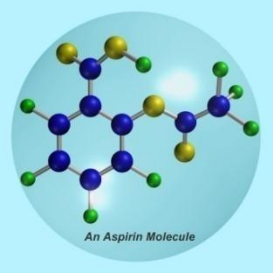
Nanoscience vs. Nanotechnology



Introduction
Student Guide

Lesson Overview

In this lesson, you will learn the differences between "Nanoscience" and "Nanotechnology." Both are extremely exciting, but have distinct differences in what the people in these fields do.

Throughout this lesson you'll be asked to research and discuss what is happening in nanoscience and nanotechnology. A lot is going on in both fields and the potential for a lot more is HUGE.

Before coming to class
Complete the on-line Knowledge Probe (KP) called KP: Nanoscience vs Nanotechnology.

Objectives

At the end of this lesson you will be able to do the following:

- List several examples of nanoscience exploration and research activities
- List several examples of nanotechnology innovations and products
- Correctly apply the terms Nanoscience and Nanotechnology to different situations
- Tell another person what the differences are between Nanoscience and Nanotechnology

Resources

National Nanotechnology Initiative (NNI) web site: www.nano.gov

NNI site "What is Nanotechnology": http://www.nano.gov/nanotech-101/what

Nano Science and Technology Institute : http://www.nsti.org/

Lesson Outline

Pre-class assignment

Knowledge Probe
Before coming to class, you complete an on-line assessment of your current understanding of nanoscience vs. nanotechnology (KP – Nanoscience vs. Nanotechnology).

In-class Activity: NanoScience vs. NanoTechnology
In this activity you will develop your own definitions of nanoscience and nanotechnology based on current knowledge. You will be required to share your results with the instructor and other students as part of the class discussion.

Discussion on the results of Activity
You will share your definitions of nanoscience and nanotechnology with other students and the instructors. The discussion should cover the differences and similarities of each. The instructor will present several examples of which you will determine "nanoscience", "nanotechnology" or "both". The class will reach a consensus on the correct definition of each.

Post-Assessment
Complete a short assessment that measures your understanding of nanoscience and nanotechnology.

Assessment Strategy

You will be assessed on the following:

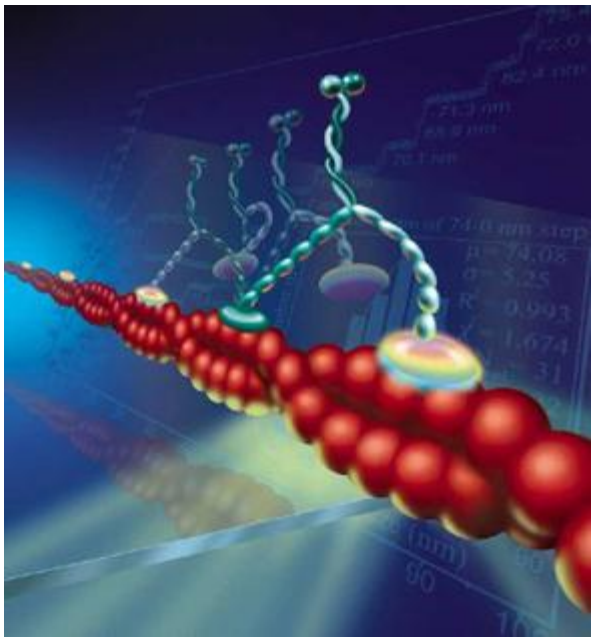
- Completion of the online Knowledge Probe: Nanoscience vs. nanotechnology
- Participation in the classroom discussion
- Grade on the in-class Post-Quiz: Nanoscience vs. Nanotechnology

Terminology

Nanoscience
Nanotechnology
Nano http://en.wikipedia.org/wiki/Nano
Nanometer http://dictionary.reference.com/browse/nanometer
Science http://dictionary.reference.com/browse/science
Technology http://dictionary.reference.com/browse/technology

Introduction

What is Nanoscience? To give you a hint, the illustration below represents a biomolecule that nanoscientists have discovered.



[Illustration by and courtesy of PrecisionGraphics.com]

What is it?
First of all, what's the red spiral? What's the figure walking on top of the red spiral?

Give up?

Very simply put, the red spiral is a microfilament, a minute fiber found in muscle cells. The green figure walking on top of the microfilament is a protein molecule called myosin.

