
Nanotechnology: Applications and Uses

Unit: Emerging Technologies

Problem Area: NANO-Tech

Lesson: Nanotechnology: Applications and Uses

- **Student Learning Objective.** Instruction in this lesson should result in students achieving the following objective:

Describe applications and uses of nanotechnology.

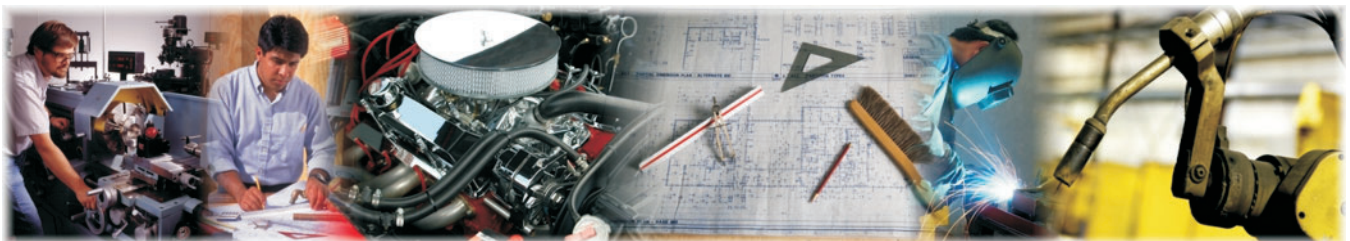
- **Resources.** The following resources may be useful in teaching this lesson:

“Applications of Nanotechnology,” *International Society for Complexity, Information, and Design*. Accessed Nov. 15, 2010. <http://www.iscid.org/encyclopedia/Applications_of_Nanotechnology>.

The Project on Emerging Nanotechnologies. Accessed Nov. 15, 2010. <<http://www.nanotechproject.org/publications/>>.

Ratner, Mark A., and Daniel Ratner. *Nanotechnology: A Gentle Introduction to the Next Big Idea*. Pearson, 2003.

Williams, Linda, and Wade Adams. *Nanotechnology Demystified*. Glencoe / McGraw-Hill, 2007.



■ **Equipment, Tools, Supplies, and Facilities**

- ✓ Overhead or PowerPoint projector
- ✓ Visuals from accompanying masters
- ✓ Copies of sample test, lab sheet, and/or other items designed for duplication
- ✓ Materials listed on duplicated items
- ✓ Computers with printers and Internet access
- ✓ Classroom resource and reference materials

■ **Key Terms.** The following terms are presented in this lesson (shown in bold italics):

- ▶ bioprocess
- ▶ catalysts
- ▶ magnetoresistance
- ▶ nanomedicine
- ▶ nanoparticles
- ▶ nanotubes
- ▶ tissue engineering

■ **Interest Approach.** Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations.

Ask the students to define nanotechnology in their own words. (Nanotechnology allows us to organize particles on a molecular level, meaning we can change the properties of materials.) Discuss how nanotechnology can be an advantage and what properties of objects would make them work better.

CONTENT SUMMARY AND TEACHING STRATEGIES

Objective 1: Describe applications and uses of nanotechnology.

Anticipated Problem: What are applications and uses of nanotechnology?

I. Nanotechnology applications

A. Medicine

1. **Nanomedicine** is the hybrid field of medicine and nanotechnology.
Nanoparticles are customized particles created on the molecular level. They can be designed to directly deliver drugs to specific diseased cells. This can be particularly helpful for cancer patients.

