

# National Center for Learning and Teaching in Nanoscale Science and Engineering (NCLT)

- An interdisciplinary Center for Learning and Teaching (NSF supported).
- Goals:
  - How and where to introduce nanoscience in K-16?
  - Professional Development - prepare teachers.
  - Research how to bring a new interdisciplinary subject into “standard” curriculum. How does nano fit existing standards and courses?
- Collaboration: Northwestern, U. Michigan, U. Illinois (Urbana and Chicago), Purdue, plus minority partners, plus more.
- A ***national*** center. Coordinate national efforts.

# Outline

- Where do we start?! => “Big ideas” workshop.
  - What are the key ideas and learning goals in nano?
- NCLT research workcircles.
  - Scanning probe group.
  - Self assembly group.
  - Learning technology.
  - Concept inventory.
- Professional development -- research and delivery.
- Higher Ed
  - Professional development
  - New courses
  - Certificate programs -- future leaders
- Coordination: Content repository, informal science ed.

AAPT - Jan 2007

# What are the “big ideas” of Nanoscience?

- Big ideas workshop held June 2006 (sponsored by SRI and NCLT).
- Participants:
  - Learning scientists.
  - Science educators.
  - Nanoscientists.
  - Nano-engineers.
- Workshop results:
  - Identify key ideas of nanoscience: what should we teach?
  - Articulate learning goals at 7-16 levels.
  - Link to relevant standards and identify new ones.

# Goals of Big Ideas in Nanoscience Workshop

- Identify and clarify the major concepts and principles of nanoscience
- Clarify the meaning of these core concepts and principles
- Specify the learning goals that emerge from the major concepts and principles
- Determine how these learning goals align with national standards
- Identify standards that do not yet exist.

# Big ideas(1)

- ***Size and scale.***
- ***Particulate nature of matter:*** All matter is composed of atoms.
- The ***forces that dominate*** interactions ***change with scale.***
- ***Properties*** of matter can ***change as you approach the nanoscale.***
- ***Self assembly:*** Materials can spontaneously assemble into organized structures.

## Big ideas (2)

- Recently developed **tools** allow the investigation, measurement, and **manipulation of nanoscale matter atom by atom ...**
- Nanotechnology is driven by the processes of science and engineering to **solve societal problems.**
- **Models** help us understand, visualize, predict, hypothesize, and interpret data about natural and manufactured nanoscale objects and phenomena, which are by their very nature, too small to see.

# Scanning probe workcircle

## (NanoSlam: student interests and motivation)

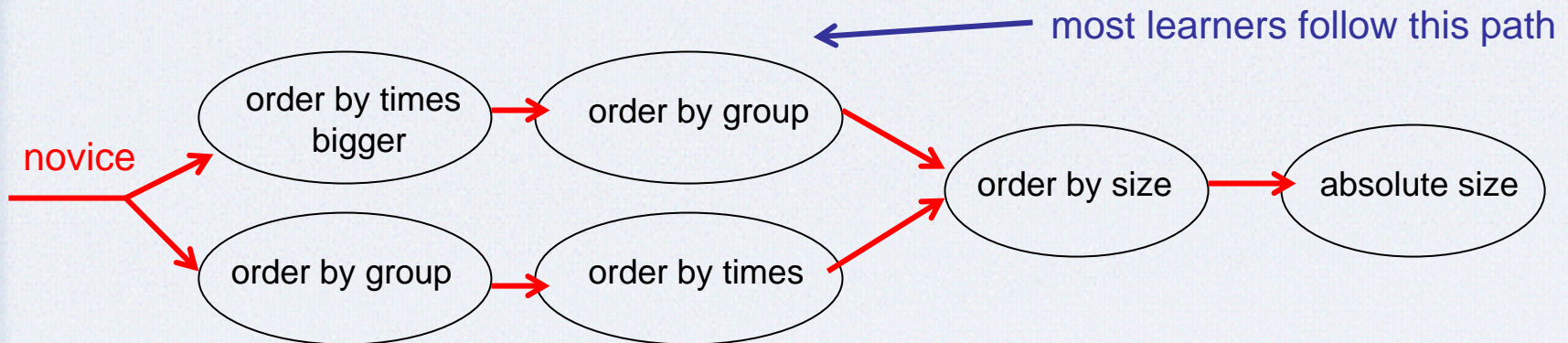
- Initial plan: use scanning probe techniques as a vehicle to teach core ideas.