Nanoscientists have discovered that the mysoin protein acts like a linear motor. To contract a muscle, the myosin molecule (or motor) walks in nano-size steps along the microfilament. As the myosin molecule walks, it pulls on the microfilament causing the muscle cells to contract.

So what is Nanoscience? This is really a two part question:

1) What is nano?
2) What is science?

By the end of this lesson, you will be able to answer these questions. You will also be able to answer the question – What is the difference between Nanoscience and Nanotechnology?

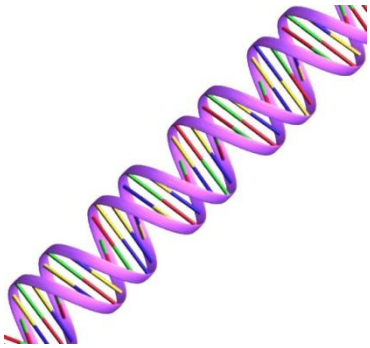
There is a huge difference! So let's find out.

Lesson Content

What is Nano?

Let's start with answering the question, "What is nano?" Here are some nano-size objects:

DNA Molecule:
DNA (Deoxyribonucleic acid)
about 2 nanometers in diameter

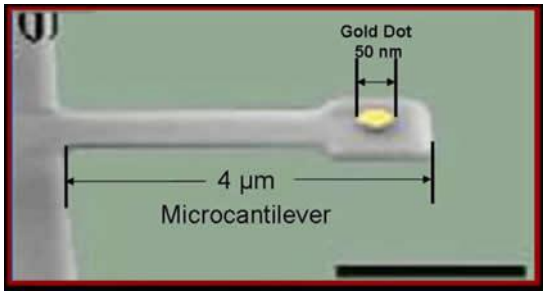


Dozens of Silicon atoms
Each silicon atom is approximately 0.234 nanometers in diameter; therefore this picture is about 4 nm wide.
This picture was taken using an Atomic Force Microscope (AFM).

[AFM image by and courtesy of Franz Giessibl]

NanoDot

This image shows a nano-size Gold particle (50 nm) sitting on the end of a microcantilever.



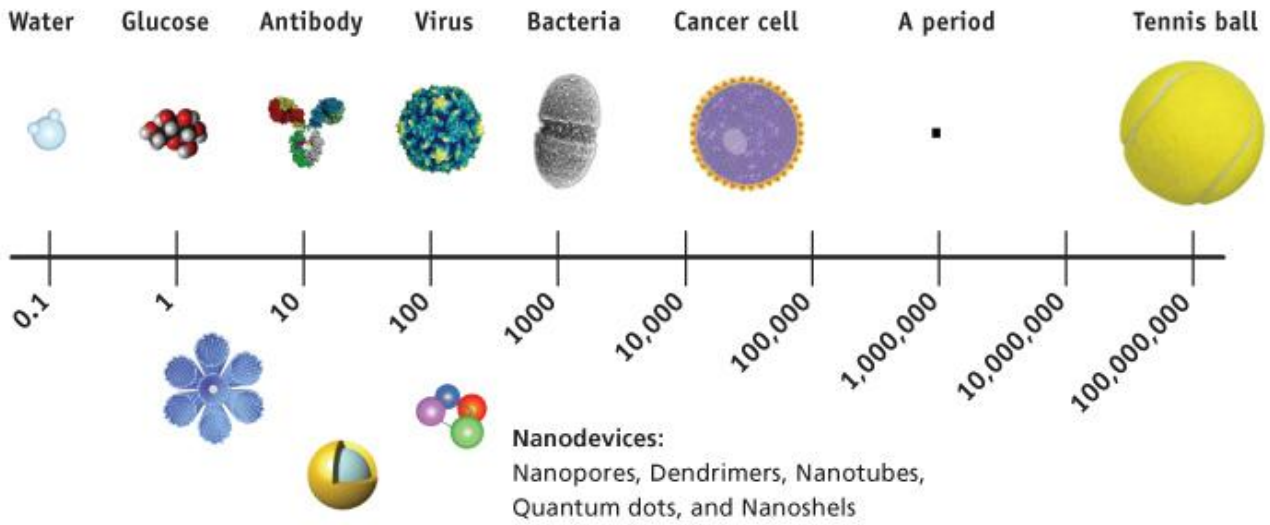
[Courtesy of the Craighead Group, Cornell]

The Definition of Nano

Nano is a metric prefix which is applied to measurements of length such as ***milli***meter, ***micro***meter, and ***nano***meters. It can also be applied to measurements that indicate the "amount" of something: ***milli***ampere or ***nano***amperes (an amounts of electrical current), ***micro***liters or ***nano***liters (the amount of a volume), and ***kilo***grams or ***nano***grams (the mass of something).