2. Drug delivery systems of nanotechnology can improve the pharmacological and therapeutic properties of the individual drug. Nanoparticles can be developed to penetrate through cell membranes to more efficiently deliver medication or therapy.
 3. Nanoparticles can be used as contrasting agents to improve MRI and ultrasound. They can be designed to attach themselves to infected cells and to deliver a higher intensity when scanned with the device.
 4. Through the same processes as contrasting agents, they can be developed to alter their appearance when in contact with different agents in the body, resulting in improved diagnostics.
 5. Another medical application is in **tissue engineering**, which is the process of growing cells artificially. Nanotechnology has the ability to repair or replace damaged tissue.
- B. Chemical sensors
1. Nanotechnology is able to create chemical sensors that can detect minute amounts of chemicals, even in vapors.
 2. This technology uses nanotubes, nanowires, and nanoparticles that have been developed to change their properties in the presence of specified chemicals. **Nanotubes** are customized particles created on the molecular level in the form of tubes.
 3. The application of chemical sensors can have a broad range of usefulness from searching and warning of dangerous chemicals to adjusting chemical mixtures and processing.
- C. Food
1. Nanotechnology can have an impact on how people eat and how food is grown. This includes smart packaging. Nanomaterials and composites can act as biosensors, monitoring the bacteria content in food.
 2. These technologies will make a difference in food safety and its taste and health benefits.
 3. The efficient manufacturing of high-quality food through sustainable means can be enhanced in the bioprocessing industry with nanotechnology. **Bioprocess** is a technique that produces genetically engineered biological materials or matter. This can include the process of manufacturing items such as food, fuel, feed, and pharmaceuticals.
- D. Cleaner water—Nanotechnology is currently being used and studied in several ways to improve water quality.
1. Nanotechnology is now used in the removal of waste contaminants in ground water through a chemical reaction. In this case, chemicals (e.g., those from cleaning solvents) can be rendered harmless as they react with nanoparticles. This can also be done at the underground source, thereby saving time and money by not having to pump out the water.

2. Another process for cleaning water is with membranes created with nanotubes. These nanoporous membranes can be created with very specific hole sizes, allowing only H₂O (water) to pass through.
 3. Nanoparticles can also be magnetized, which allows them to attach to heavy metals in water and increases their ability to be absorbed. Magnetic separation processes can be used to remove the particles.
- E. Better air quality
1. Nanoparticles are being developed in such a way that they have very high surface-to-area ratios. This can be useful in increasing the effectiveness of catalysts. **Catalysts** are processes that use chemical substances to increase or decrease changes in chemical reactions. The larger surface area from the nanoparticles increases the reaction amount and time.
 2. They can be used to transform harmful exhaust from automobiles and industrial plants.
- F. Electronics
1. Our ability to create smaller and more efficient devices has improved all elements of electronics. Nanotechnology is increasing this ability.
 2. Electronics rely on resistors and transistors. The ability to work at a nanoscale in their creation allows for more information and control on a smaller scale.
 3. One field is in ultra high-density memory. A carbon nanotube can be used as a switch to reconfigure connections in storing electrons. This can replace how transistors were previously used.
 4. By controlling the magnetoresistance of a material, there can be a strong increase in the density of data storage on hard disks. **Magnetoresistance** is the ability of a material to change its electrical resistance when an external magnetic field is applied.
 5. Electrically conductive carbon nanotubes can be used to emit fields of light. Their nano size makes them efficient for displays.
- G. Solar cells
1. Some companies have manufactured nanotech solar cells that cost much less than those currently on the market. The solar cells on the market use layers of semiconductors that roughly gather about 40 percent of the sun's energy. Nanotechnology can develop catalysts that utilize a maximum surface-to-area ratio. This greatly improves the efficiency of the cells.
 2. Scientists have developed a spray-on substance that uses nanoparticles to instantly transform a surface into a solar collector.
- H. Batteries
1. Current market batteries require frequent replacement or recharging. Nanomaterials are being developed that increase their storage capacity.
 2. These batteries have much longer shelf lives and can be recharged quicker and over a longer period of time.

3. They will become super capacitors, with a much higher energy content and a longer operating time. This technology creates batteries that are more recyclable and are safer for the environment, addressing current disposal problems.

I. Fuel cells

1. Catalysts are used in fuel cells to produce ions from methanol and other fuels.
2. The more efficient catalysts developed from nanotechnology enhance the membranes used to separate hydrogen ions from oxygen. Hydrogen fuel cells are environmentally friendly and renewable.
3. Nano-structured materials (e.g., carbon metal particles) can store large amounts of hydrogen, which can reduce the use of combustion engines.
4. The very porous nanomaterial can be used as a filter, cleaning the exhaust from engines as catalytic converters or can be used in the fuel as a catalytic mixture.

J. Fuels

1. With a finite supply of fossil fuels, the need to find new energy sources and more efficient means of using current fuels is increasingly important. Nanotechnology can address these issues (e.g., solar and fuels cells) and aid in designing processes that are much more efficient in their use and production of raw materials.
2. Lower grade materials can be converted into fuel at a cheaper cost with higher yields.
3. Fuel consumption by engines will decrease as new nanomaterials are developed that specifically utilize their molecular structure in converting fuel into energy. These materials can be used in engine production as well as in the car's frame, creating stronger and lighter structures that lower consumption.

