It's a Small World After All

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Overview:

This unit is entitled, "It's A Small World After All." There is a whole world of microorganisms that we can't see. Physical and chemical changes are taking place all around us. Nanotechnology is the study of materials at atomic or molecular scale. This technology is concerned with dimensions of less than 100 nanometers. Atoms are said to be less than one nanometer. This unit will look at the science we can't see and the products that have been developed using nanoscale technology. The properties of atoms, molecules and matter are all a part of the 11th grade Core Curriculum of the School District of Philadelphia. This unit will help students understand the manipulation of matter at the atomic level. This unit will last for 2 weeks. Each class session will be 47 minutes in length. Activities will be conducted in the classroom, science lab, computer lab and library.

Rationale

In science we learn about the changes that take place all around us. Changes we can see and changes we can't see. Some changes are physical and some are chemical. In chemistry, students learn about atoms, molecules and matter. The various arrangements of atoms determine different outcomes. Carbon atoms arranged one way could result in a diamond. Carbon atoms arranged another way, could produce graphite for a pencil. Manufactured products are made from atoms. Some of our consumer products are produced by nanotechnology. Everyday items such as sunscreen, fabrics, cleaning products and sports equipment are just a few of the items produced by nanotechnology. The science of small things is happening all around us. This concept is bigger than we can imagine. It is slowly becoming the science of the future.

Complex chemical reactions involving carbon based molecules take place constantly in every cell of our bodies. Chemical reactions may release or consume energy. Light can initiate many chemical reactions such as photosynthesis. A large number of important

reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions and molecules or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds.

For those who are not familiar with nanoscale, it is about as small as you can get. When it gets down to molecular or atomic level it has been found that properties of things can change.[1] (Smith, Alan p.10) To help understand how small the nanoscale is, it would take 80,000 nanoparticles in a row to be just the diameter of a human hair. Scientists are developing exciting new products that make use of the new properties offered by nanotechnology. Nature has been the leader in this science.

There is a beetle that lives in the scorching heat of the Namibian Desert that gets water through nanotechnology. It's back has a surface which repels water, but some bumps on its shell do not have this special surface. In the early mornings the water in the atmosphere condenses on those bumps and when the drop gets large enough it runs down the water repellent surface straight into into the beetle's mouth. Such hydrophobic surfaces are now being used in textile applications; Hugo Boss sells suits that have self clean surfaces based on nanotechnology coatings.[2] (Smith, Alan p.10) Similar effects are being used by other companies for wind and water proofing. It is known as the lotus effect since water just runs off lotus leaves.

Many sunscreen products use nanoparticles to bounce off the bad ultraviolet light and let through the good tanning UV light. It is estimated that there are already 700 "nano" based products on the market. Governments worldwide are investing heavily in this technology. Nanotechnology is multidisciplinary and the speed at which products are being introduced exceeds most previous developments. Nanotechnology promises to surpass the current age of information technology and is as fundamental as civilization's shift from farming to the agricultural age.[3] (Hodge, Bowman & Binks p.1) The term nanotechnology has evolved over the years to mean anything smaller than microtechnology.[4] (Nanotech-now.com)

Students will be able to study how manufactured products are made from atoms. The properties of those products depend on how those atoms are arranged, for example, if we rearrange the atoms in sand we get computer chips. Nanotechnology will allow scientists to make most products lighter, stronger, smarter, cheaper, cleaner and more precise. Nanotechnology is about is about rearranging atoms and building products in the right place. Nanotechnology refers to the ability to control the composition of molecules and atoms within the range of 100 nanometers (nm) down to $1.0nm^3$. This enables scientists to create specific molecular structures and devices. These concepts are a part of the National Science Education Standards in chemistry.

Our society is becoming highly technological. Nanotechnology is becoming a more important science in the world. Since 2002, Taiwan has conducted a nanotechnology national project. It's no secret that Americans have been trying to keep up with the technological advances of other countries for years. The focus of the nanotechnology

project was to provide teachers with information about nanotechnology and to develop material to inspire students to learn about advanced technology.[5] (nano.edu) President Obama has laid a vision for the nation to lead the world in science and technology, not follow it. In his plan, he makes the following proposals:

- Devote 3% of the U.S. Gross Domestic Product to science research
- New initiatives to ensure better science technology and math education
- Give opportunities to translate basic research into relevant innovation
- Engage and inspire the next generation of scientists, technologists and engineers
- Translate new knowledge into innovative solutions

There are an estimated 1200+ companies around the world operating in the nanotechnology industry.[6] (Monash Business Review) Some researchers believe nanotechnology can be used to significantly extend the human lifespan or produce replicator-like devices that can create almost anything from simple raw materials.[7] (UnderstandingNano.com) Others see nanotechnology as a tool to help us do what we do now faster or better.

