



# **Bio-Nanotechnology: Challenges for trainees in a multidisciplinary research program**

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**University of California, Davis**

**NASA Ames Research Center**



## Where I came from



- Received a BS in chemistry from Santa Clara University
  - Traditional chemistry education
- Worked 3 years for the NASA Ames Center for Nanotechnology
  - Introduction to interdisciplinary research



Team:  
chemists, physicists,  
engineers, molecular  
biologists

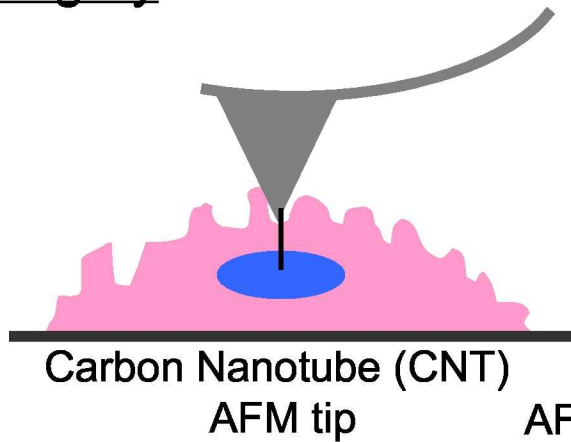
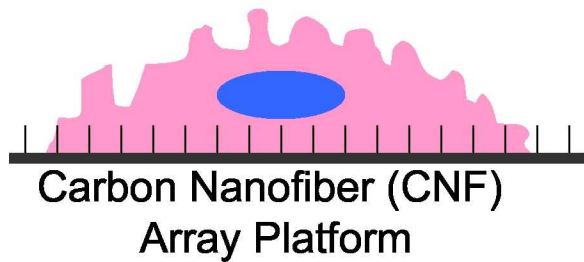


# Nanomaterials size lends them to biological investigations



## Cell impalement and cell surgery

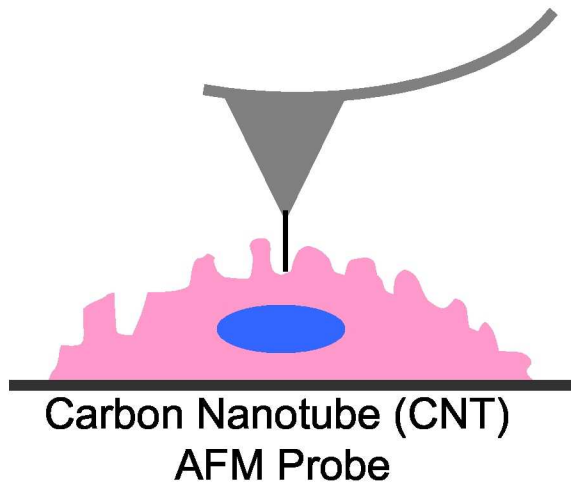
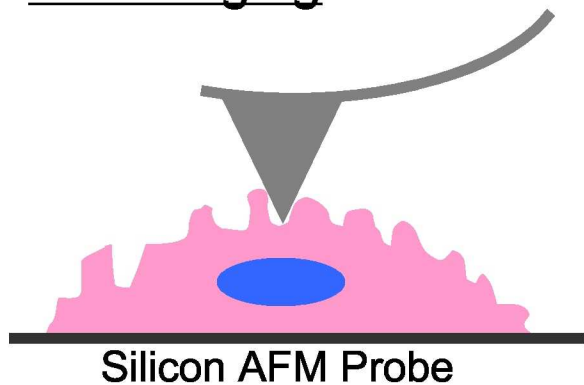
Site specific drug delivery