- K. Space—Materials, as noted above, that are stronger and lighter will reduce the amount of rocket fuel necessary to reach orbit. They can be used in the production of alternate ways to produce energy in space (e.g., solar sails). This technology will provide aircraft with better designed navigation systems that will increase performance.

L. Sporting goods

1. Nanotechnology is already being commercially used in sporting goods. This includes harder and lighter metal alloys used in golf clubs and nanomaterial used in the production of golf balls.
2. Tennis racquets have increased strength. New materials are used to make the shaft more rigid, and nanotechnology has increased the retention of air in tennis balls.

M. Fabric

1. Nanotechnology has been responsible for a range of composite fabrics and fibers. They have improved durability and function through designed properties, such as wrinkle-resistant and stain-repellent clothes.

2. Nanothreads can be programmed into “smart” clothing. These clothes can have woven in electronics and communicate whether the clothes require cleaning.

Teaching Strategy: *Bring samples of nanoparticle products to class for the students to see. Have the students do individual reports on a product or material of interest, and have them explain how nanotechnology could improve its function and use. Require the students to give an oral presentation on their findings. Use VM–A through VM–D, and assign LS–A.*

- **Review/Summary.** Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the textbook may also be used.
- **Application.** Use the included visual masters and lab sheet to apply the information presented in the lesson.
- **Evaluation.** Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.

■ **Answers to Sample Test:**

Part One: Matching

1. c
2. a
3. d
4. e
5. f
6. b

Part Two: True/False

1. T
2. T
3. F
4. F
5. T
6. F

Part Three: Short Answer

1. Answers will vary. See “Content Summary”: I.D.3–4.
2. Answers will vary. See “Content Summary”: I.E.1.2.
3. Answers will vary. See “Content Summary”: I.J.1.2.3.

Nanotechnology: Applications and Uses

► Part One: Matching

Instructions: Match the term with the correct definition.

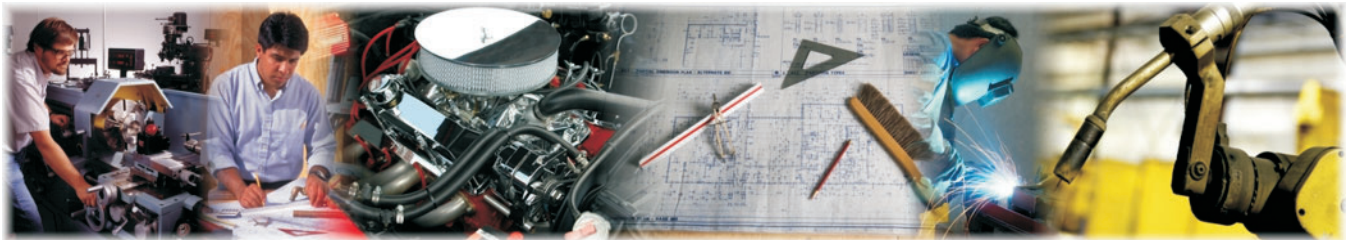
- | | |
|-----------------------|----------------------|
| a. tissue engineering | d. bioprocess |
| b. nanoparticles | e. catalysts |
| c. nanomedicine | f. magnetoresistance |

- ____ 1. The hybrid field of medicine and nanotechnology
- ____ 2. The process of growing cells artificially
- ____ 3. A technique that produces genetically engineered biological materials or matter
- ____ 4. Processes that use chemical substances to increase or decrease changes in chemical reactions
- ____ 5. The ability of a material to change its electrical resistance when an external magnetic field is applied
- ____ 6. Customized particles created on the molecular level

► Part Two: True/False

Instructions: Write T for true or F for false.

- ____ 1. Lower grade materials can be converted into fuel at a cheaper cost and higher yields with the aid of nanotechnology.
- ____ 2. Some golf clubs are using harder and lighter metal alloys from nanomaterials.