The prefix ***nano*** is used as another indication of size or amount.

You may already know, or soon will find out, that a nanometer is defined as one-billionth of a meter (1×10^{-9} meter). A meter is a little longer than a yard (1 meter = 1.09 yards).



Graphic unit is "nanometer"
Graphic source: National Cancer Institute

What is Science?

Now let's look at the second question: What is science?

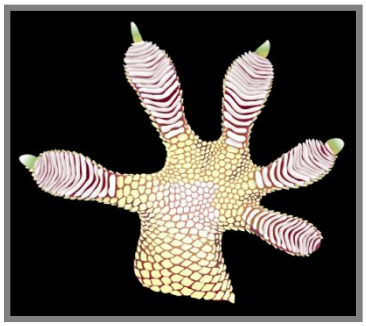
There are many definitions of science. Here are a couple:

1) *"The systematic observation of natural events and conditions in order to discover facts about them and to formulate laws and principals based on these facts."[Academic Press Dictionary of Science and Technology]*
2) *"The organized body of knowledge that is derived from such observations and that can be verified or tested by further investigation." [Academic Press Dictionary of Science and Technology]*

Sound pretty complicated? Well it isn't really. It just takes some time to think about it.

One way to look at the definition of science is that science is trying to figure out nature's rule book.

- What are the rules which govern material properties?
- How do things move?
- Why do natural events occur as they do?



An example of nanoscience was the discover of how the gecko can walk on ceilings and stick to glass walls of an aquarium. Hint: It has something to do with nano-size objects in the feet. You'll study this later in this course.

Through science we know the answer to questions such as these:

- Why are plants green?
- Why do some things float and others sink?
- How do our lungs pull the oxygen out of the air?

Scientists are the people who do the investigations or experiments and try to determine what the rules of nature are. The experiments are done in a very precise and systematic way so that others can re-do the experiments and (hopefully) get the same results. Getting the same results is what is meant by being "verifiable" and "repeatable."

So now you should have a better idea as to what science means: Figuring out the rules which determine how things work in nature.

What is Technology?

What does the term "*Technology*" really mean? We live in a society which is packed with all sorts of "technology": iPODs, iPads, cell phones, laptops, GPS (Global Positioning Systems), gaming systems (Wii, Nintendo, X-box, Playstation), DLP (Digital Light Processors) displays, LCD (Liquid Crystal Display), WiFi …

I'm sure you can come up with dozens more technology driven devices and systems.

How is Technology defined?

The National Institute of Health (NIH) defines technology as

> *"A body of knowledge used to create tools, develop skills, and extract or collect materials; the application of science (the combination of the scientific method and material) to meet an objective or solve a problem."*

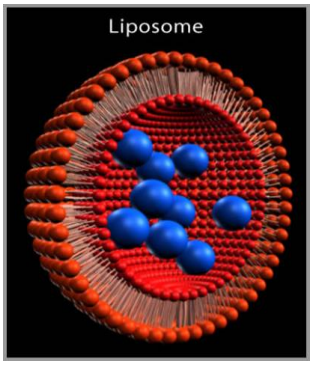
Merriam-Webster on-line dictionary defines technology as

> *1 a: the practical application of knowledge especially in a particular area*
>
> *b: a capability given by the practical application of knowledge*
>
> *2: a manner of accomplishing a task especially using technical processes, methods, or knowledge.*

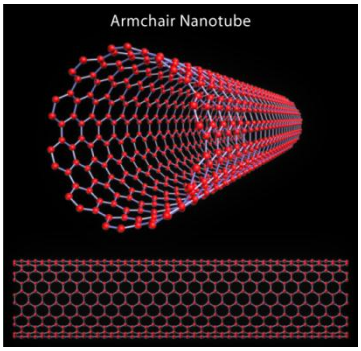
So What is NanoTechnology?

Here are a couple of examples of Nanotechnology.

Liposome
A liposome is a tiny nanoparticle or vacated sphere made out of the same material as a cell membrane. It is hoped that one day we can fill a lipsome with drugs and inject it into the blood stream. Using the properties associated with the liposome's membrane, it will connect to a cancerous tumor, emit the drugs and kill the cancerous cells.



