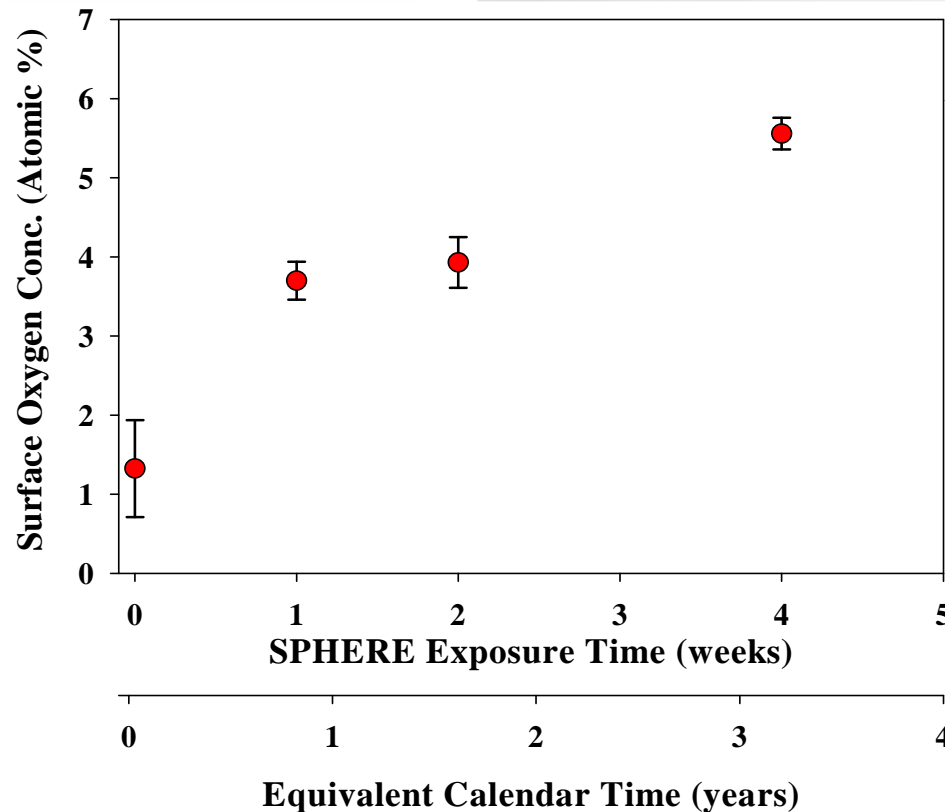
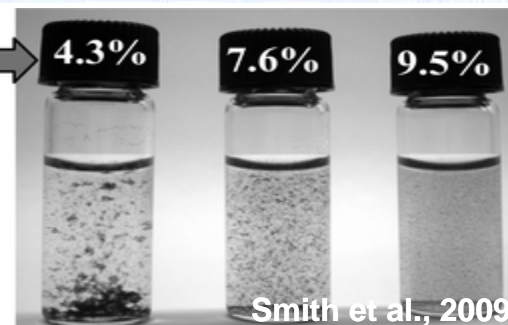
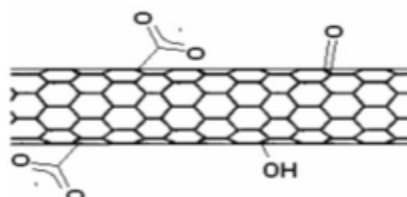
Smith et al., Langmuir, 2009