- ____ 3. Nano structured materials (e.g., carbon metal particles) are not able to store large amounts of hydrogen.
- ____ 4. Some companies have manufactured nanotech solar cells. However, they cost much more than those currently on the market.
- ____ 5. Electrically conductive carbon nanotubes can be used to emit fields of light.
- ____ 6. Nanoparticles cannot be developed that have very high surface-to-area ratios.

▶ **Part Three: Short Answer**

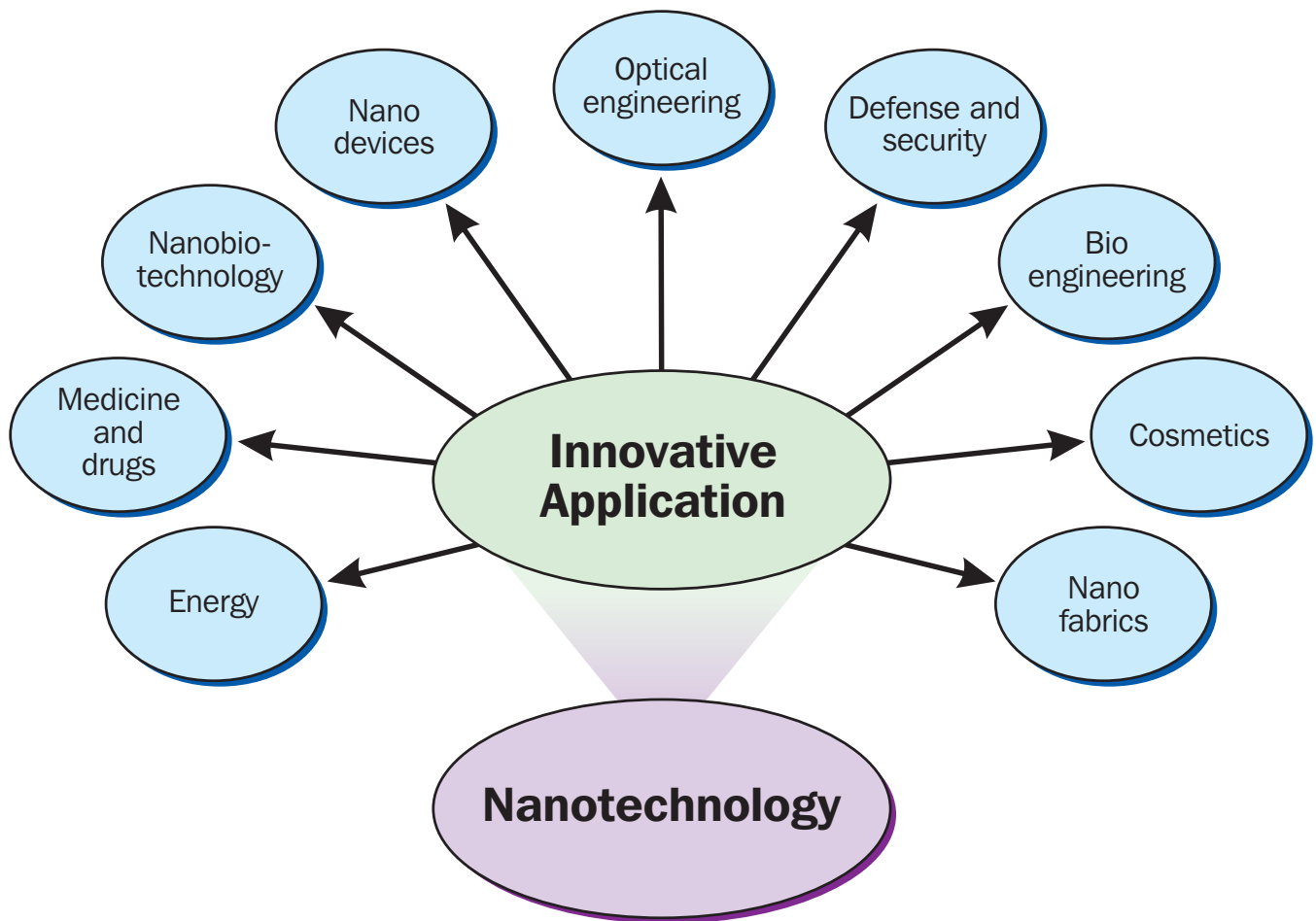
Instructions: Answer the following.

- 1. List two ways in which nanotechnology is being used to clean water?