Carbon Nanotubes (CNTs)
Carbon nanotubes use the properties of carbon to form tubes with a length to diameter ratio greater than 1,000,000!
Potential applications of CNTs include electrical connections for micro and nano-sized electronics, fibers 20 times stronger than bullet-resistent kevlar fibers, and surfaces slicker than Teflon.



[Images by Junifer Nez, SCME]

So, what do you think? ***What is NanoTechnology?***

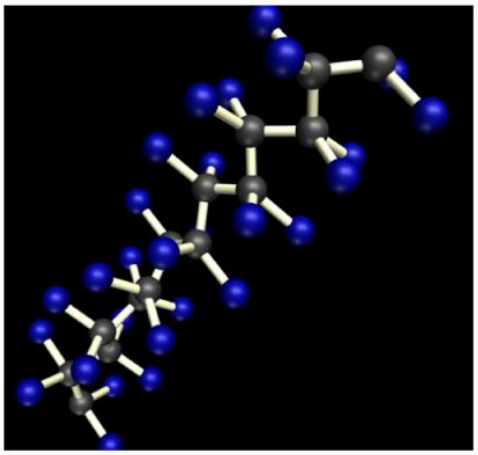
Activity: NanoScience vs. NanoTechnology

Link to and complete the activity – Nanoscience vs. Nanotechnology

An Example of Nanoscience Enabling Nanotechnology

Now that you have developed definitions for nanoscience and nanotechnology, what do you think is the difference between the two?

In this picture you see a depiction of a molecule. This particular molecule makes up the famous non-stick Teflon coating used on cookware, telecommunication cables, and clothes.



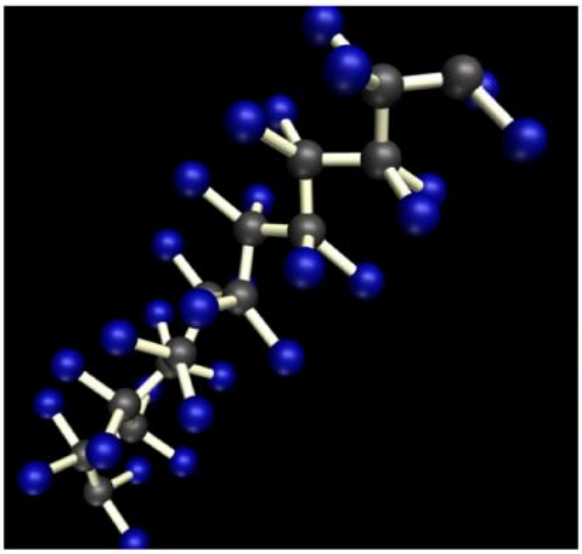
[Images by SCME]

Identifying the molecule's design and determining its physical and chemical properties are examples of ***nanoscience.***

Learning how to control and mass produce the molecule to make the desired Teflon coatings is an example of ***nanotechnology***.

More on Teflon Coatings

The molecules that are used for Teflon coatings repel water molecules when assembled in a film. These Teflon coatings are said to be ***hydrophobic.*** *"Hydro" means water and "phobic" means "scared of" or "repulsed by."* Nanotechnology has lead to the development of a process that takes billions and billions of these molecules to make a continuous coating. The result is a hydrophobic surface called a Teflon coating.



Summary

In this lesson you have learned

- what is nanoscience,
- what is nanotechnology, and
- what are the differences and similarities between nanoscience and nanotechnology.

Through the applications you've seen, you should have recognized that nanoscience and nanotechnology are not science fiction, but are areas of study that are growing at a tremendous pace throughout the world in a variety of fields.

Homework

Complete the on-line Assessment – Nanoscience vs. Nanotechnology

References

[1] Academic Press Dictionary of Science and Technology

National Nanotechnology Initiative (NNI) web site: www.nano.gov

Nano Science and Technology Institute : http://www.nsti.org/

This work has been funded through the support of a National Science Foundation grant, DUE #

Activity - Nanoscience vs. Nanotechnology

Nanoscience vs. Nanotechnology
Student Guide

Introduction

This activity will help you to better identify the difference between nanoscience and nanotechnology. In this activity you will develop your own definitions of nanoscience and nanotechnology. Once your definitions have been developed, you will work with the other students and reach a consensus on what is the best definition for each of these two areas.