AFM = atomic force microscope

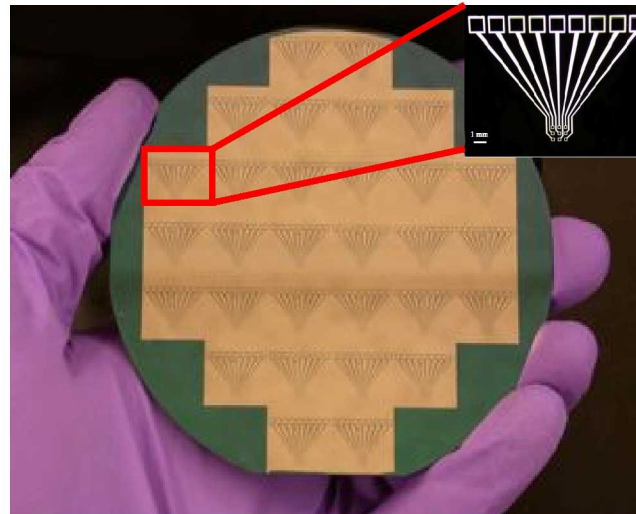
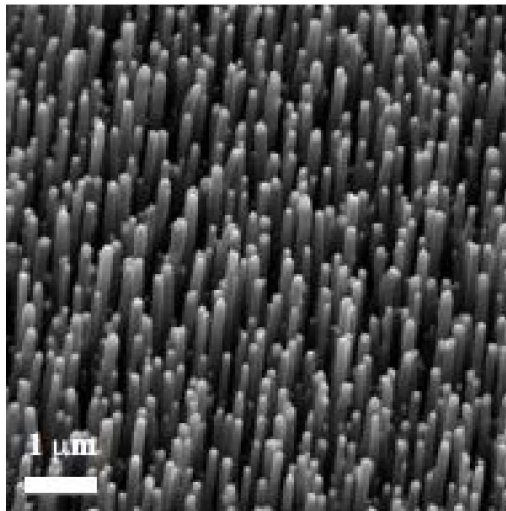
## Cell imaging

High resolution of membrane morphology

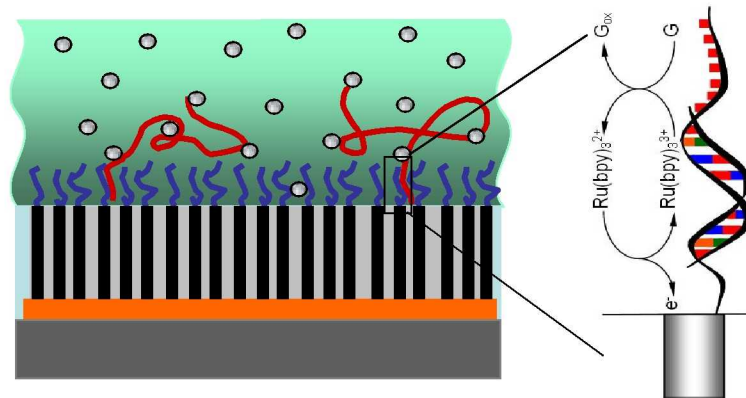




# NASA Ames Center for Nanotechnology



CNF array as DNA biosensor



Skills acquired  
growth, characterization  
and functionalization of  
CNTs and CNFs



