Preface

Is nanotechnology the gateway to the future for human beings on Earth?

Figure 1.1: Where does your imagination take you?

Introduction to Nanotechnology

Mrs Corea
JEDTA
Elizabeth Public Schools

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Dr. John Carpinelli
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Dr. Linda Hirsch
Dr. Rajesh Dave
Dr. Ecevit Bilgili
Sayani Bhaumik
Zhonghui Huang
RET participants

Objectives

- Make measurements using multiple measuring techniques.
- Perform unit conversions.
- Interpret the nano-sized length scale as it compares to multiple references.
- Interpret how nanoscience works as it pertains to real-world applications.
- Describe how ferrofluids work, including a conceptual knowledge of magnetic requirements.
- Identify key applications and potential applications for specific nanotechnologies
- Describe physical and chemical properties of nanoparticles

Standards and Indicators

- International Technology and Engineering Educators Association: Technology
  - I. Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. (Grades 9 - 12) [2000]
- Next Generation Science Standards: Science
- Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (Grades 9 - 12) [2013]

Materials

- Rulers, round object, square
- ferrofluid, penny
- Set of object cards
- CaCl2
- Iodine/sodium alginate solution
- Starch solution
- Iodine
- Starch/sodium alginate solution
- Sand
- Sand(mystic sand)

Brief History

The concepts of nanotechnology are not new to nature or to mankind. An early example of a manmade nanoprocess is stained glass.

Figure 1.7: Stained glass windows.

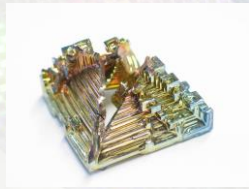


Figure 1.8: Picture of gold nano particles.

The color known as "Purple of Cassius" in glass and glass enamel is created by incorporating a colloidal suspension of gold nanoparticles, a technology in use since ancient times. Colloidal silver is yellow, and alloys of gold and silver create shades of purple-red and pink.

Brief History, Continued

Dr. Richard P. Feynman
• *"Why cannot we write the entire 24 volumes of the Encyclopedia Britannica on the head of a pin?"*

Dr. Richard Feynman, one of America's most notable physicists, 1918-1988.

Figure 1.11: Richard Feynman.

More History, Continued

Eric Drexler, Continued

Cell Repair Machines

• "By working along molecule by molecule and structure by structure, repair machines will be able to repair whole cells. By working along cell by cell and tissue by tissue, they…will be able to repair whole organs…they will restore health." - Drexler, 1986

Figure 1.16: Stylized example of targeted cell repair.

Brief History

Birth of Nanotechnology
• Professor Taniguchi of Tokyo Science University used the word "nanotechnology" to describe the science and technology of processing or building parts with nanometric tolerances.
•A nanometer is a unit of length in the metric system, equal to one billionth of a meter.

Figure 1.9: Tokyo Science University.

1 nanometer =	
1×10^{-9}	meter
1×10^{-3}	µm
3.281×10^{-9}	feet
39.37×10^{-9}	inches

Figure 1.10: Equivalent Units

NOBEL PRIZE

Buckyballs

• Three gentlemen—Harold Kroto from the University of Sussex, Robert Curl and Richard Smalley from Rice University—were awarded the Nobel Prize in Chemistry in 1996 for their discovery of a new composition of carbon, Carbon 60.

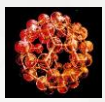


Figure 1.19: Carbon-60 buckyball is shaped like a soccer ball.

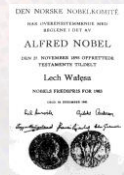
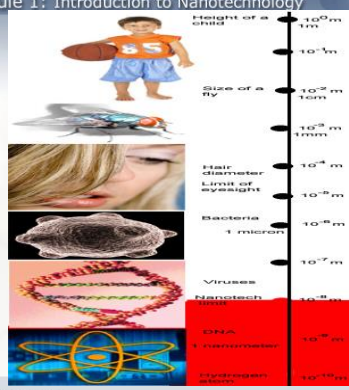


Figure 1.20: Example of Nobel prize diploma.



