NSTA Web Seminar:

NanoScale Science: Activities for Grades 6-12

Tuesday, December 18, 2007
NanoScale Science

Tiny Science: Big Ideas

Presenters:
Gail Jones, NCSU
Mike Falvo, UNC-CH
Amy Taylor, NCSU
What is nanotechnology?

• The study of materials at the nanoscale. Nanotechnology examines ways to control matter that exists at the size of atoms.
Quick Vote:
How Big Is A Nanometer?

Place your vote in the box with a stamp:

<table>
<thead>
<tr>
<th>A hundredth of a meter</th>
<th>A thousandth of a meter</th>
<th>A millionth of a meter</th>
<th>A billionth of a meter</th>
</tr>
</thead>
</table>
Nanometers: How Small?

1 nanometer 1 micrometer 1 millimeter 1 meter

Georg Fuellen

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Nanotechnology…

Involves the manipulation of materials at the nanoscale….

– Building and altering materials atom by atom.
How many nanometers across is your hair?

1 cm
How big is a water molecule?

Larger than 1 nm

About 1 nm

Smaller than 1 nm
One Nanometer
One Nanometer

Water ($H_2O$)

Small Protein

DNA
One Nanometer

Water ($H_2O$)

Quantum Dot

Carbon Nanotube
Lots and Lots of Atoms

How many atoms do you think you have in your body?

Type your thoughts on the chat window
Lots and Lots of Atoms

How many atoms do you think you have in your body?

- A billion? $10^9$
- A trillion? $10^{12}$
- A billion billion? $10^{18}$
- A billion billion billion? $10^{27}$
- A trillion trillion trillion? $10^{36}$
Lots and Lots of Atoms

How many atoms do you think you have in your body?

A billion billion billion?

$10^{27}$
Lots and Lots of Atoms

How many atoms do you think you have in your body?

Easy **rough** estimation: You weigh 75 kg. You are basically the same density as water (1000 kg/m$^3$)

So your volume is \[ V = \frac{75 \text{ kg}}{1000 \text{ kg/m}^3} = 0.075 \text{ m}^3 \]

Convert m$^3$ to nm$^3$ \[ V = (0.075 \text{ m}^3) \times (10^9 \text{ nm/m})^3 \]

\[ V = 8 \times 10^{25} \text{ nm}^3 \]

Atoms \( \sim \frac{1}{4} \text{ nm} \) in width - We can fit 4$^*4^*4$ atoms into a cubic nm.

Total number of atoms \( \sim (8 \times 10^{25} \text{ nm}^3) \times (64) \sim 5 \times 10^{27} \text{ atoms} \)
Lots and Lots of Atoms

Do you think there are more stars in the universe or atoms in your body?
Lots and Lots of Atoms

Do you think there are more stars in the universe or atoms in your body?

1 million atoms in your body for every star in the universe

$10^{27}$ Atoms in your body

$10^{21}$ Stars in Universe
Nano: The Middle Ground

- Galactic: $10^{20}$ m
- "Macroscopic": $10^{10}$ m
- "Microscopic": $10^1$ m
- Nanoscopic: $10^{-6}$ m
- Molecular/Atomic Scale: $10^{-9}$ m
- Subatomic/Nuclear Particle: $10^{-10}$ m
- Nanoscopic: $10^{-15}$ m
Unique Properties of the Nanoscale: *Nanoscience*

- *Gravity doesn’t matter* (it's there, just really weak)
- *Sticky* (intermolecular forces)
- *Shaky* (thermal energy)
- *Bumpy* (Quantum effects)
Why now?

What enabled Nanoscience?

An incomplete list . . . .

- Advances in Computing Power
- Advances in Materials Synthesis
- New Generation of Scientific Instruments
  - Scanning Probe Microscopes
    - Scanning Tunneling Microscopes
    - Atomic Force Microscopes

Very Sharp Tip scans over sample surface

ATOMIC RESOLUTION
Nanoscience-Nanotech

- **Biomedical Applications**
  - tissue engineering
  - sensing
  - drug delivery

- **Advanced Materials**
  - strong light materials
  - self cleaning materials
  - smart materials (self healing, self regulating)

- **Information Technology**
  - molecular electronics
  - DNA computing
An example: Drug Delivery
Let’s Pause for Two Questions
Fact or Fiction?