# PC12 cells grown on CNF array

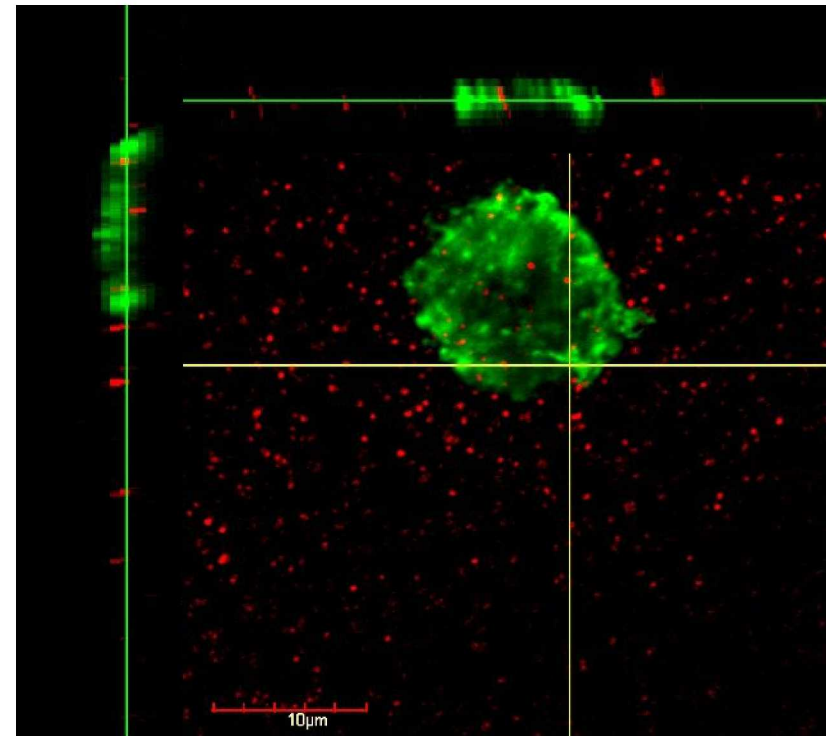
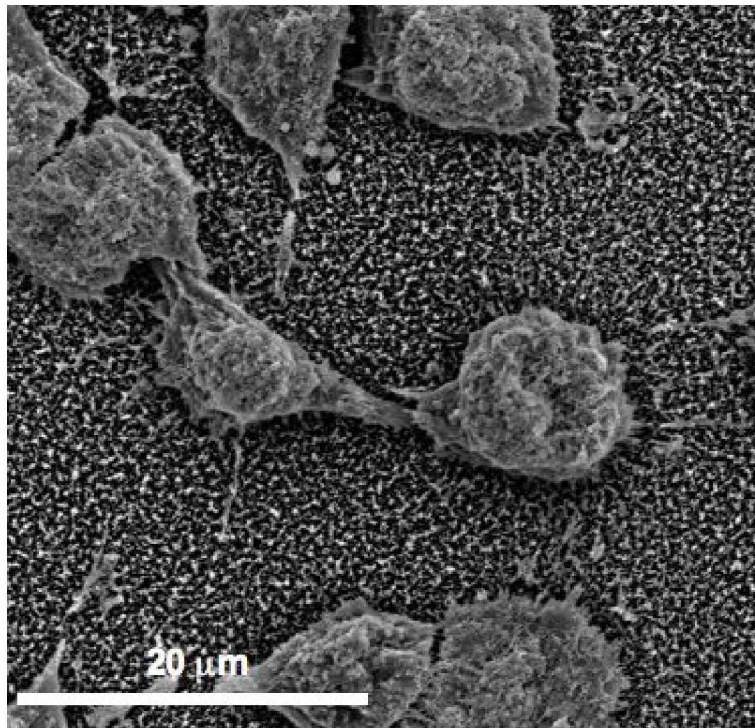


## NASA Ames

Substrate preparation  
CNT functionalization

## UC Davis

3-D fluorescence characterization



Koehne, J. E.; Chen, H.; Cassell, A.; Liu, G. Y.; Li, J.; Meyyappan, M. *in press*.

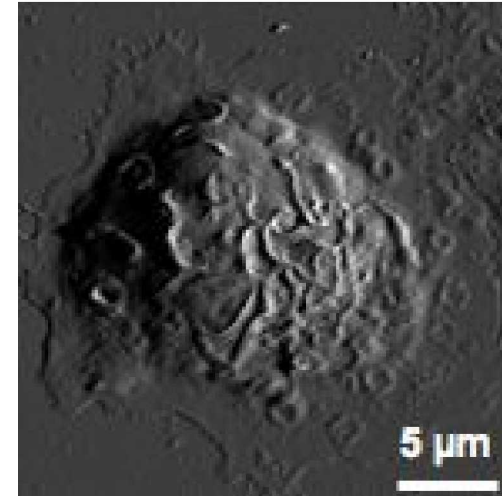


# Professor Gang-yu Liu, UC Davis cellular imaging studies

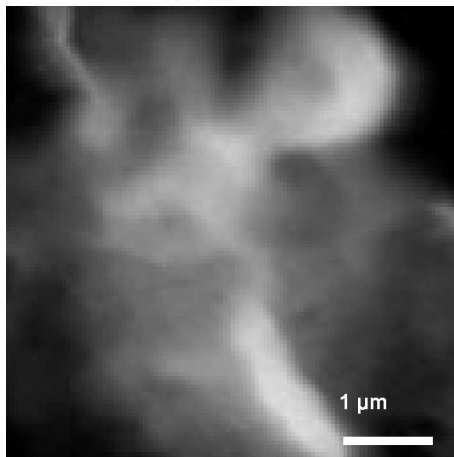


Use AFM for:

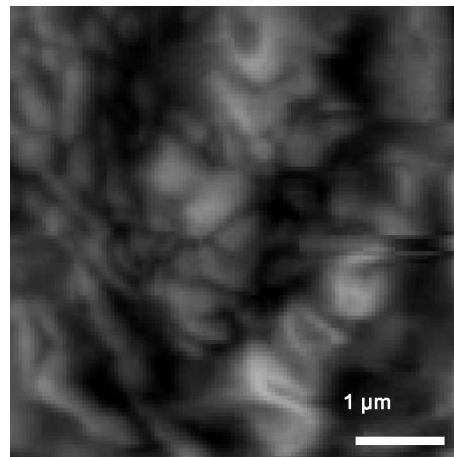
- 1) High-resolution imaging
- 2) Three-dimensional imaging
- 3) Hydrated cell imaging



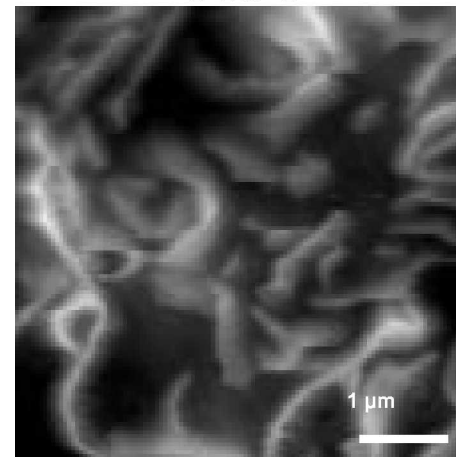
Cell 1



Cell 2



Cell 3



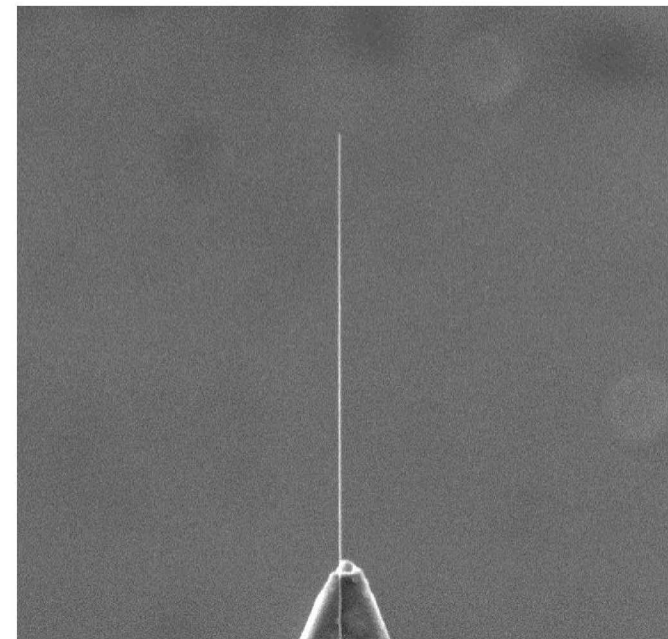
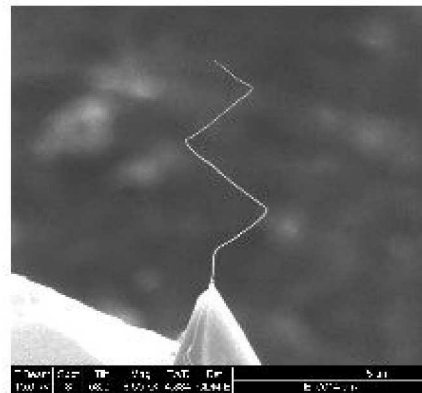
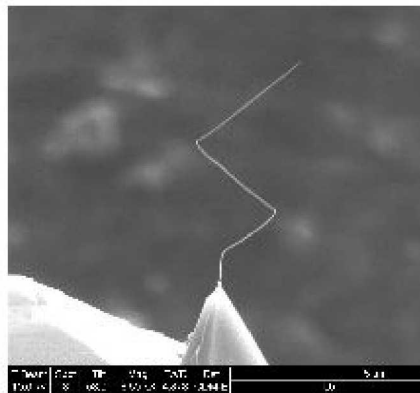
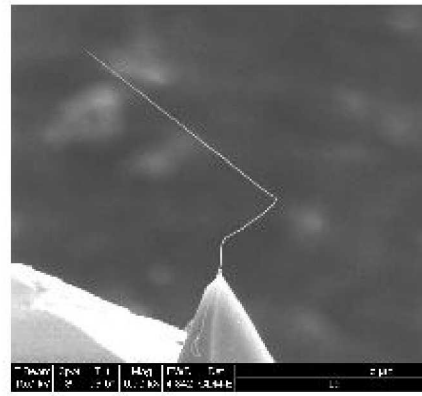
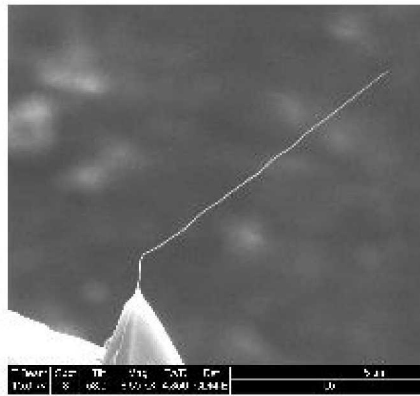
3 distinct  
bone marrow  
derived mast  
cells with  
varied  
membrane  
structure