Nanotechnology applications

- Nanotechnology is the creation of useful materials, devices, and systems through the manipulation of matter on this miniscule scale. The emerging field of nanotechnology involves scientists from many different disciplines, including physicists, chemists, engineers, and biologists.
- There are many interesting nanodevices being developed that have a potential to improve cancer detection, diagnosis, and treatment.

Module 1: Introduction to Nanotechnology

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The tokay gecko uses nanotechnology to stick itself to trees, walls, windows, and even ceilings. The gecko's feet are covered in microscopic hairs, called setae, which branch into thousands of smaller hairs with paddle-shaped ends. Those branches, or spatulae, are a mere 200 nanometers wide at the tip. The extra surface area of the spatulae maximizes the effect of van der Waals forces, the weak electrical pull between every molecule in the gecko and every molecule in whatever it's sticking to. The combined force is so strong that a gecko can hang its whole weight from a single toe, even on a sheer piece of glass. Engineers have used carbon nanotubes mimicking gecko setae to create super-sticky tapes, glues, and even a wall-climbing gecko robot.

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Nanotechnology in Medicine - Nanomedicine

- Futurists have long speculated that nanotechnology will revolutionize virtually every field it touches, medicine being no exception. Here's what to expect when you have fleets of molecule-sized robots coursing through your veins.

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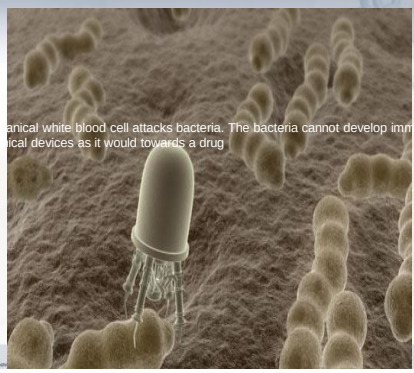
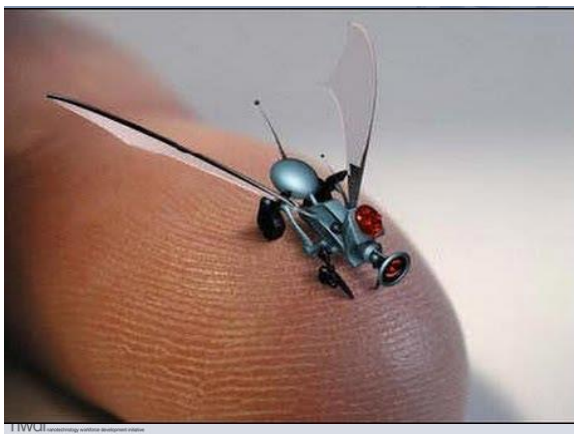


anical white blood cell attacks bacteria. The bacteria cannot develop immunity to
ical devices as it would towards a drug



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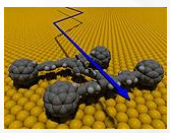
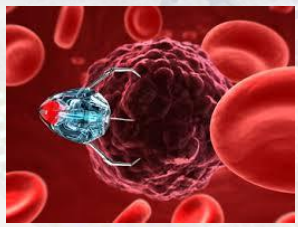


Figure 1.2: A nanocar made from a single molecule.



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What is so big about nanotechnology?

- From nanofabric to nanobots, nanotechnology has created a “buzz” that is hard to tell where the science ends and the science fiction begins

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Nature has perfected the science of manufacturing matter molecularly. For instance, our bodies are assembled in a specific manner from millions of living cells. Cells are nature's nanomachines. At the atomic scale, elements are at their most basic level. On the nanoscale, we can potentially put these atoms together to make almost anything.

