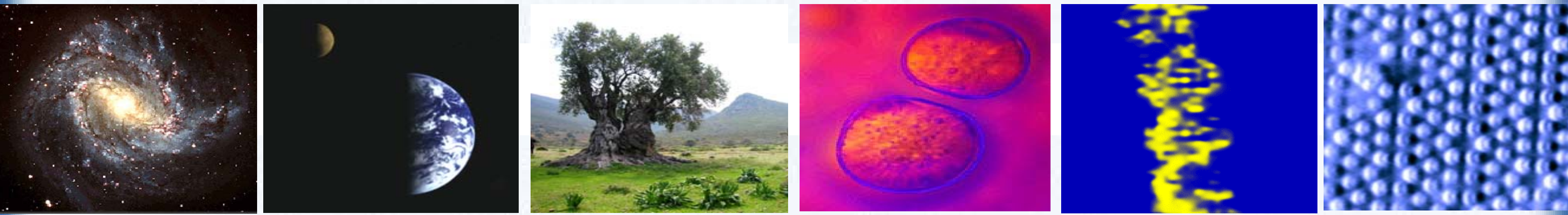


Big Ideas and Learning Goals in Nanoscience Workshop

Joe Krajcik and Shawn Stevens

University of Michigan

Tom Mason

Northwestern University

Outline of Workshop

- Explain big ideas and learning goals
- Describe the 7 - 12 NCLT/SRI Big Ideas Workshop
- Share findings from the Big Ideas Workshop
- Describe the NCLT Faculty Workshop Big Ideas
- Share findings from the Higher Ed. Workshop
- Compare findings
- Small group task to further clarify big ideas and learning goals
- Share issues

Why the switch in the format of Center-Wide Meeting?

- Inform each other of the work we are doing
- Open up communication between fields
- Help develop a common language

Why Big Ideas and Learning Goals?

- Core foundation for the work that goes on in NCLT and in nanoscience teaching and learning.
- Teaching nanoscience without a foundation of learning goals is a challenge for practitioners and teachers!
- Informs instructional design, enactment and assessment