# Collaboration with CoVsystems CNT AFM probes



High aspect ratio CNT probes  
with control over geometry,  
angle and length



Stevens, R.; Nguyen, C.; Meyyappan, M. *IEEE Trans. Nano.* 2006, 5, 255-257.



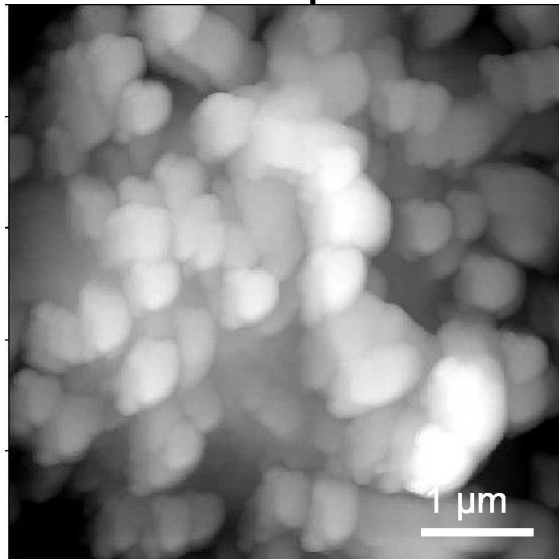
# CNT AFM probes for cellular imaging



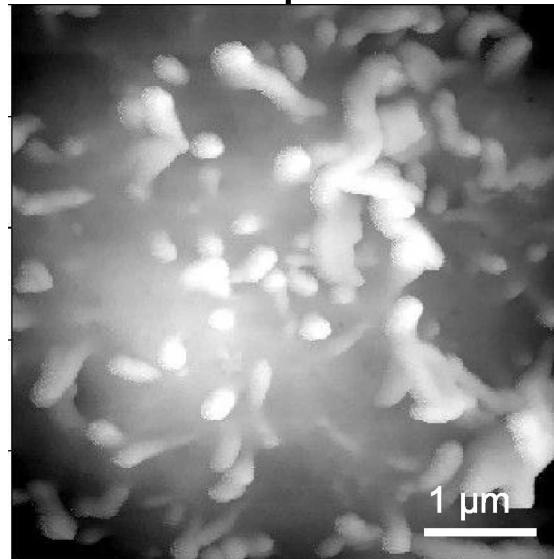
<u>NASA</u>	<u>UC Davis</u>	<u>CoVsystems</u>
Growth, characterization and functionalization of CNT/CNFs	High-resolution imaging of hydrated cells	Fabrication of CNT AFM imaging probes