# Abiotic Effects on Nanoparticles



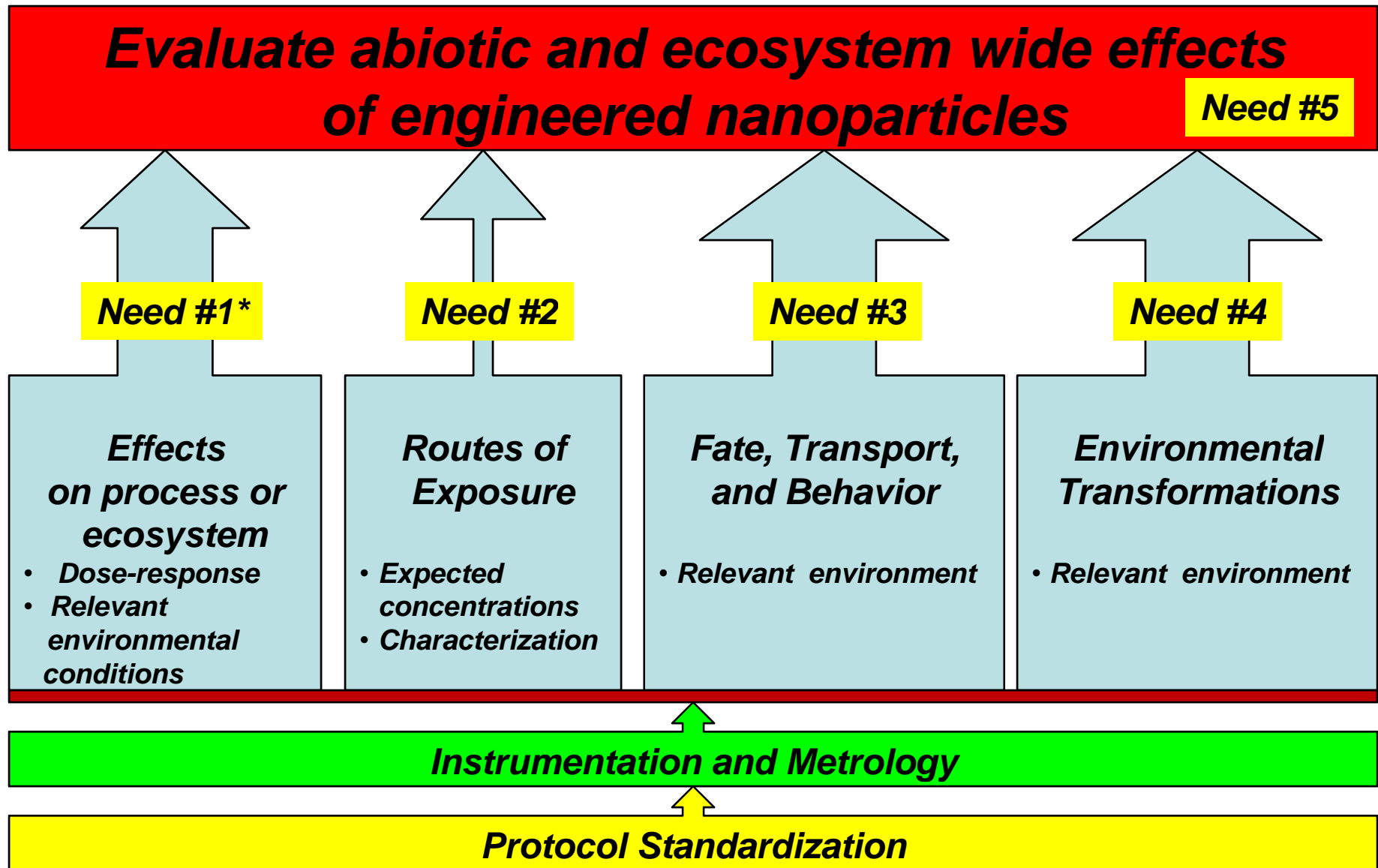
CNT Surface Oxide Concentration



# 1. Current State of Research?

- **Stability and aggregation of NP**
  - Arguably most researched topic
  - Engineered nanoparticles behavior appears to mirror that of “natural” nanoparticles (colloids)
  - NP aggregates “should” be less toxic, but...
- **Abiotic transformations of NP**
  - Growing area of research
  - Most research related to stability and aggregation
  - Critical area for NP-containing products used outside
- **Impact of transformations on ecosystems**
  - Future area of research