Activity:

Time to Complete: approximately 45 minutes**.**

Procedure:

1. Write down your definition of nanoscience.
2. Write down your definition of nanotechnology.
3. Share your definitions with the other students in the class or through the discussion board.
4. Review others' definitions of nanoscience and nanotechnology.
5. Discuss your definitions and, as a group, reach a consensus on a definition for each term. (Do not use the definitions used in this lesson. Come up with your own.)
6. Submit your activity results to your instructor.

Post-Activity Questions / Answers

1. List at least two examples, experiments or discoveries that would fall under your definition of nanoscience.

2. List at least two examples, experiments, or developments that would fall under your definition of nanotechnology.

3. Is there a clear dividing line between nanoscience and nanotechnology? Support your answer with examples.

Summary

This activity allowed you to further your understanding of nanoscience vs. nanotechnology and identify examples of each.

This work has been funded through the support of a National Science Foundation grant, DUE #

This quiz must be taken before the first class meeting.

Online quiz: Knowledge Probe - Nanoscience vs. nanotechnology

1. Nanoscience
    a. Develops means by which to manipulate particles at the molecular level
    b. Develops the systems for studying particles at the molecular level
    c. Studies the properties of particles at the molecular level
    d. Studies the formation of particles at the molecular level
2. Nanotechnology
    a. Develops means by which to manipulate particles at the molecular level
    b. Develops the systems for studying particles at the molecular level
    c. Studies the properties of particles at the molecular level
    d. Studies the formation of particles at the molecular level
3. For each of the following, identify it as either nanoscience or nanotechnology
    a. The exploitation of the properties of self-assembly
        i. Nanoscience
        ii. Nanotechnology
    b. The study of the rules that govern material properties at the nanoscale
        i. Nanoscience
        ii. Nanotechnology
    c. The development of liposome vesicles into drug delivery systems
        i. Nanoscience
        ii. Nanotechnology
    d. The design of a process that yields hydrophobic films
        i. Nanoscience
        ii. Nanotechnology
    e. The identification of the molecular design of hydrophobic materials
        i. Nanoscience
        ii. Nanotechnology
4. Nanotechnology _____ the findings of nanoscience.
    a. Validates
    b. Exploits
    c. Manipulates
    d. Clarifies
5. Which of the following is a job requirement for a technologist working for a nanotechnology company?
    a. Operate commercial-scale production equipment to produce, test, or modify materials, devices for the purpose of understanding their chemical and physical properties.
    b. Research and manipulate structures at the atomic and subatomic level for the purpose of understanding their hydrophobic characteristics.
    c. Experiment with and modify processes for the development of new energy producing products using nano-size particles.

Post-Discussion Quiz – Nanoscience vs. nanotechnology

1. Nanotechnology is the manipulation of matter at the nanoscale for the purpose of
    a. Discovering new physical properties
    b. Analyzing how molecules react to each other
    c. Proving or disproving established theories
    d. Creating new products or applications
2. For each of the following, identify it as either nanoscience or nanotechnology
    a. The study of the rules that govern material properties at the nanoscale
        i. Nanoscience
        ii. Nanotechnology
    b. The development of liposome vesicles into drug delivery systems
        i. Nanoscience
        ii. Nanotechnology
    c. The exploitation of the properties of self-assembly
        i. Nanoscience
        ii. Nanotechnology
    d. The identification of the molecular design of hydrophobic materials
        i. Nanoscience
        ii. Nanotechnology
    e. The design of a process that yields hydrophobic films
        i. Nanoscience
        ii. Nanotechnology
3. Which of the following statements is TRUE?
    a. Nanotechnology enables the advancement of nanoscience.
    b. Nanoscience enables the advancement of nanotechnology.
    c. Nanoscience exploits the properties of nanoparticles for human gain.
    d. Nanotechnology is the study and discovery of the properties of matter in the nanoscale.
4. Which of the following is a job requirement for a technologist working for a nanotechnology company?
    a. Operate commercial-scale production equipment to produce, test, or modify materials, devices for the purpose of understanding their chemical and physical properties.
    b. Research and manipulate structures at the atomic and subatomic level for the purpose of understanding their hydrophobic characteristics.
    c. Experiment with and modify processes for the development of new energy producing products using nano-size particles.
5. Which of the following questions would be answered by a technologist versus a scientist?
    a. What is needed to create a hydrophobic surface?
    b. How do our lungs extract oxygen from air?
    c. Why don't plants stay green year round?
    d. What is the melting temperature of nano-particles of gold?