One of the basic principles of nanotechnology is positional control.[8] (Merkle, Ralph) At the macroscopic level, scientists can manipulate parts in their hands and position them with respect to each other. Most humans pride themselves on using tools. Nanotechnology or molecular nanotechnology as it is sometimes called, allows scientists to manipulate at the microscopic level. Scientists can now arrange atoms and molecules exactly as they want. As educators, it is our job to develop skills and inspire ideas. One of the goals of the National Nanotechnology Institute (NNI) is to sustain educational programs and resources required to produce the next generation of nanotechnologists, inventors, researchers and engineers. This information helps guide topics used to supplement the curriculum. Nanotechnology is an important topic for the present and the future.

Objectives

This curriculum unit is for students in 11th grade chemistry. Students will learn key terms and vocabulary pertaining to measurement, atoms, molecules and matter. Students will develop reading and writing skills through the use of current news articles and journal writing. Students will have the opportunity to research ideas and identify nanotech products. Students will have the opportunity to use technology in the computer lab. Students will identify the difference between physical and chemical changes. Students will be able to recognize the parts of an atom. Students will identify the properties of matter. Students will have the opportunity to travel to the library once a week and use the classroom for the future (CFF) laptops for further study and research.

Strategies

The Core Curriculum for the School District of Philadelphia provides opportunities for cooperative learning activities, oral presentations, group discussions, journal writing, illustrations, demonstrations, formulas and mathematical equations. There will also be opportunities for science lab as well as computer lab so that students can access websites that are current to what they are studying in class. This is the time that is used to relate science concepts to real life activities. A variety of teaching strategies allow all students to be included in the learning process. Teaching strategies should cover the multiple intelligences of the students.

We want students to be able to:

1. Apply scale as a way of relating concepts and ideas to one another by some measure.
2. Describe patterns in nature, physical and manmade.
3. Use scientific inquiry to solve problems.
4. Apply concepts about the structure and properties of matter.
5. Explain how the forces that bind solids, liquids and gases affect their properties.

Classroom Activities

The first two days should be spent introducing vocabulary that will be used throughout the unit.
Lessons 1 and 2

Objective: To identify the words and their meanings

Procedure:
The teacher will introduce vocabulary to the students. They will begin to develop a glossary of terms that they will keep in their notebook.

Key Terms: atom, molecule, matter, physical change, chemical change, nanometer, nanotechnology, nanoscale, microscopic, atomic force microscope (AFM)

- Students will write definitions in their notebook.

- Students will make study cards using 3x5 cards
- Students will write the vocabulary word on one side of the card and the definition on the other side of the card.
- Students can work in pairs to quiz each other on the word and its meaning.
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Teacher reviews the words with the students and then give an assessment.

Teacher may use matching key terms with meaning or reading the definition aloud and have students write the correct vocabulary word.
Students should return to vocabulary words and be able to "show what they know."

This is a word or illustration used as an example for each word.

Vocabulary words should be posted around the room or listed on a word wall for students to refer to during this unit.

Lesson 3

Objective: Students will identify nanoscale dimensions.

Procedure:

Teacher explains that nanotechnology is the manipulation of matter at a scale of 1-100 nanometers. Using nanotechnology, we can control molecules at an atomic level and create materials with unique properties.

- "Nano" is Greek for dwarf.

- Ask, "How big is a nanometer? Wait for responses. Explain that a nanometer is 10^{-9} (a billionth) of a meter. A strand of hair is approximately 100,000nm and a blood cell is 10,000nm.
- Have students look at a strand of hair with the unaided eye and under a microscope. You may want students to draw what they see.

- Have students play "How Small Am I."
    1. Each group of 3-4 students should have a pack of cards. The cards should have words and pictures of the following: a wavelength, a dust particle, bacterium, a red blood cell, and hair.
    2. You may have students copy pictures from textbooks or download pictures from the internet.
    3. Have each group of students arrange the cards from biggest to smallest.

Check each group for accuracy.

Review and discuss the actual size of each picture and its relationship to nanoscale.

Lesson 4

Objective: Students will construct a nanometer to scale.

Procedure:

- Students will cut a piece of paper in the length of one meter.
- Students will further cut the paper into one tenth and again and again.
- Students will compare the different lengths of paper to learn the concept of scales.