But this led to many questions

- **Student motivation** - what really interests students?
- **Size and scale** - what do students really know?
- **Learning trajectory** - how does nano fit into curriculum?
- **Learning progression** - in what order do/can students learn nano concepts?
- **Measure, test and refine** - classroom work with 7-12 students.

# Learning progression research (C. Delgado & J. Kraicek)

- Size and scale is essential to all of nanoscience
  - In what “order” do students learn S&S?
- Four “conceptions” of S&S:
  - Order by size
  - Order by times bigger
  - Order by groups
  - Absolute size



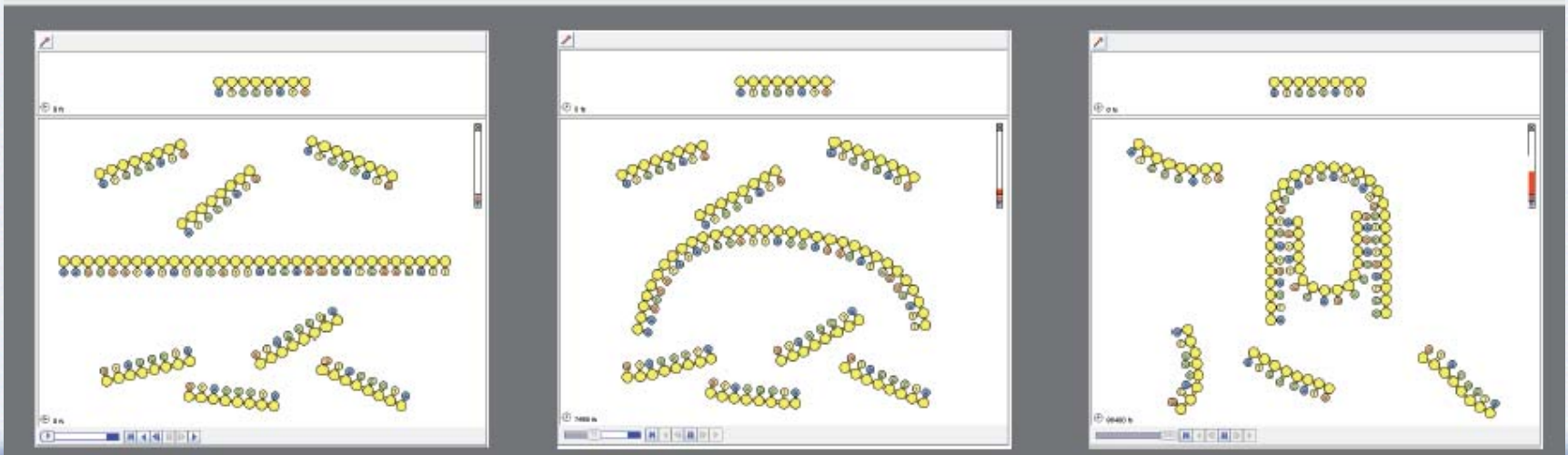
See also: Tretter et al, 2006

# Self assembly workcircle

- Develop interactive self assembly activities.
- Student design projects (inquiry-based).
- One example: DNA origami
  - DNA strands designed to self-assemble into “interesting” structures. [Rothermund, et al 2006]



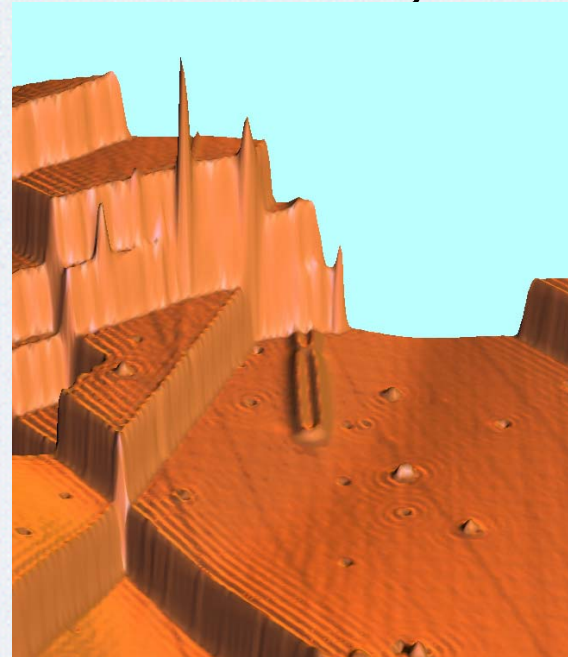
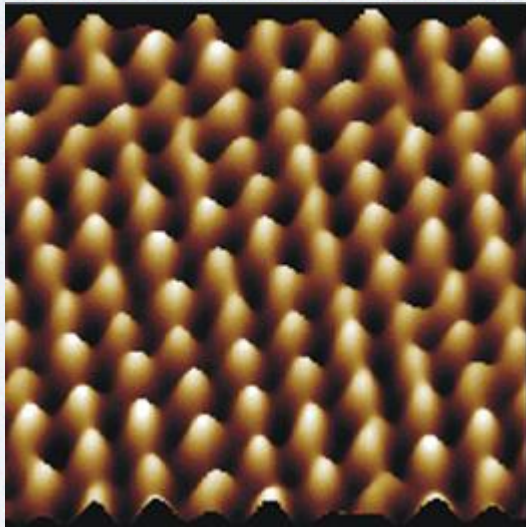
## Simulation