• What do you think…
  – For each case that is presented… is the innovation a fact or a fictional nanoscale science achievement?

Use emoticons to respond:
  Smiley face for fact. ☺
  Frown face for fiction. 😞
Fact or Fiction?

• There are currently biological nanomachines that naturally exist in your body.

Use emoticons to respond:
Smiley face for fact. 😊
Frown face for fiction. 😞
Fact

- Viruses are nano-sized biological machines that self-replicate, which means that parts spontaneously come together and create new viruses.
Fact or Fiction?

• Gold nano-sized balls can be injected into the body to destroy cancer cells.

Use emoticons to respond:
Smiley face for fact. ☺
Frown face for fiction. ☹
Fact

- Tiny gold capsules (a few nanometers in diameter) are coated with antibodies.
- When injected into the body the antibodies adhere to tumors and when irradiated with a laser, the gold capsids heat up destroying only the tumor while leaving the healthy tissue unharmed.

Fact or Fiction?

• There are frying pans that have the salt and pepper built into the pan.

• When you cook with the pan the food is automatically seasoned.

Use emoticons to respond:
Smiley face for fact. ☺
Frown face for fiction. 😞
Fiction

• Although scientists are experimenting with new materials -- so far there isn’t a pan with salt and pepper.
Fact or Fiction

• There are clothes that do not stain due to nanotechnology.

• You can throw coffee on your pants and the coffee will just roll off.

Use emoticons to respond:
Smiley face for fact. ☺
Frown face for fiction. ☹
Fact

- Textile chemists can now treat fabric with a special process to alter the fabric’s properties at the nanoscale.
- The fabric resist stains and repels spills.

- http://www.nano-text.com
Fact or Fiction?

Scientists have created nano-size bar codes that are being bred into fruit. In the near future grocery stores will be able to scan the fruit without a paper label.

Use emoticons to respond:
Smiley face for fact. 😊
Frown face for fiction. 😞
Fiction

Although there currently isn’t a fruit label--nano labels are an area of hot research.
Walk Through the Book

• Introduction
  – Key NanoScience and Engineering Concepts
  – Nano Investigations and the Science Domains
  – Interdisciplinary Science

• Other resources for teachers
Interdisciplinary NanoScience:

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<tr>
<th>Physical Sciences</th>
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<tbody>
<tr>
<td>• Motions and forces</td>
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<tr>
<td>• Interactions of energy and matter</td>
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<td>• Entropy and conservation of energy</td>
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<tr>
<th>Life Science</th>
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<tr>
<td>• The cell</td>
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<tr>
<td>• Molecular basis of heredity</td>
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<tr>
<td>• Matter, energy, organization in living systems</td>
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<tr>
<th>Earth Science</th>
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<td>• Properties of Earth materials</td>
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<td>• Geochemical cycles</td>
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<th>Science and Technology</th>
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<tr>
<td>• Abilities of technological design</td>
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<tr>
<td>• Understandings about science and technology</td>
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Interdisciplinary NanoScience:

<table>
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<tr>
<th>Mathematics</th>
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<td>• Measurement</td>
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<tr>
<td>• Proportionality</td>
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<td>• Mathematical modeling and representations</td>
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<tr>
<td>• Problem solving</td>
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<th>Unifying Concepts and Processes</th>
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<td>• Constancy, change and measurement</td>
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<td>• Systems, order and organization</td>
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<th>Science in Personal and Social Perspectives</th>
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<td>• Health</td>
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<td>• Risks and benefits</td>
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NanoScale Science Education
Research Group

http://ced.ncsu.edu/nanoscale/

Ideas for Teaching NanoScale Science

Free software

Research about Scale

This material is based upon work supported by the National Science Foundation under Grants No. 0354578, 0303979, 0087389, and 0411656.
Thanks to our presenters, Gail, Michael, and Amy, and to NSTA Press
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