Lesson 5

Objective: Students will research current applications using nanotechnology in various fields.

What specific nanoscale products are under development and how would we benefit most from this technology?

Procedure;

1. Students will use journal entries or notebooks to record their research and answers to the questions.
2. Students will use the computer lab or the laptop cart to research topics on the internet.
3. Students will report their findings to the class using power point presentations or posters.

Lesson 6

Objective: Students will identify the properties matter.

Procedure:
Matter has mass and takes up space.
Matter can be in the form of solid, liquid, gas and plasma.

1. Have students identify items for each category.
2. Discuss the movement of particles for each form of matter

Use Holt Chemistry textbook

Lesson 7

Objective: Students will identify the parts of an atom (atomic structure)

Procedure:

1. Discuss the parts of an atom: proton +, electron -, neutron 0 and nucleus.
2. Have students make atomic models of the elements using clay or construction paper

Use Holt Chemistry textbook

Lesson 8

Objective: Students will identify the difference between physical and chemical changes

Procedure:

Teacher demonstrates how copper sulfate ($CuSO_4$) changes color and solubility when the size of the particles change.

Assign each group of students a list of various actions (for example, burning wood, chopping wood, bleaching clothes, chewing gum, etc.)
Have students classify the actions and explain the reason for the classification of each action as physical or chemical. A reporter will report out for each group.

Homework: Keep a log identifying physical and chemical changes they notice in their everyday life for a period of time (perhaps 1 or 2 days).

Use Holt Chemistry textbook

Lesson 9

Objective: Students will identify career opportunities in the field of nanotechnology.

Procedure:

Students will use various websites to locate career information.

(http://www.foresight.org/NewsJobsInNanotech.html)

(http://www.zyvek.com/AboutUs/Jobs/home.html)

"Choose a job/career that comes closet to interesting you and write a career plan describing what would be required to become a successful applicant for this position." (Length: up to 2 pages)

Some students may volunteer to read/share with class. Classroom discussion may follow.

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Appendix 1: Figure 1

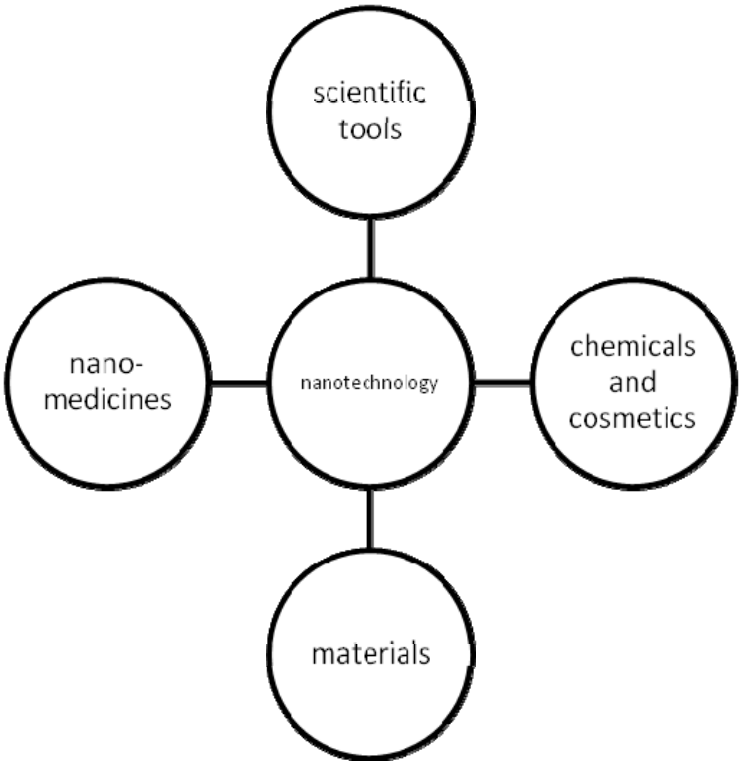

Figure 1: Partial Illustration of Nanotechnology applications. These applications and others can be developed into the core curriculum and meet the goals of the National Science Standards.

Appendix 2: Standards

This unit may be used to address the academic content standards listed. These standards are drawn from *Standards and Benchmarks for K-12 Education*.

- Technology Standard 3: understands the relationships among science, technology, society, and the individual.

- Language Arts Standard 1: demonstrates competence in the general skills and strategies of the writing process.

- Language Arts Standard 8: demonstrates competence in speaking and listening as tools for learning.

- Science Standard 3: Apply concepts of systems, subsystems, feedback and control to solve complex technological problems.