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Background-Nanotechnology Language

- *Nanobio*
- *Nanodots*
- *Nanowires*
- *Nanoelectronics*
- *Nanobots*
- *Nanomaterials*
- *Nanochondria*

Figure 1.4: Searching for nanotechnology.

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Concepts

Properties and behaviors of materials can be quite different at the nanoscale.

- Nanotechnology
- Disease control
- Hydrophobic versus hydrophilic
- Physical and chemical properties
- Relative size
- Diffusion

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CLASSROOM ACTIVITY-1

Students are introduced to the nano-size length scale as they make measurements and calculate unit conversions. They measure common objects and convert their units to nanometers, giving them a simple reference frame for understanding the very small size of nanometers. Then, they compare provided length data from objects too small to measure, such as a human hair and a flea, giving them a comparative insight to the nanotechnology scale. Using familiar and common objects for comparison helps students understand more complex scientific concepts

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Class discussion

- compare results and realizations about the extreme smallness of the nano length scale.
- compare and contrast giga and nano scale

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Activity 2: How big? how small?

- Students will be given a set of 15 object cards different sizes from the nucleus of an atom to a galaxy.
- Students have to arrange the cards from the largest to the smallest

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Class discussion

- Which objects were more difficult to arrange correctly? Why do you think this is so?
- Would a carbon nanotube that is 4 nm long and 2 nm wide be visible under a light microscope?

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Activity 3 Water Repellant Sand

- Ordinary beach sand is silicon dioxide. Hydrophilic
- Mystic sand is white beach sand that treated with dye and coated with nanoparticles of chemical treated silica. Hydrophobic
- By adding water to both sands students observed hydrophobic and hydrophilic properties.

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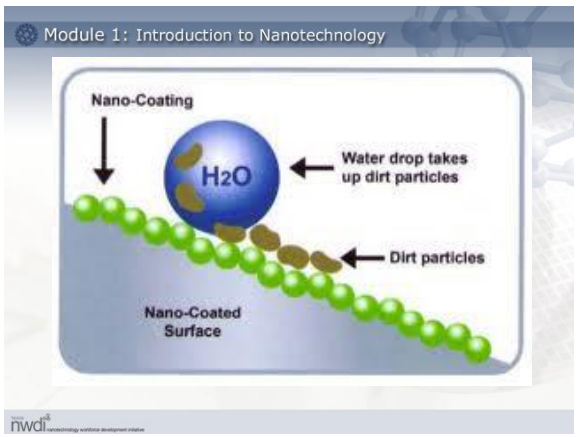
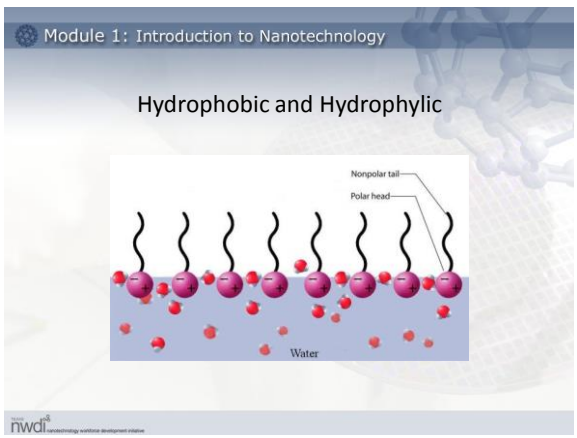

Module 1: Introduction to Nanotechnology
Nano-Coating
H2O
Water drop takes up dirt particles
Dirt particles
Nano-Coated Surface


Module 1: Introduction to Nanotechnology
Hydrophobic and Hydrophylic
Nonpolar tail
Polar head
Water

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Class discussion

1.Describe how the two types of sand exhibit either hydrophobic or hydrophilic properties?

2. Roots of most plants need water and air. if plants are over watered, air pockets in the soil become filled with water and tiny root hairs cannot get oxygen. How would adding Mystic sand to potting soil help with the problem of overwatering?