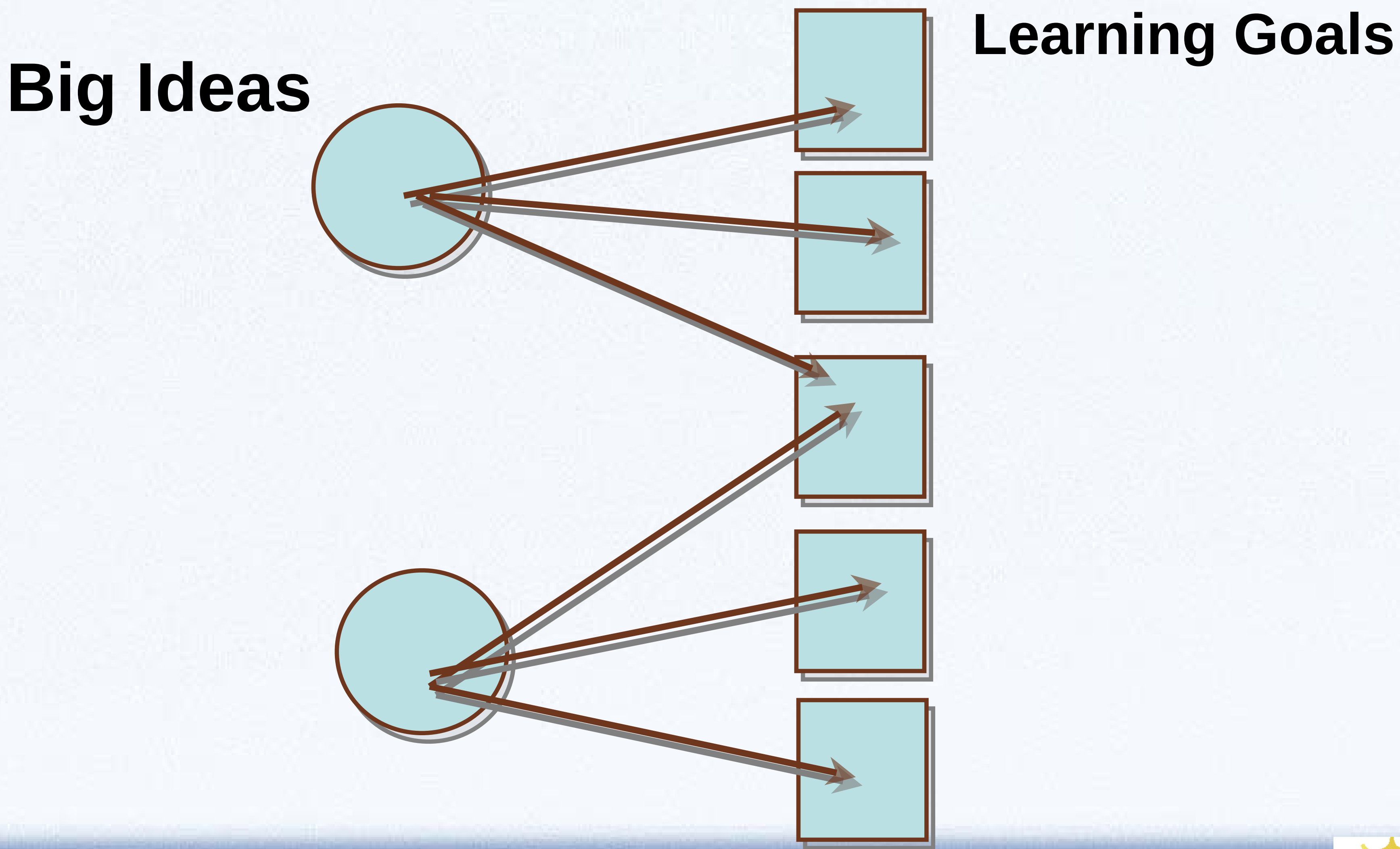
Big Ideas

- The core concepts and principles representing the ‘big ideas’ of the field.
- Big ideas
  - help learners understand a variety of ideas about field
  - provide insight into the development of the field or have a key influence on explaining the major ideas in the domain
  - provide ideas/models to explain a range of phenomena
  - allow learners to intellectually make individual, social, and political decisions regarding science and technology

What is a learning goal?

- A statement of knowledge that we want **ALL** students to use!
- Specifying how we want students to use that knowledge.
- Used to drive instructional design, enactment and assessment.
- By the end of 12th grade (8th grade), all students need to understand that…

Why big ideas?



Big Ideas in Nanoscience Workshop

A collaboration between NCLT and SRI to identify and clarify the big ideas of nanoscience for grades 7 -12 science education.

Interdisciplinary Work Circle

NCLT

–Joe Krajcik (UM)
–Shawn Stevens (UM)
–Molly Yunker (UM)
–Nick Giordano (PU)
–Chris Quintana (UM)
–Cesar Delgado (UM)
–Tom Mason (NU)
–Ramez Elgammal (UM)
–George Bodner (PU)
–Carmen Lilley (UIC)
–Denise Drane (NU)
–Greg Light (NU)

SRI

–Nora Sabelli
–Patti Shank
–Anders Rosenquist

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
- Vet and reach consensus.

About the NCLT/SRI Workshop

- June, ‘06 at SRI
- Participants
  - – Nanoscientists, nanotechnologists, science educators, informal educators
  - – 40 plus
- Process
  - – Small group work to identify and elaborate big ideas and learning goals
  - – Reach consensus within the working groups
    - Lots of discuss and debate!
  - – Reach consensus across the working groups
  - – Reach consensus with a larger audience

Findings: The Big Ideas

Size and Scale- Concepts of size and scale form the cognitive framework used to make sense of nanoscale phenomena.

