Nanotechnology: Small Science, **BIG DEAL!**

Introductory Lesson

Grade Level 9-12

Subjects Biology, Chemistry, Environmental Science, Physical Science, Physics

Objective Students will gain interest in the rapidly-growing field of nanoscience by seeing how it connects to their own existing interests. Students will distinguish between observations and inferences.

Keywords antibodies; bioMEMS; biomimetics; blood-brain barrier; catalyst; chlorophyll; composite; conductance; dendrimers; electrostatically charged; gene therapy; hydraulics; MRI; nanometer; nanoshells; nanotechnology; neutralizing; nucleic acids; pesticide; photochemical cells; properties; smart materials; trichloroethylene; tsunami

Time one class period

Materials (different colors of "mesogold", e.g. nanosized colloidal gold solution)

- 2-3 samples of mystery fluid
- A gold object, e.g. chain, coin, nugget or ring
- Nanotechnology: Small Science, BIG DEAL! article
- **http://nanosense.org/activities/sizematters/index.html** lesson number 3 is a good extension of this lesson.

Engagement Ask students to observe what is different about two sample solutions, then to infer why this difference exists. They should write down both their observations and conclusions.

Discussion Questions

What difference(s) did you observe in the mystery fluids?
To what cause(s) do you attribute the difference(s)?
Does a difference in properties imply a chemical difference: always, sometimes, or never? How can we tell if this object is made of real gold? Would a magnifying glass help? A light microscope? Why not?* How can we tell if the colloidal particles are real gold?** Acid test? Color? (What causes colors?) Conductivity? Density? Hardness? Melting point?
Which area of nanotechnology interests you the most? Why?
How do you think nanotechnology could improve your life?

*10^{-6} m resolution limit vs. 10^{-9} m size **Atomic emission spectrography or condense

Name_____Period_____Date_____

Demonstration: Mystery Fluid Differences

Observations: *Describe the differences you see in the fluid samples.*

Draw a picture of your observations.

Inferences: *What do you think causes the apparent difference(s)?*

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Nanotechnology:
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Nano?

Nano is a Greek prefix meaning "dwarf". Scientists use the nano prefix to mean "one-billionth". A nanometer is therefore one-billionth of a meter.

How small is a nanometer?

A nanometer is so small that your pinkie fingernail measures about ten million nanometers across! The head of a pin has a diameter of one million nanometers, and a one dollar bill is one hundred thousand nanometers thick.

Since when?

Scientists from many different disciplines (biology, chemistry, physics, etc.) have been working diligently on nanotechnology for about twenty years.

What they are discovering will so greatly impact our lives that it has recently been described as a tsunami – a long, low wave that is at first hard to perceive, but shows itself to be incredibly powerful when it makes its impact known.

Why is such a small science such a big deal?

For one thing, we have discovered that the properties of normal, everyday materials sometimes change dramatically when they are nano-sized.

For example, aluminum foil isn't too scary when you wrap a baked potato with it, but when aluminum foil is nano-sized (around 25 nanometers) it can literally explode! That could improve rocket fuels and may have military and other important applications.

Also, smaller technology is generally more efficient. We have limited resources, and more efficient use of resources can translate into more availability. More availability should translate into lower cost (supply and demand).

According to the National Science Foundation, nanotechnology will have one trillion dollars worth of impact on the global economy by the year 2015. Already, more than 60% of companies that make up the Dow Jones Industrial Average have begun nano-initiatives. Remember that as you consider your future career and higher education.

Let's consider nanotechnology's potential impact on you in the next few decades. What technology interests you?

Your Electronics

COMPUTERS

Computers are a key component of most American businesses. Improved computer efficiency could lower our cost of living since they are often a significant cost of doing business.

Nanotechnology will make it possible to store and retrieve much more memory in much less time and space. Processors will be much more energy efficient and faster. After all, speed is calculated by dividing distance by time. Shrinking the sizes of computer components will shorten the distance so that computing takes less time.

COMMUNICATIONS

Your cellphone pictures aren't real clear, and it needs to be re-charged every few days, and the image it displays goes into a dark standby mode to save energy. You could use a better antenna, also. Nanotechnology to the rescue! High resolution pictures, once a month recharging and a cellphone display that never goes off are all in the works and the phone will be so small you might want to wear it like a watch.

Your Health

BIOMIMETICS

Good science studies what already exists in nature, then attempts to copy natural technology to benefit people. We have made airplanes, cameras, computers and Velcro like this. Nanotechnology plans to apply biomimetics, which means "mimicking life", to the human body to stimulate regeneration and self-repair. A blood substitute (not easily contaminated, less perishable than blood, and of a universally acceptable type) is one goal. Rapid clogged artery expansion and better joint repair/replacement are other current areas of research.

BioMEMS (Biological Micro-ElectroMechanical Systems) are tiny medical devices designed to do work inside your blood vessels. Smart Metal Alloy plates can keep compression on broken bones so that they actually heal faster.