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Class discussion

- 3.The textile industry has used nanotechnology to develop fabric that repels liquid. If you were to design an experiment to test the effectiveness of liquid-repellent, what question might be asked that would begin the process of investigation?

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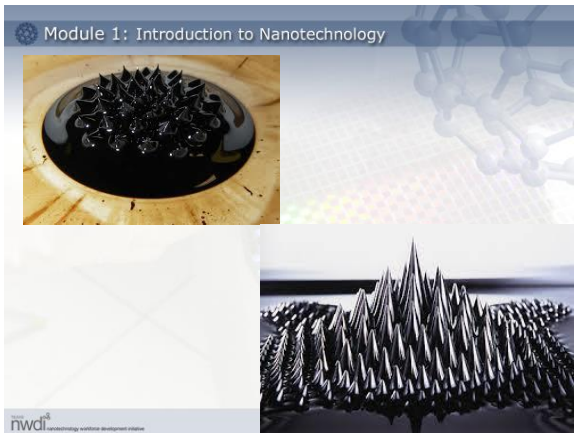
Activity 3 FERROFLUID

Ferrofluid was developed in cooperative with NASA in 1960. Ferrofluid consists of extremely small, solid-phase magnetic particles about 10nm in diameter that are coated with a surfactant and suspended in a liquid


Module 1: Introduction to Nanotechnology
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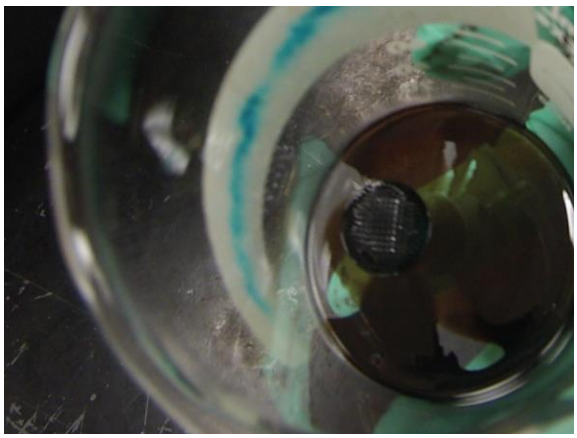

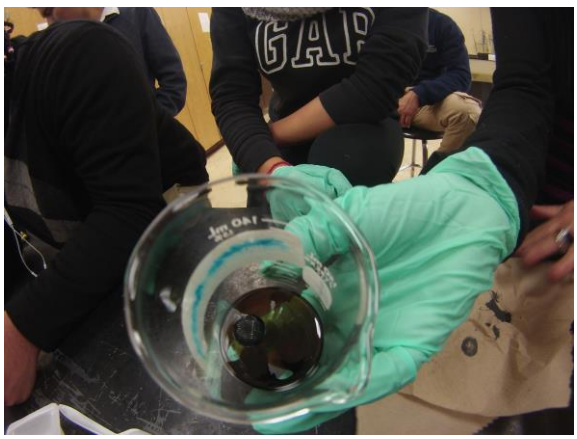

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- In this fun, engaging activity, students are introduced to a unique type of fluid—ferrofluids—whose shape can be influenced by magnetic fields! Students act as materials engineers and create their own ferrofluids. They are challenged to make magnetic ink out of ferrofluids and test their creations to see if they work. Concurrently, they learn more about magnetism, surfactants and nanotechnology. As they observe fluid properties as a standalone-fluid and under an imposed magnetic field, they come to understand the components of ferrofluids and their functionality

Module 1: Introduction to Nanotechnology

CLASS DISCUSSION:

- Ferrofluids Discussion
- **How was I able to magnetize the fluid?**
- **How big are these magnetic nanoparticles? How might I utilize this technology?**

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ACTIVITY 5 Encapsulation in Medicine