Matter- All matter is composed of atoms.

Dominant Forces- The forces that govern interactions tend to change with the scale of the objects involved.

Properties of Matter- The properties of matter can change with scale. In particular, as the materials approach the nanoscale in size, they often exhibit unique functionality and properties. The source of these unique properties may be surface- or bulk- related.

Models- Models help us understand, visualize, predict, hypothesize and interpret data about natural and manufactured nanoscale objects and phenomena, which by their very nature are too small to see.

Findings: The Big Ideas

Tools- Recently developed tools allow the investigation, measurement and manipulation of matter, leading to the development of new understandings and creation of new structures. These tools drive the scientific progress in nanoscale science and technology.

Technology and Society- Nanotechnology is driven by the processes of science and engineering to solve problems. The products of nanotechnology may impact our lives in both positive and negative ways.

Self-Assembly- Under certain conditions, some materials can spontaneously assemble themselves into organized structures at a lower equilibrium state. This process provides a useful means for manipulating matter at the nanoscale.

Properties

- Big idea: Properties of matter can change as you approach the nanoscale [and through the nanoscale].
- Learning goals:
  - By the end of 9-10th grade, all students will know and understand that the characteristic properties of matter can change with particle size as you approach and go through the nanoscale.
  - By the end of 12th grade, students will know and understand that
    - the surface area-to-volume ratio increases as particles become smaller. As a result, the fraction of the atoms that are on the surface increases, and surface-related properties become more important as a particle's size approaches the nanoscale.
    - that unique shapes and structures occur at the nanoscale, leading to unique properties.

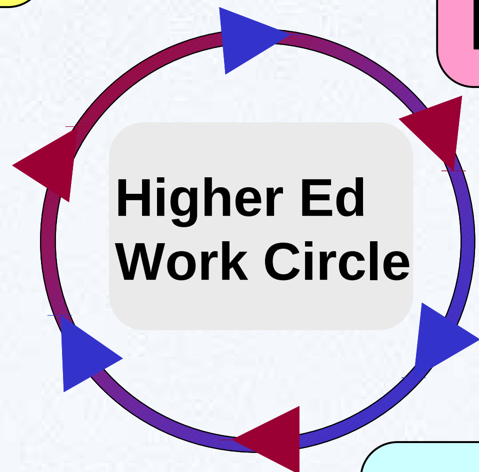
What we still need to do

- In the near future:
  - Refine our learning goals
  - Reach consensus with a larger group
  - Make links to national standards
    - Where are the overlaps
    - What is missing
  - Develop potential learning progressions
- In the distant future:
  - Obtain research evidence for the learning goals and learning progression

Higher Ed Work Circle Activities

Degree Programs

Learning & Teaching Research & Evaluation



Instructional Resources

Big Ideas/ Nanoconcept Inventories

Faculty Enhancement

2006 NCLT Faculty NSEE Workshop

- August 6-9, 2006, Cal Poly San Luis Obispo
- 32 faculty participants from 17 colleges/universities
  - 8 from community colleges
  - 24 from 4-year institutions
- Emphasis on partnering with the NCLT for learning & teaching research in nanoscale science & engineering

Participants:

Activities:

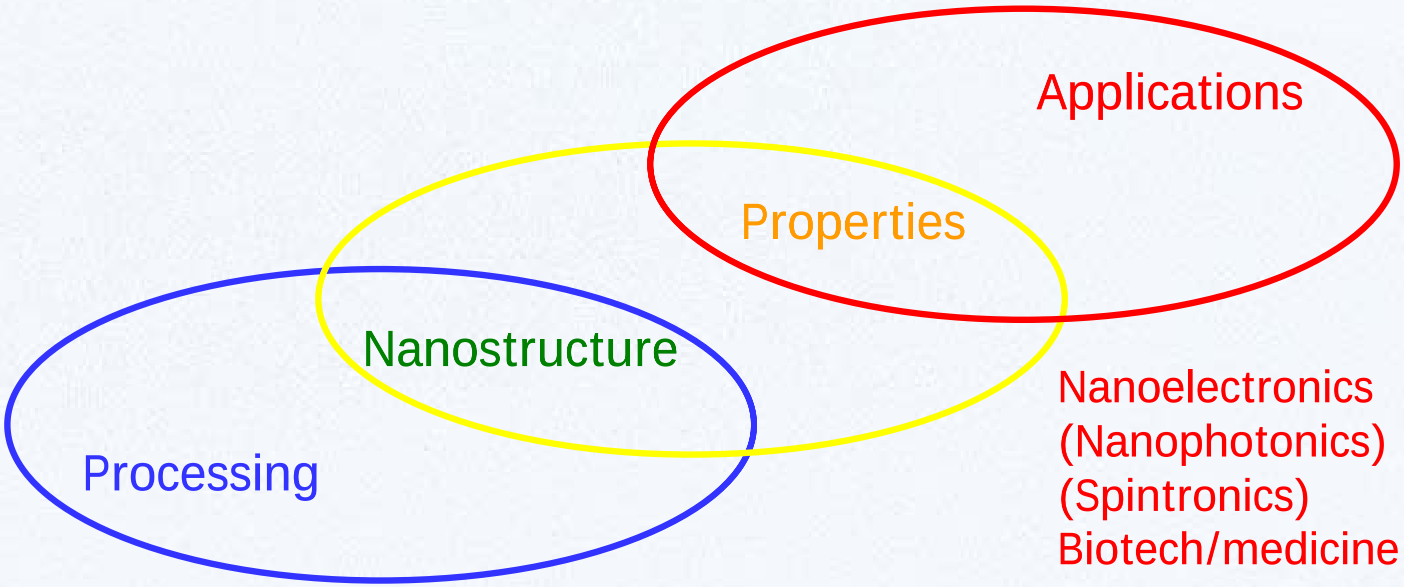
Big Ideas Workshop: What do our students need to know?

- How do the "big ideas" play out in higher ed?
- Break out into 4 disciplinary groups (~ 8 per group) to discuss
  - Chemistry
  - Physics
  - Engineering
  - Science Education
- Regroup and report back to entire group
- Results based on response from the 4 disciplinary groups

Learning Goals Workshop: Sketching out learning goals

- Introduction to learning goals/outcomes
- Each participant to write an "action plan" that includes learning goals
- Results based on 20 individual presentations by participants