AAPT - Jan 2007

# Learning technologies workcircle

- Visual representations: what do students really “see”?



- (How) can learning technologies be developed to help students understand nanoscience concepts?
- Use classroom research to get answers.

# Concept inventory workcircle

- Goal: develop a nano-concept inventory.
- Build on “big ideas” workshop.
- Plans:
  - Test / refine instrument.
  - Apply across 7-16 levels.
  - Gather baseline data -- need help from other groups.
- Essential tool to evaluate new curricula and materials.
- Important distinction:
  - Nano **facts** vs. nano **concepts**.

# Professional Development (1)

- PD goals:
  - Enhance the teaching of nanoscience at 7-12 level.
  - **Research** the design and delivery of PD in a new interdisciplinary area.
- Workshop threads:
  - Give teachers (nano)science knowledge.
  - Introduce classroom activities (**inquiry-based**).
  - Explore connections between nano and other areas of science.
  - Assist teachers in developing their own nano-activities.

# Professional Development (2)

- 2006: Workshops at Purdue and UTEP (~30 teachers)
- 2007: Expand to Fisk, Hampton, AAMU, Argonne Nat Lab
- 2 week workshops. Topics include:
  - ↗ size and scale
  - ↗ allotropes of carbon
  - ↗ space elevator
  - ↗ self-assembly
  - ↗ scanning probe microscopy
  - ↗ quantum dots
  - ↗ lithography and Moore's law
  - ↗ nanomedicine
  - ↗ ferrofluids
  - ↗ biosensors
- Research findings:
  - ↗ Pre: Teachers saw nano as revolutionary (instead of evolutionary).
  - ↗ Pre: Teachers did not see connections to traditional disciplines.

# Higher Ed Workcircle

- 2006 NCLT Faculty NSEE Workshop
- August 6-9, 2006, Cal Poly San Luis Obispo
- 32 faculty participants from 17 colleges/universities
- Emphasis on partnering with the NCLT for learning & teaching research in nanoscale science & engineering
- Develop and share new nano courses
- Develop a certificate program - aim to nurture nano-scientists/educators and nano-educators/scientists.



# Coordinate National Efforts in Nano

---

- Repository of nano classroom activities.
- Online lectures and classes.
- Disseminate research results.
- Support informal nanoscience ed.
- [www.nclt.us](http://www.nclt.us)

# Summary

- The NCLT's research findings should inform
  - All nanoscience educators.
  - Professional development programs.
  - Evaluation of nano curricula (concept inventory).
- A model approach for bringing future new interdisciplinary topics into classroom.

# Participants (partial list):

- Northwestern: Bob Chang, Tom Mason, Mark Hersam, Lincoln Lahon, Greg Light, Denise Drane, Emma Tevaarwerk, ...
- Purdue: Nick Giordano, Lynn Bryan, George Bodner, Kelly Hutchinson, Shanna Daly, David Sederberg, Fatima Benaissa,...
- U. Michigan: Joe Kraicek, Chris Quintana, Shawn Stevens, Cesar Delgado, Namsoo Shin, Clara Cahill, ...
- U. Illinois, Chicago: Tom Moher, Jim Pelligrino, Carmen Lilly, ...
- U. Illinois, Urbana: Umberto Ravioli, Richard Bratz, ...
- UTEP: Eric Hagedorn
- Fisk: Debbie Thomas,
- plus many more