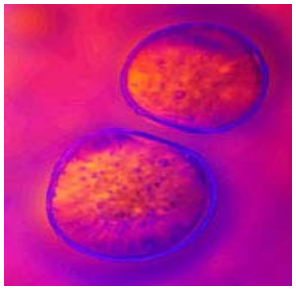
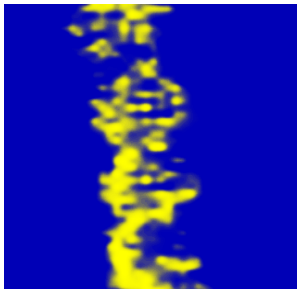
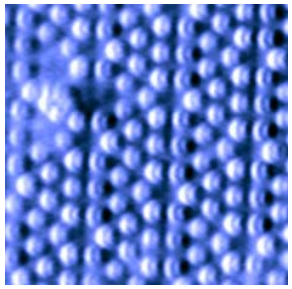
Catalyzing Change in Science Education through Nanoscience



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How can a Gecko walk up a wall or on a ceiling?

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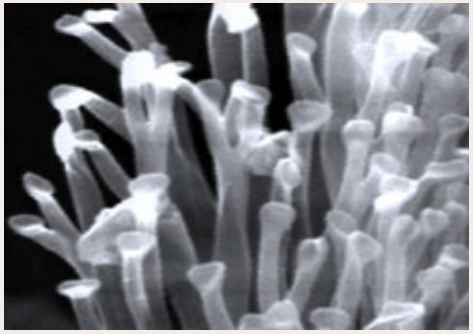


Gecko foot-hairs (seta) split into hundreds of nanosize structures called spatulae, each 100 nm in diameter. Spatulae bond to surfaces through electrical forces (van der Waals). The summation of the attractive forces are greater than the force of gravity!

Image: Kellar Autumn & Ed Florance
http://www.sciencentral.com/articles/view.php3?article_id=218392449&cat=3_5

A big idea: dominant forces

All interactions can be described by multiple types of forces, but the relative impact of these forces changes with scale. On the nanoscale, electrical forces with varying strengths tend to dominate the interactions between objects.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

http://www3.ocn.ne.jp/~herpsgh/yamorikabe.jpg

Science Education Today

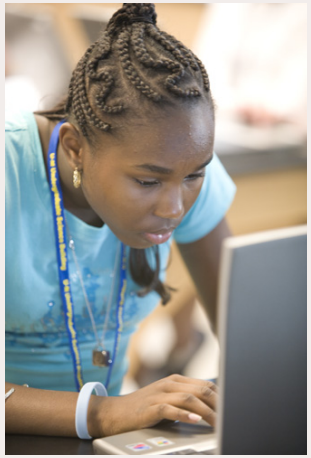
- An exciting time
  - Emerging ideas in science
  - New ideas on how students learn
  - Emergence of standards
- A challenging time
  - US students continue to fall behind internationally
  - US students are not pursuing STEM degrees
  - Too much to teach
  - Learning through inquiry remains underused and challenged
  - No Child Left Behind
  - Dwindling resources

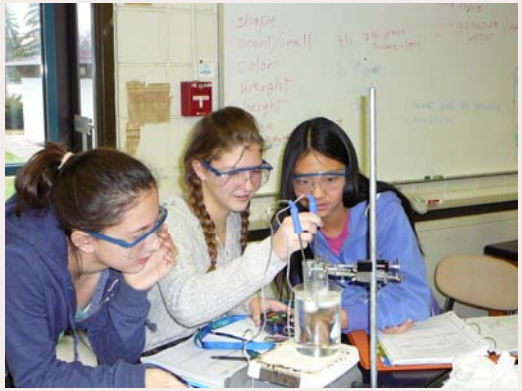
US Science Education 7 - 12 Failing in Five Critical Areas

- Helping students understand big ideas of nanoscience
- Developing curriculum that allow learners to develop deeper and more useable knowledge
- Supporting students in grasping the interconnectedness among the science disciplines
- Helping learners use scientific habits of minds and engaging in scientific practices

Evidence Supported by Research

- Our research work as well as that of others shows that students:
  - Demonstrate little understanding of the big ideas of nanoscience
  - Lack interdisciplinary connections among the big ideas
  - Fail to apply big ideas to understand nano phenomena
  - Do not take part in scientific practices





Why aren't we succeeding??

Inadequacies of Science Teaching Materials

- Science curriculum materials cover many topics at a superficial level
- Focus on technical vocabulary
- Failure to consider students' prior knowledge
- Lack coherent explanations of real-world phenomena,
- Provide students with few opportunities to develop explanations of phenomena
- Fail to focus on big ideas

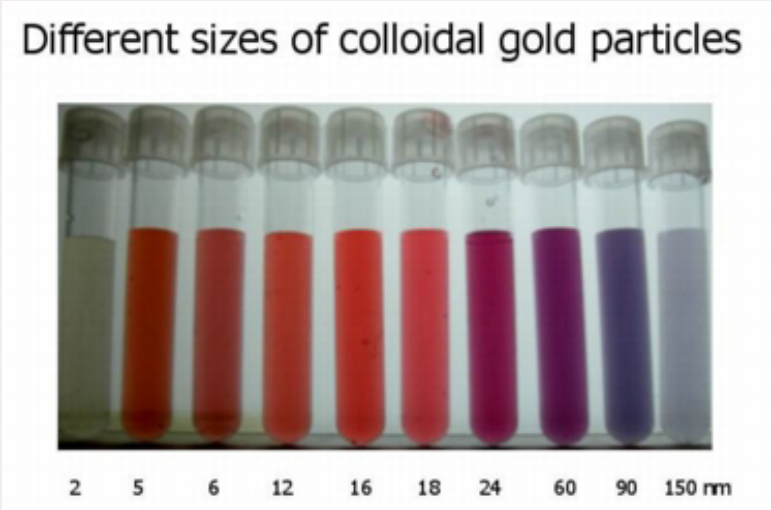
Inadequacies of appropriate, longer term professional development