COOKING CANCER CELLS

Nanoshells of glass, coated with nano-amines, then coated with nano-gold are being tested in animals for two huge purposes. First, searching for cancer by electronically scanning bodies injected with nanoshells coated with antibodies made by various types of cancer cells. Second, targeting cancer cells by injecting the body with nanoshells coated with 10 nanometers of gold and also with the antibodies of an individual's own cancerous cells. They stick to the cancer cells only, and then absorb laser light which cooks (kills) the cancer cells.

DRUG DELIVERY

It's a shame when the treatment makes a patient sicker than their illness does! Drugs, especially chemotherapy drugs, can cause severe side effects. Nanopackages can be built to deliver drugs to specific tissues. Dendrimers (three nanometers across) can even carry segments of DNA/RNA past our immune defenses into cells for gene therapy.

EARLY DIAGNOSIS

When certain nucleic acids are attached to nanowires, they bond with certain diseased genes in a tiny drop of blood, thereby changing the conductance of the nanowires and making a current of electricity to flow. Tiny sensors may catch such diseases very early in the near future.

Also, imagine shrinking a medical lab down to the size of a miniaturized microchip. Harmful chemical agents and viruses could be detected much faster, so appropriate treatment can begin quickly.

Nanomaterials are also being explored for their abilities to provide better contrast to improve resolution in medical images (MRI, X-Ray), faster scans, lower toxicity and even to penetrate the blood-brain barrier.

Your Resoursces : Man-Made

COMPOSITES

Less expensive, lighter stronger materials can be made by making a composite of two or more materials together. Nanotechnology could give a whole new life to plastics.

Want your own helicopter or airplane? Nanocomposites could make it much more affordable.

Nanotubes in plastics can allow them to produce images on their surfaces. Plastic signs could change their message as you read them. Composites can even make painting much more efficient – even coats with very low waste since electrostatically charged paint particles can be attracted to the grounded object.

NANOFIBERS

Carbon nanofibers could be arranged so that they are 500 times stronger than steel, yet they weigh less than one-third of the weight of steel. Theoretically, you could lift a car with a perfect carbon nanotube fiber as thick as a thread.

Adding these nanofibers can add useful properties to materials, like: bulletproof, lighter, self-cleaning, spill-resistant, quick-drying and wrinkle-resistant. Nanotube fibers in clothes could even store energy to run your favorite electronics – cellphone, mini-computer or MP3.

SMART MATERIALS

Composite materials that can repair damage to themselves, and metal alloys and polymer plastics that are designed to detect and respond to changes in their environment are called smart materials. So far they are really expensive, but also really beneficial and way cool.

Airplane wings could sense strain and change their shape without heavy high-maintenance hydraulics. Bridges and buildings could advise you when they need repairs and strengthen themselves by mixing hardening chemicals and their catalyst when microcapsules break in the structure as it starts to crack. Bullet-proof vests can harden when they are hit. Tools could even warn you when they are about to break.

Your Resource: Natural

CHEAPER ENERGY

Inexpensive, light-weight solar cells may be sprayed or printed onto entire roofs so efficiently that the electric company may lose your business! Transparent solar cells in between panes of glass are another area of exploration currently.

Lighter weight, longer-lasting batteries with more power and faster recharging are also on the horizon.

Nano-photoelectrochemical cells may soon use sun's energy to split water into hydrogen and oxygen to store chemical energy to use later. Another goal is to invent a molecule that mimics chlorophyll – splitting water into hydrogen and oxygen.

CLEANER AIR

Future production of electricity by nano solar cells, as well as widespread use of hydrogen fuel cells will greatly reduce the need to burn dirty fuels that pollute our air.

Meanwhile, nanocrystal catalysts in smokestacks can greatly reduce dangerous and toxic emissions. Bus fumes got you down? A nanocatalyst added to diesel fuel could help us all to breath a little easier, too.

CLEANER WATER

Pesticide and waste contamination in water can also be cleaned up cost effectively thanks to nanotechnology. The palladium catalyst that converts trichloroethylene (irritated eyes, nausea & **vomiting) to harmless ethane is even more expensive than gold. Nanotechnology allows us to coat small particles with the expensive stuff, so it is still at the surface where it can do its work, but it saves us a fortune. Injection of iron nanoparticles into nasty groundwater can also produce cleaner, healthier water, neutralizing many contaminants.**

Additionally, nanotechnology can allow us to economically turn saltwater into freshwater for drinking and watering our crops. Want a farm and a swimming pool near the ocean in the desert?

Your Safety & Security

AIRPORT, BORDER & MILITARY

- **Armor-Police Soldiers & Tanks**
- **Artificial Muscles for Soldiers**
- **Biological Warfare Sensors**
- **Chemical Warfare Sensors**
- **Communications Systems (nano)**
- **Nanomunitions-Power & Control**

Many of the ideas in this article came from the book, "Nanotechnolgy for DUMMIES" by Richard Booker and Earl Boysen, Wiley Publishing, Inc., 2005. Ask the authors questions, or get updated information at:

www.nanotechnologyfordummies.com

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Mystery Fluids

Three samples of colloidal gold solution purchased from enanoparticles.com.

25 mL each:

30 nm solution - $80

60 nm solution - $80

90 nm solution - $80