Thesis became interdisciplinary out of necessity

Silicon probe



CNT probe



Images represent the top surface of the same rat basophilic leukemia cell





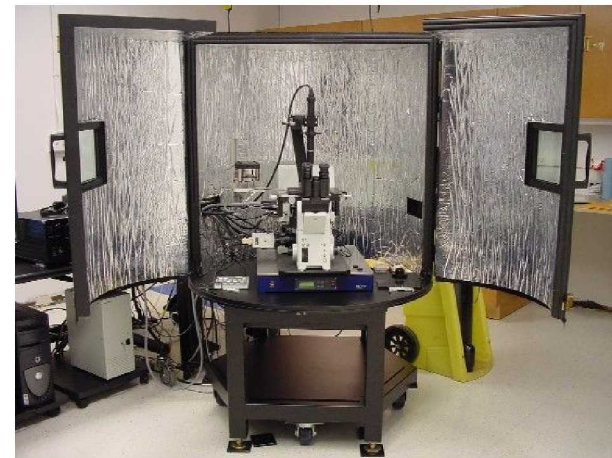
# Interdisciplinary Programs at UC Davis



**Definition:** A group that gives students intellectual freedom to transcend disciplines and areas of research.

- Interdisciplinary Departments
  - UCD has 47
- Programs, Centers and Institutes
  - UCD has 57

**UCDAVIS**  
OFFICE OF GRADUATE STUDIES



Nanomaterials in the Environment,  
Agriculture and Technology (NEAT)

Northern California Nanotechnology Center (NCNC)



# How to participate in interdisciplinary research



## Interdisciplinary department

- **Advantages**
  - Program is designed to promote interdisciplinary exposure and training
  - University advisors are participating in interdisciplinary research
- **Disadvantages**
  - No centralized department
  - Students can feel lack of camaraderie with fellow graduate students

## Standard core department

- **Advantages**
  - Strong sense of community
- **Disadvantages**
  - Student has to find advisor who is participating in interdisciplinary research
  - Curriculum can be limiting



# Outcomes of an interdisciplinary thesis



## Challenges

- Large number of courses
- Longer thesis completion time
- Pulled between collaborators
- Lack depth of knowledge

## Benefits

- Wide range skill set
- Well equipped for the 21st century
- Very employable





# Recommendations to current educators



Embrace paradigm shift from multidisciplinary research as the minority to the majority

- Universities
  - Develop interdisciplinary departments and programs
  - Encourage faculty participation
  - Provide university wide interdisciplinary conferences
- Departments
  - Encourage cross department collaborations
  - Encourage participation in interdisciplinary departments and programs
  - Allowance for more cross discipline curriculum



# Conclusions



- Interdisciplinary thesis is formed out of necessity to answer complex problems
- Interdisciplinary research is fostered by interdisciplinary departments and groups, centers and institutes
- Graduate students may face additional obstacles, but will be prepared for research of the 21st century
- Universities and departments can utilize interdisciplinary departments and groups, centers and institutes to foster graduate education



# Acknowledgments



- Prof. Gang-yu Liu - UC Davis
- Prof. Fu-tong Liu - UC Davis
- Dr. Huan Chen - UC Davis
- Prof. Jun Li - Kansas State University
- Dr. Hua Chen - UARC
- Dr. Meyya Meyyappan - NASA Ames
- Dr. Harry Partridge - NASA Ames
- Ramsey Stevens - CoVsystems
- Prof. Rod Hill - University of Idaho
- Dr. Sally Tinkle - NIH
- Dr. Andrew Maynard - Woodrow Wilson International Center for Scholars

## Funding

NASA Ames Full Time Graduate Study Program

University of California, Davis

NIH 1R21 GM077850-01

NSF CHE-0809977

NCI (under Unconventional Innovation Program)