## 2. Are NNI research needs complete?



# 3. Research Timeline?

Protocol Standardization



Instrumentation and Metrology

1-5 years

Need #4

*Fate, Transport, and Behavior*

Need #3

*Environmental Transformations*

Need #2

*Routes of Exposure*

Need #1\*

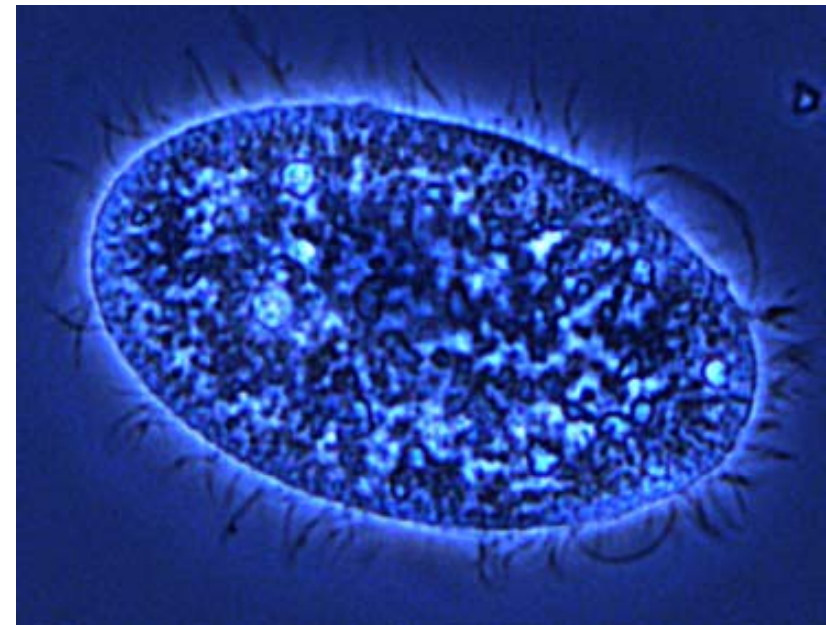
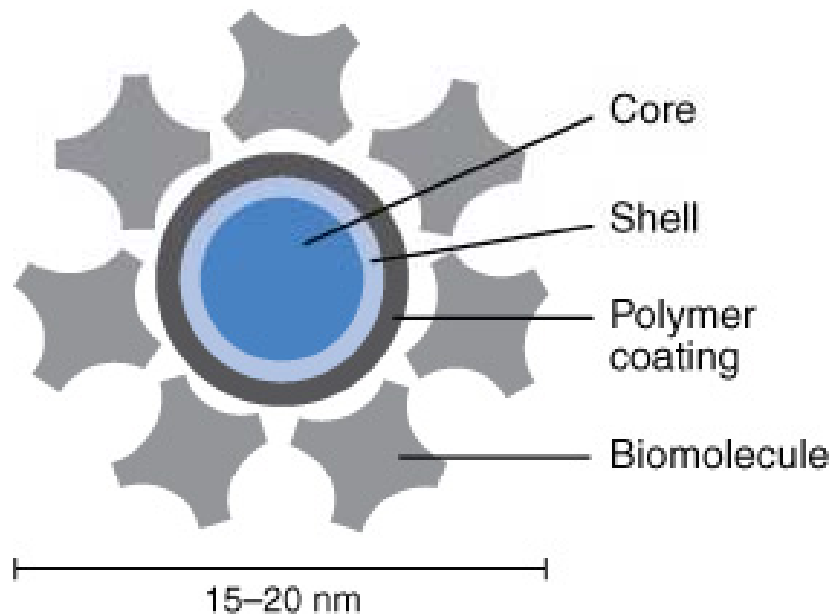
*Effects on process or ecosystem*