“Big Ideas” in Nanoscience/Nanotechnology



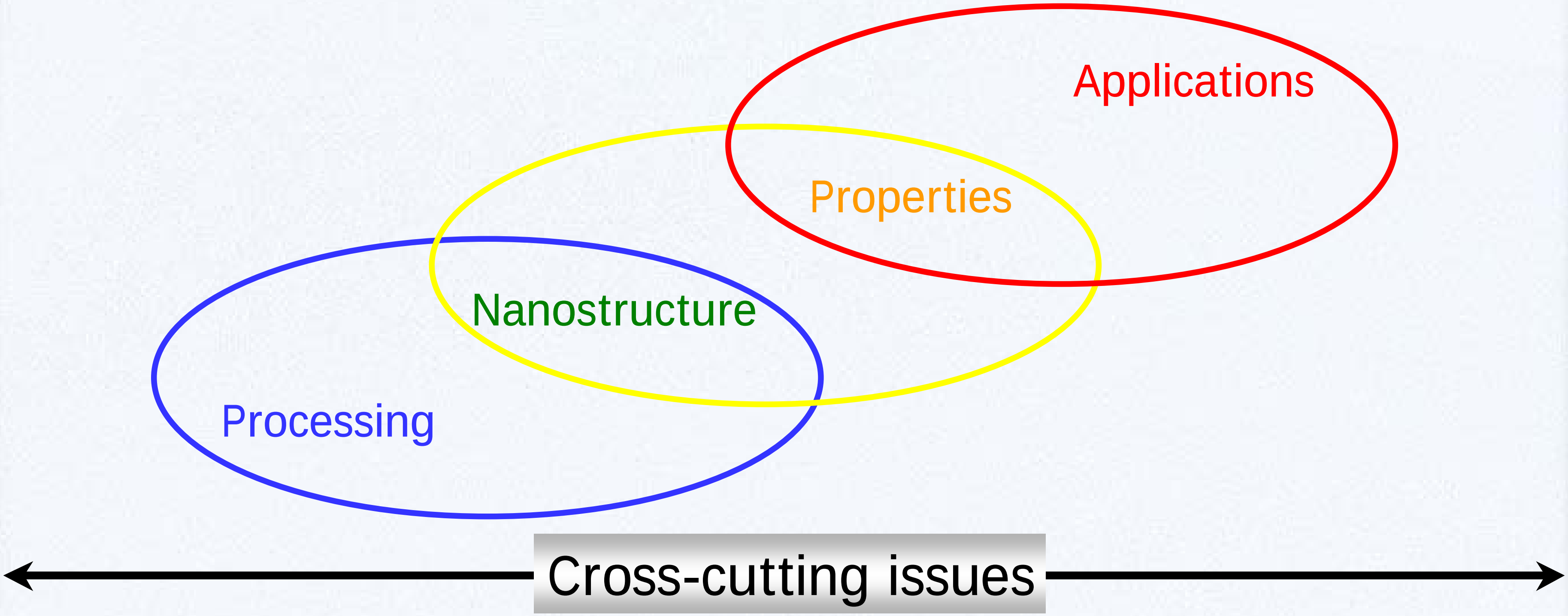
Nanoelectronics
(Nanophotonics)
(Spintronics)
Biotech/medicine

Surface-dominated behavior
Size-dependent properties
Quantum mechanics

Tools/instrumentation/characterization
Size & scale
Surface-to-volume ratio

Bottom-up/self-assembly
Top-down/lithography

Some cross-cutting issues:



Importance of biology/life sciences
Importance of models/simulations
Interdisciplinarity of nano
Societal impact/public education
Safety procedures/hands-on experience

Two Workshops: Comparison of Big Ideas

"Big Ideas in Nanoscience" Workshop (6/06)

Self-Assembly
Dominant Forces
Tools
Modeling
Properties of Matter
Particulate Nature of Matter
Technology and Society
Size and Scale

NCLT Faculty NSEE Workshop (8/06)

Self-Assembly
Surface-Dominated Behavior
Tools/Instrumentation/ Characterization
Models/Simulation
Size-Dependent Properties
Societal Impact/Public Education
Size and Scale
Surface-to-Volume Ratio
Quantum Mechanics

Points for general discussion:

- Do you agree with the list(s) of “big ideas”?
  - Should any of the listed “big ideas” be removed or modified?
  - Does “dominant forces” deserve to be a separate “big idea”? Why, or why not?
  - Should the list be different for K-12 vs. 13-16?
- Are the following items “big ideas” for NSEE? If so, do they pertain to K-12, 13-16, or both?
  - Surface-to-volume ratio
  - Quantum mechanics
- Is there anything missing?

Working Group Task

Evaluate the big idea and learning goal (45 minutes)

- Pick and evaluate the articulation of your ‘big idea’.
  - (if new big idea -- need to articulate)
- What does it really mean?
- Do you agree that it is a big idea? Why should it be considered a Big Idea? (or why not)
- What are some phenomena that the big idea helps explain?
- Evaluate the learning goals.

Report-out and discussion (5 minutes per group)

- Come back to the group with a breakthrough idea and/or a question or controversy that you would like the group to discuss.