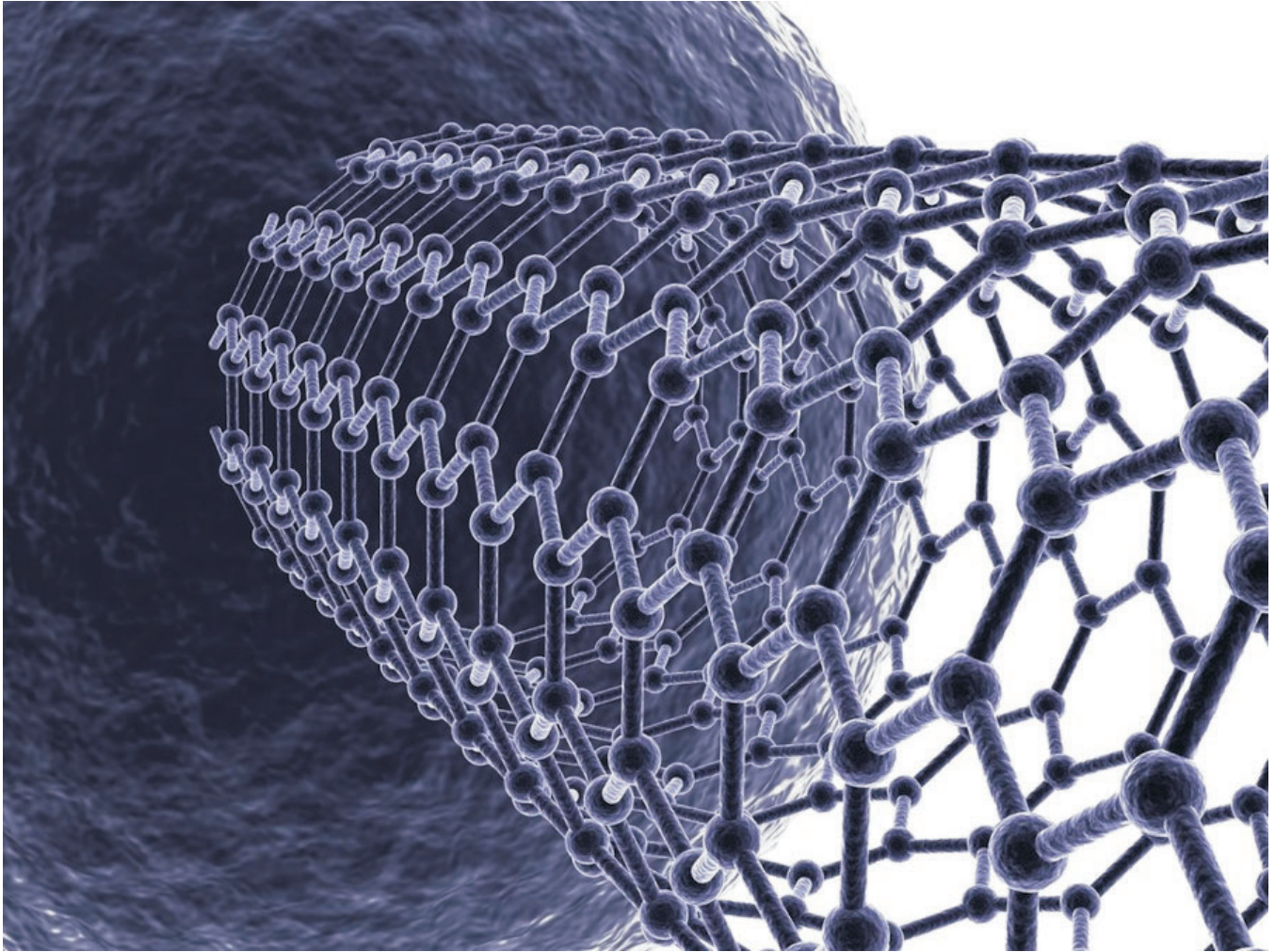
- 2. In what ways can nanotechnology be used to create better air quality?

- 3. How is nanotechnology used to improve fuels?