- Students observed in the lab that when drops of iodine/sodium alginate were dropped to a CaCl2 solution yellow spheres were formed, then the spheres were moved to a starch solution they changed their color to dark blue around outside the sphere
- Students observed that when drops of drops of starch sodium/alginate solution were dropped to a Cacl2 solution clear floating spheres were formed, then the spheres were moved to a iodine solution they changed their clear color to a dark blue color

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Module 1:

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Module 1: Intro

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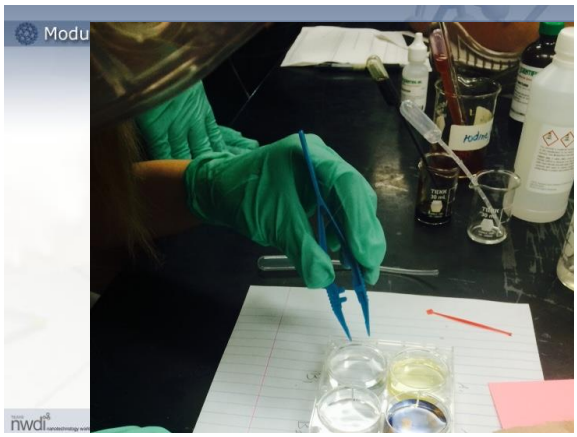
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Module 1: Introduction to Nanotechnology

Class Discussion

- 1. Explain the difference in color between spheres formed in both solutions?
- 2. This activity is a macroscale model of what could take place at the nanoscale in medicine. What questions would need to be considered in using encapsulation to deliver chemotherapeutical drugs to only cancer cells?

Module 1: Introduction to Nanotechnology

Team Poster Project: After students have completed the 5 lessons and four activities of the unit, assign student pairs to each create posters that summarize what was learned during the unit. (grading rubric for the teacher)

Team member names: _____ Poster topic: _____

Point Value	5	4	3	2
Topic	• Topic clearly defined with subheadings	• Topic defined, but subheadings not appropriate	• Topic defined, but no subheadings	• No clear topic stated
Organization	• Defined sections • Clear headings • Flows well to assist the reader without help • Finished product	• All headings present, but unclear • Requires rereading to understand	• No heading, but sectioned • Hard to follow, requires assistance • Missing parts	• Cluttered, no definitive sections; all over the place • Some sections missing
Creativity	• Interesting, engaging, visually stimulating • Appealing use of color, diagrams and text • Interest, motivation, effort and time obviously present	• Some use of color, diagrams • Engaging, but will not stimulate	• Very little use of color or graphics, although enough to engage and hold attention	• Bland, no variability • No use of color or diagrams • Boring to look at, does not catch your attention • Interest, motivation, effort and time obviously absent
Science Content and Literacy	• Concept fully and correctly explained • Insight present • Science-specific and engineering-specific connections made • Content is accurate, comprehensive and well supported • Excellent use of resources	• Adequate explanation • Science and engineering connections present, but could be further developed • More than one resource presented	• Poor explanations • Inaccurate science and engineering connection • Misinterpretation of the science and/or engineering • Minimum of one resource	• No analysis of science topic • No explanation • No science- or engineering -specific connections • No use of resources
Level of Difficulty and Understanding	• Difficulty appropriate for grade level • Understanding is present and apparent	• Task difficulty could be increased or developed • Some level of understanding shown	• Explanation describes minimal level of validity • Needs serious refinement	• Task difficulty not suitable for grade level/not related to science (too easy) • Superficial/irrelevant task

Summary

Nanotechnology is ubiquitous and pervasive. It is an emerging field in all areas of science, engineering and technology.

Figure 1.26: Robot image.

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Contributors

Claudia Corea, Elizabeth Public Schools, Elizabeth, NJ, Primary Author

Howard Kimmel, Levelle Burr-Alexander, John Carpinelli - Center for pre-College Programs, NJIT.

Dr. Zhonghui Huang, Dr. Rajesh Dave - C-SOPS, NJIT