Need #5

*Evaluate abiotic and  
ecosystem wide effects*

10+ years





## Quantum Dots (QDs)

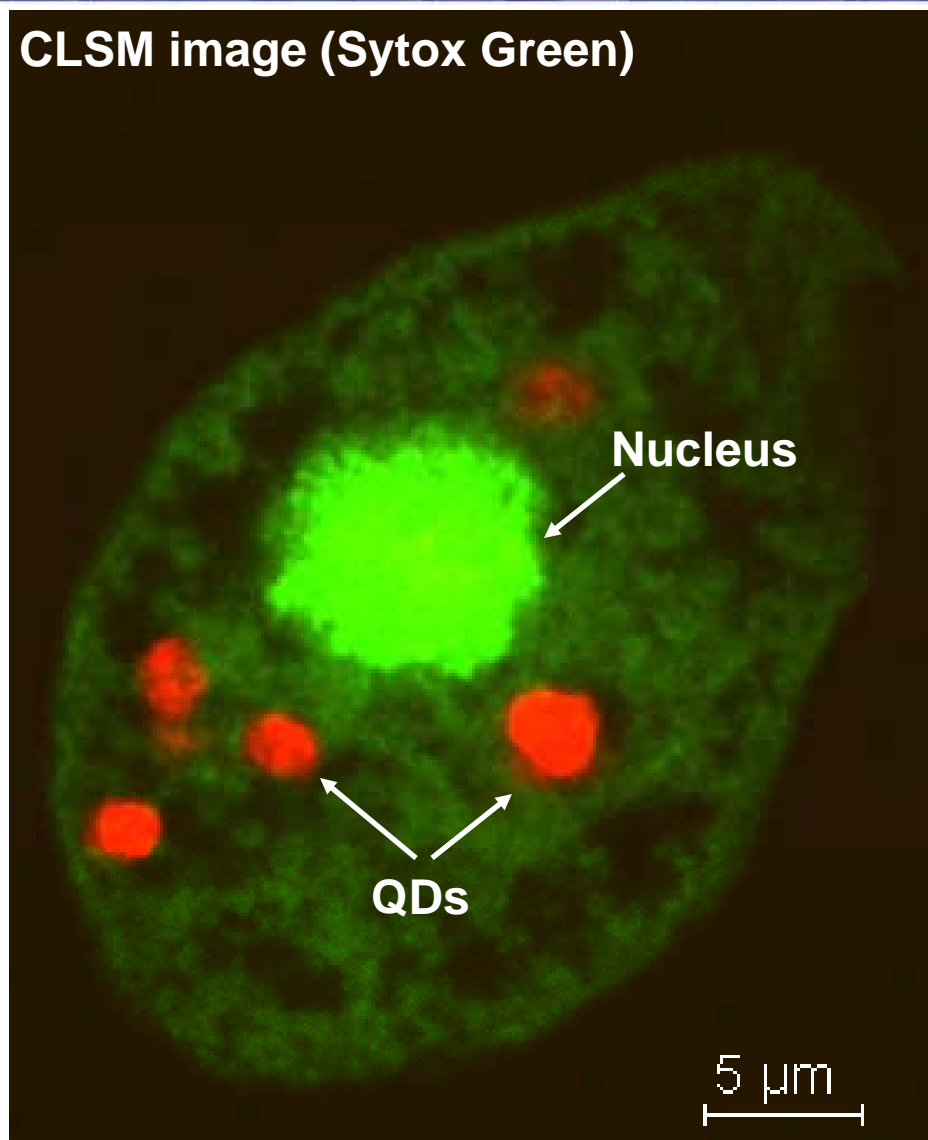
- 655 nm emission, Cd/Se core
- Carboxylated and Biotinylated

## Ciliates

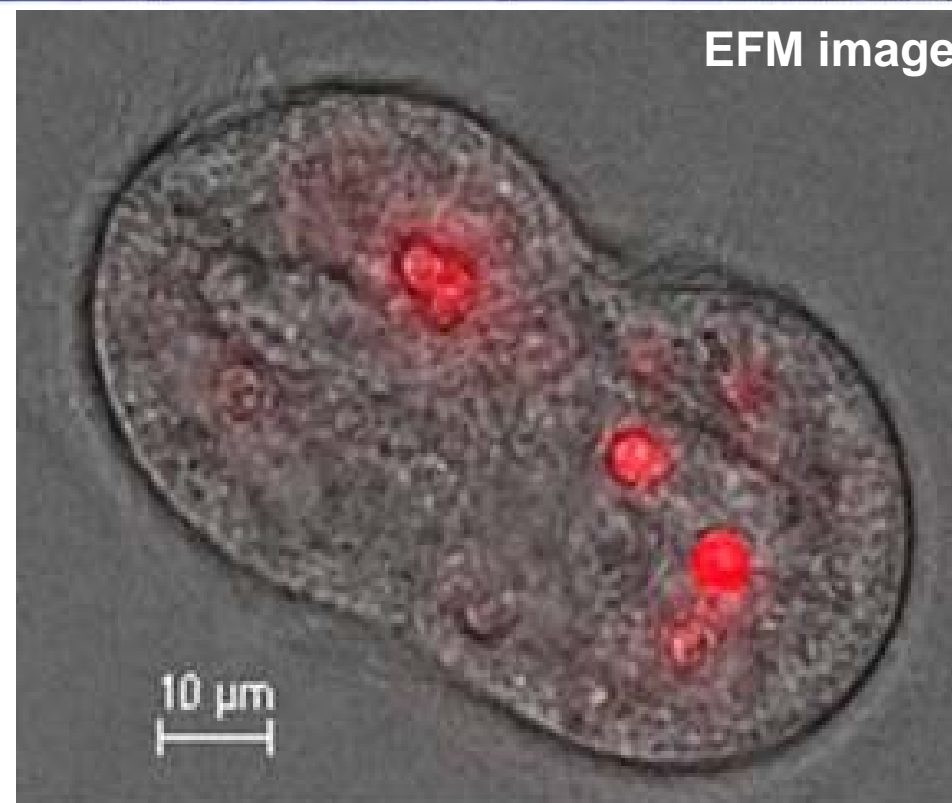
- Grown in ATCC media
- Length = 40 – 50  $\mu\text{m}$
- Width = 20 – 30  $\mu\text{m}$