An example of a missing big idea: size-dependent properties

The properties of matter can change with scale. In particular, as the size of a material approaches the nanoscale, it often exhibits unexpected and new properties.

http://en.wikipedia.org/wiki/Gold

Not true of gold at the nanoscale, where properties change!



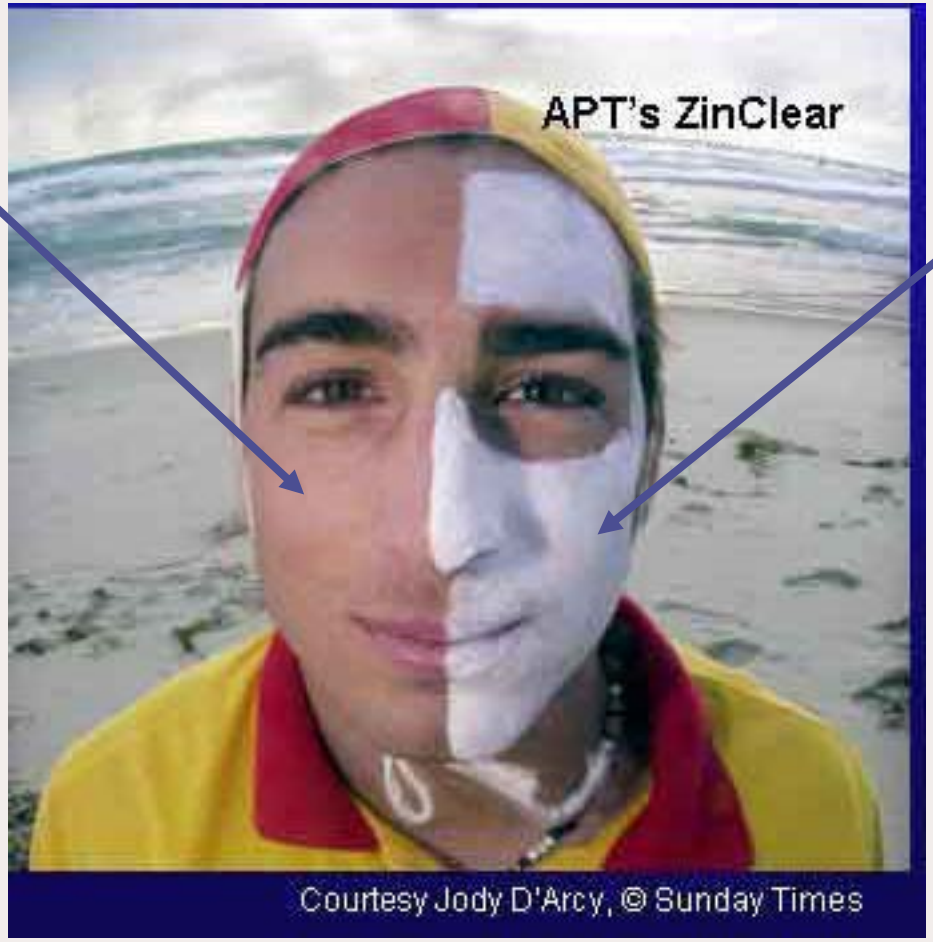
http://www.ansci.wisc.edu/facstaff/Faculty/pages/albrecht/albrecht_web/Programs/microscopy/colloid.html

If you cut a block of gold into smaller & smaller pieces, it would still look like gold

Thanks to Richard Braatz - University of Illinois

How does sunscreen work? Properties change at the nano level!

Nano Zinc Oxide particles Don't scatter light



Macro Zinc Oxide Scatters light

National Institute of Health
http://science.education.nih.gov/supplements/nih1/cancer/activities/activity5_database3.htm

Big Ideas of Nanoscience

Size & Scale

Structure of Matter

Quantum Effects

Size-Dependent Properties

Dominant Forces

Self-Assembly

Tools & Instrumentation

Models & Simulations

Technology & Society

Revisiting the argument

- Science and technology have made substantial breakthroughs.
- Yet, US educational institutions (7 - 12) are failing to prepare graduates for productive citizenship and workforce needs.
- US curriculum covers too many ideas superficially.
- New developments in science, such as nanoscience and genomics, can serve as an appropriate and opportune vehicle to upgrade science education
- New curriculum and professional development is needed
- Such change needs
  - Collaboration between scientists, learning scientists, and teachers
  - National leadership

Productive Steps Forward

- Design new curriculum that
  - Focuses on Big Ideas
  - Builds understanding of the big ideas over time
  - Engages students in scientific practices
- Offer sustained professional development
- Provide necessary resources
- Build partnerships between practicing teachers, scientists and science educators

Acknowledgments

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National Center for Teaching and Learning
in Nanoscale Science and Engineering

http://www.NCLT.US

Questions and Comments

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