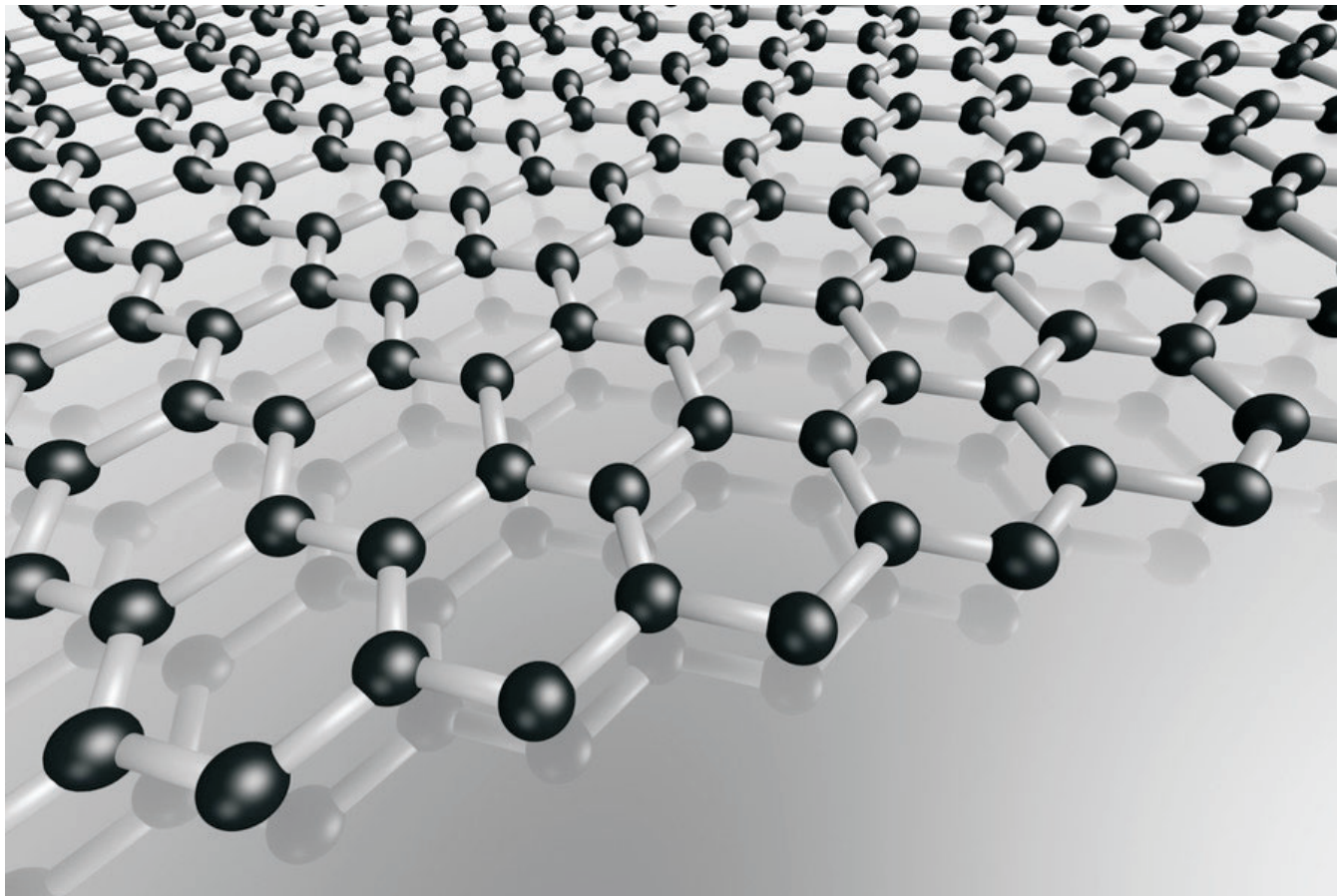
DIAGRAM OF APPLICATIONS FOR NANOTECHNOLOGY



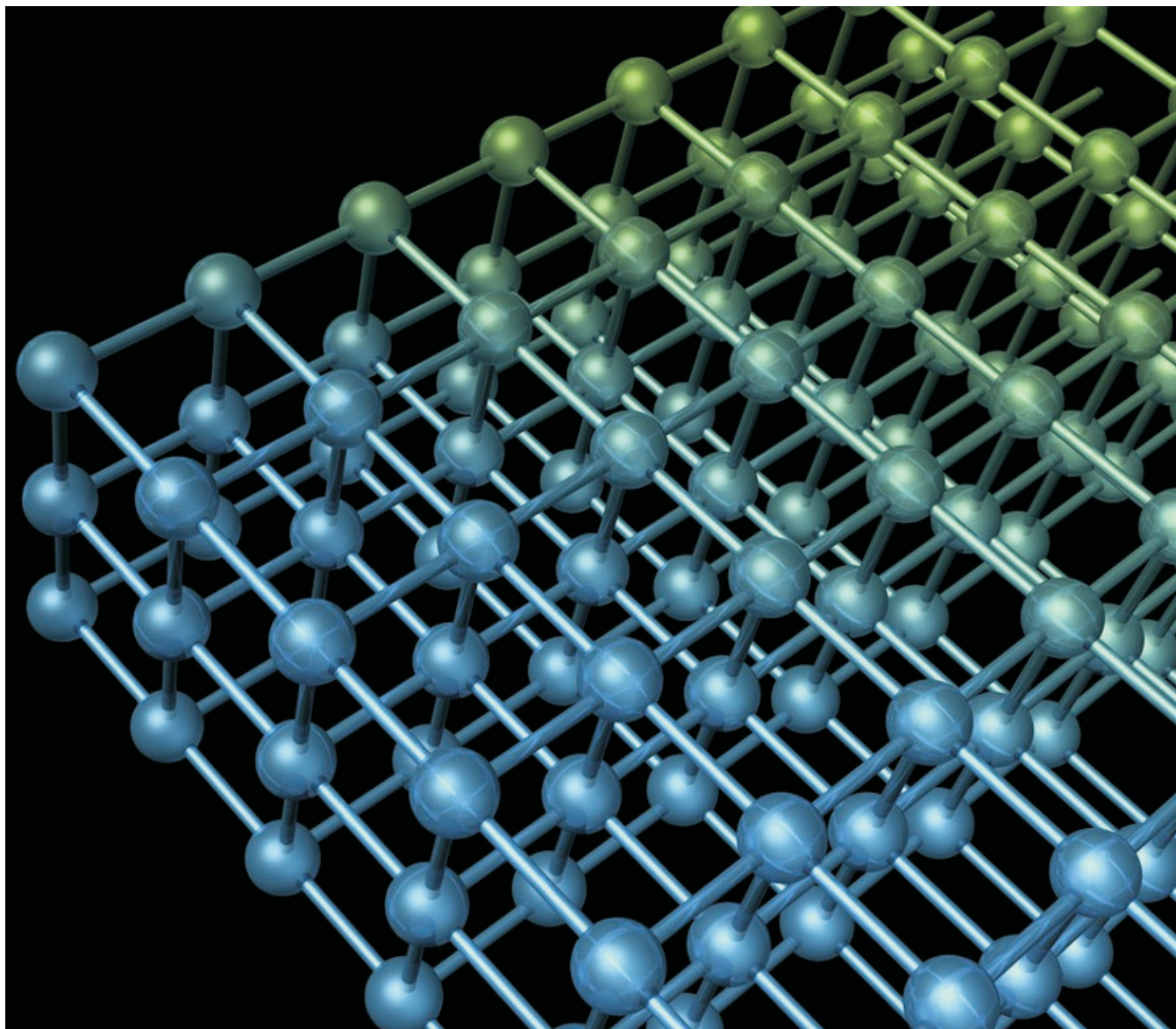
NANOTUBE OF CARBON



GRAPENE NANO CARBON MONOLAYER



NANOPARTICLES



Nanotechnology

Purpose

The purpose of this activity is to develop understanding and knowledge of how nanotechnology can be used to improve materials and products.

Objectives

1. Describe useful applications of nanotechnology.
2. Explain how nanotechnology can be used to improve material performance.

Materials

- ◆ lab sheet
- ◆ writing utensil
- ◆ paper

Procedure

1. Work alone or in a small group. Choose a product that you commonly use, and list all the materials that go into manufacturing the product.
2. Research on the Internet how nanotechnology can be used to improve those materials. These improvements should be relative to how your product uses the materials.
3. Then create a list or diagram of your findings. On the top of the page, name the product and the material. Then list how the material can be altered and improved from nanotechnology.
4. Finally, list how these material improvements can specifically better the product you have chosen.