# Results – QD uptake by ciliate

CLSM image (Sytox Green)

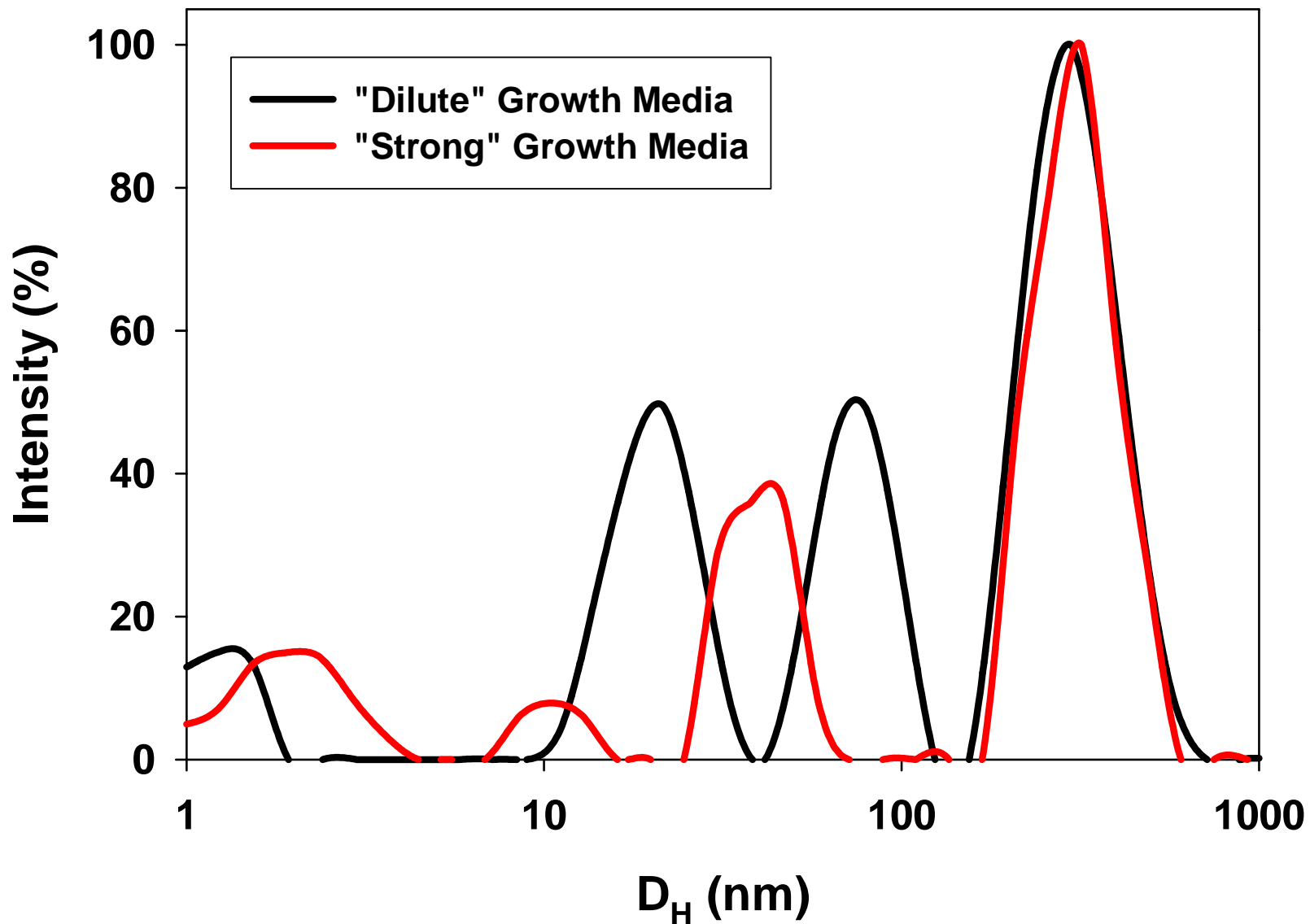


EFM image

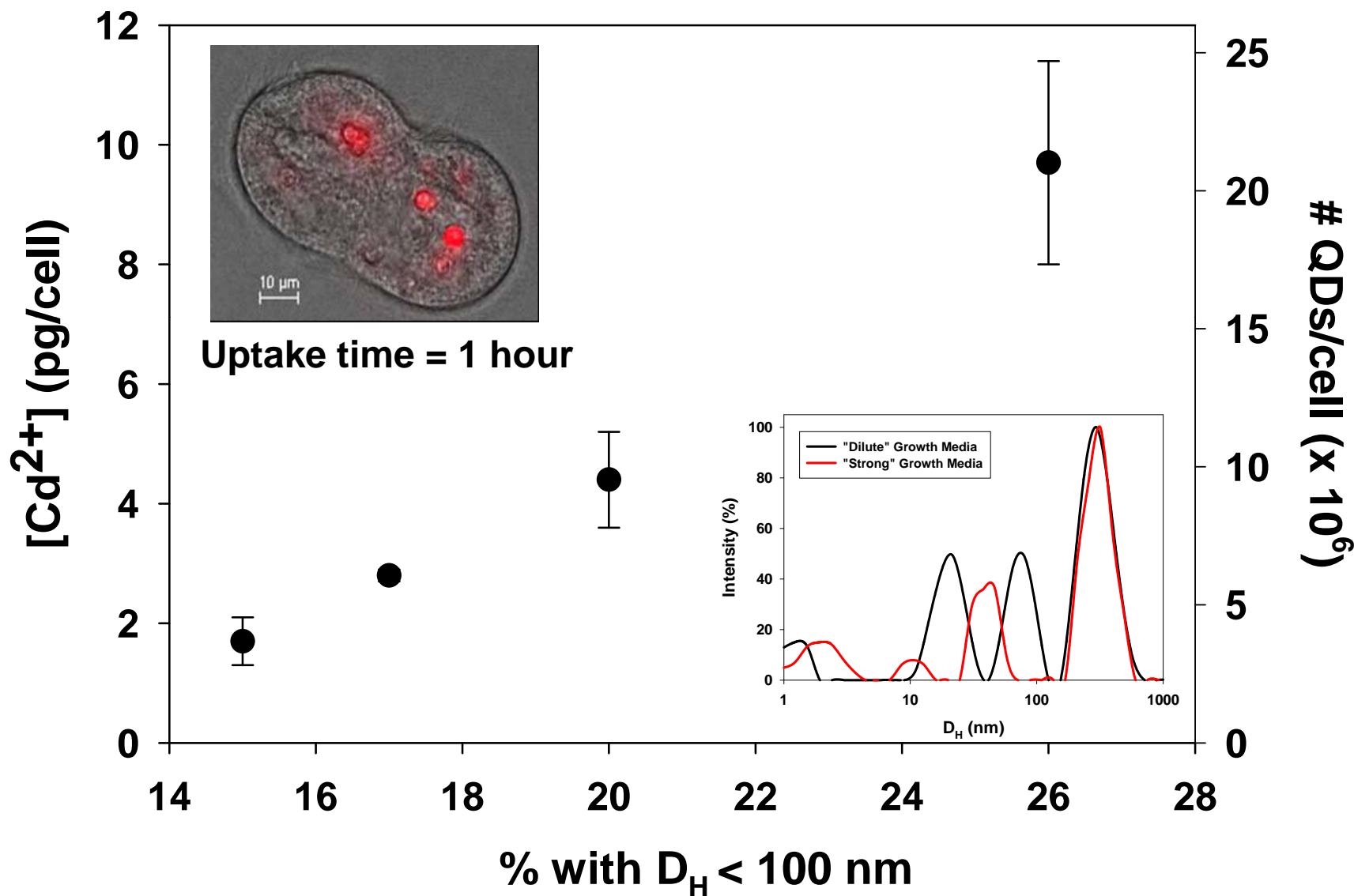


- Internal QDs easily observed
- Appear membrane-bound
- No external QDs observed
- No QDs associated with nucleus

