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EDCI 627

1. Concepts:

* **Size & Scale:** A nanometer is 1/1,000,000,000 of a meter. Since it is difficult to visualize this, we did the nanometer scaling activity where we took one everyday object to be a nanometer and considered how large that would make a meter. To get a sense of scale, we placed objects a timeline for the “How big is it?” activity. In Ali Shakouri’s presentation, we heard about how the small size of nanoparticles resulted in their wave-like behaviors becoming more apparent.
* **Surface-Area-to-Volume Ratio:** At the nanoscale, objects have a much larger surface-area-to-volume ratio. Volume increases/decreases with respect to the side length cubed, whereas surface area increases/decreases with respect to the side length squared. So as the side length decreases, volume decreases faster than surface area, so the surface-area-to-volume ratio increases.  
    
  This was seen experimentally when we dissolved equal masses of cubed sugar and granulated sugar. The granulated sugar dissolved much more quickly due to the increased amount of surface area. Ali Shakouri mentioned the impact of this ratio during his talk when he said that at the nanoscale, surface effects play a much more important role than the volume effects.
* **Forces (EM vs Gravitational):** Electromagnetic forces dominate over gravitational forces at the nanoscale. Gravitational forces get weaker as objects become smaller due to the decrease in mass, but electromagnetic forces do not diminish with size. In the “Does it pour out?” lab, the EM force between the nanoscopic polar water molecules contained within the test tube creates cohesion. If this force due to cohesion is stronger than the force of gravity (which will happen in smaller test tubes), the water molecules remain in the test tube. From Ali Shakouri’s talk, we heard about how atomic force microscopes sometimes alter the material it is measuring due to the EM forces acting between the tip of the microscope and the object.
* **Models:** It is very difficult to construct a model of nanoscale objects. The STM and AFM can be used to scan a nanoparticle, but these microscopes can interact and interfere with the original nanoparticle. The Heisenberg uncertainty principle tells us that we can never exact know an object’s position and momentum. We tried to construct a model of a “nanoparticle” during the black box experiment, but had much difficulty. Ali Shakouri pointed out during his talk that it is difficult to define what ‘seeing’ really means, especially at the nanoscale.
* **Size-Dependent Properties:** When objects are shrunken down the nanoscale, sometimes certain properties begin to differ with what is observe at the macroscale. We saw these different properties experimentally in the different sunscreen colors and the hydrophobic vs. hydrophilic sand experiment, just to name a couple. Alex Wei mentioned that the gold nanorods he works with appear to be a different color than that of macroscopic gold. This is due to the difference in how photons are reflected by the two objects.
* **Self-Assembly:** Self-assembly occurs when multiple particles are attracted to each other via electrostatic forces, which causes the particles to create a more structured resulting shape. We worked with simulations to see how molecules like fibroin self-assemble. Peter Bremel showed during his presentation how a photonic crystal could be created from the self-assembly of silica balls.

2. All of the nanoscience concepts are interrelated. Because of the small size and scale of nanoparticles, it is difficult to model nano-sized materials. When we do attempt to model nano-sized materials, the electromagnetic force (which are stronger than the gravitational forces at the nanoscale) between the measuring device and the material may affect the material. The force created between measuring device and the material depends on the conductivity of the material, however conductivity is a size-dependent property that may be different at the nanoscale versus the macroscale. As the properties change with size, so does the surface-area-to-volume ratio. This ratio increases as the material decreases in size. If the surface of the material is charged appropriately, electrostatic forces may cause the material to self-assemble with other materials.

3A. Our driving question centers around the future of cell phone technology. This is relevant to nanoscience because of all of the nano-sized components that exist within a phone. So far, we have found articles about nano-sized components affecting the display, processor speed, memory, battery life, size, heat output, microphone, camera, and many more areas of the cell phone.

3B. Depending on the component of the phone under consideration, different nanoscience concepts are at play. For example, it is now possible to create pixels a few hundred nanometers wide, allowing for super high-resolution (see Nano-pixels’ promise thin, flexible high-res displays). This example shows the benefits of the small size of nanoparticles. In regards to heat output, “When reduced to sub-millimeter sizes…Silicon becomes very brittle and easily shatters…Carbon nanotubes, however, maintain their impressive combination of high strength, low weight, and excellent conductivity” (Berger, 2007). The brittleness of silicon is thus a size-dependent property.

4. We plan on teaching the “How big is it?” and some of the size-dependent properties activities (magic sand, t-shirts, etc.). The “How big is it?” activity will give students an idea of how various items compare in size with each other, so this activity teaches the concept of size and scale. The magic sand and t-shirt activities demonstrate the size dependent properties of certain materials. These activities will help students understand that the same material can have different properties (such as hydrophobic, different color, different conductivity, etc) at the nanoscale versus the macroscale.

5. A common size and scale misconception students may have about nanoscience is that everything is better at the nanoscale. However, this is not always the case. As Alex Wei mentioned during his presentation, when gold nanoparticles are used to eliminate tumors, some stray particles end up the liver. According to Wei, the research is not clear on how harmful these particles in the livers are to humans. The best way to address this misconception would be to mention and example such as this.

Another misconception is that the surface area and volume change linearly with length. Having students compare and do calculations involving cubes of side lengths 1, 2, and 3 can rid of this misconception.

A 3rd misconception is that particles that self-assemble will do so naturally. Depending on the environment, this may not be the case. If too much heat is present in the system, self-assembly will not occur. This misconception can be addressed by having students work through the Molecular Workbench interaction.

Finally, students often believe that items are always the same color regardless of size. However, color is a size-dependent property for some items (i.e. gold). Having students work through any of the size-dependent property labs, such as the nano gold and magic sand labs, can clear this misconception.

6. How can nanoscience improve the performance of athletes? Is nanoscience technology already being used in sports?

Answers:

<http://www.nanowerk.com/spotlight/spotid=30661.php>

* <http://www.sporttechie.com/2014/07/15/the-present-and-future-impacts-of-nanotechnology-in-sports/>

Sources

Presentations:

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* Shakouri, Ali. “Overview of Nanotechnology.” Purdue University. DLRC, West Lafayette, IN. 8 June 2015. Presentation for Research Goes to School.
* Wei, Alex. “Nanomedicine: Science or Science Fiction?” Purdue University, DLRC, West Lafayette, IN. 9 June 2015. Presentation for Research Goes to School.

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