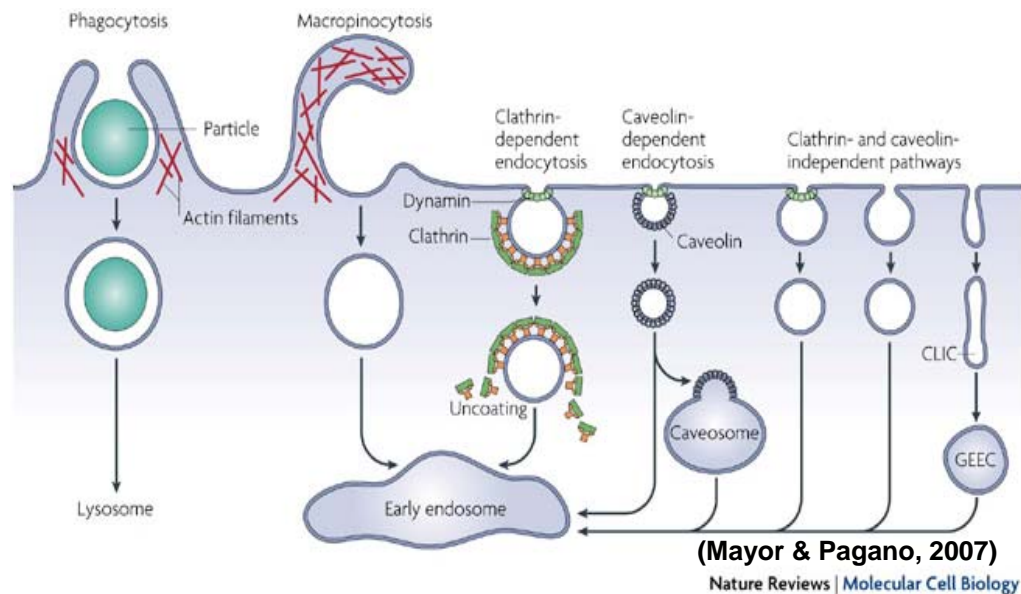
# QD distribution in different growth media



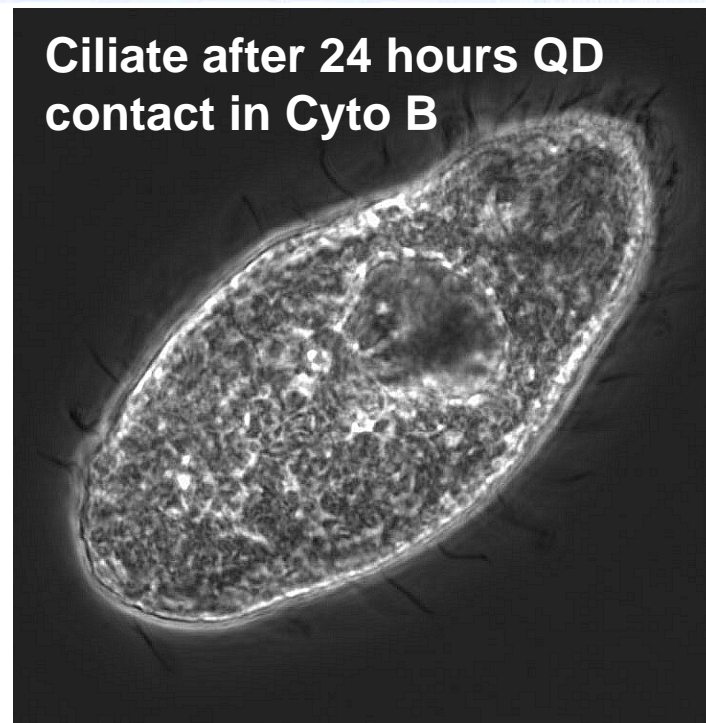
# QD Uptake vs. Particle Size Distribution



# Inhibition of QD uptake by Cytochalasin B



Ciliate after 24 hours QD contact in Cyto B



- **Lysosomes are digestive organelles, typically with lower pH levels**
- **Endosomes can have more less aggressive pH levels**
  - Fate of internalized QDs much different based on mode of uptake
- **QD uptake by ciliate appears to be via macropinocytosis**
- **Uptake modes are basic cellular processes**

## Questions?

For more information, please contact:

Dave Holbrook

[dave.holbrook@nist.gov](mailto:dave.holbrook@nist.gov)

301.975.5202