STARS

# STARS Mentor Teacher Workshop-IV
# 2007-2008
# Nanotechnology & Nature of Matter


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April 19th, 2008


UNIVERSITY OF SOUTH FLORIDA COLLEGE OF ENGINEERING

National Science Foundation WHERE DISCOVERIES BEGIN

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# *The Nature of Matter*

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**Fall 2007**
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**The University of South Florida**

**STARS – Science, Teachers, And Resources in the Sciences**
**NSF GK-12 Program**

## Outline:

- An Introduction to Matter:
  - What Is Matter Made Of
    - Atom
    - Molecule
    - Element
    - Activity 1 - Show Me A Million!
  - Physical Changes in Matter:
    - Change of State
    - Physical Change
    - Activity 2 & 3 - Pressure Effects on States of Matter
    - Activity 4 - Slime
  - How Does Matter React Chemically:
    - Physical Properties
    - Chemical Properties
    - Chemical Reactions
    - Activity 5 - Combustion Reaction Demonstration

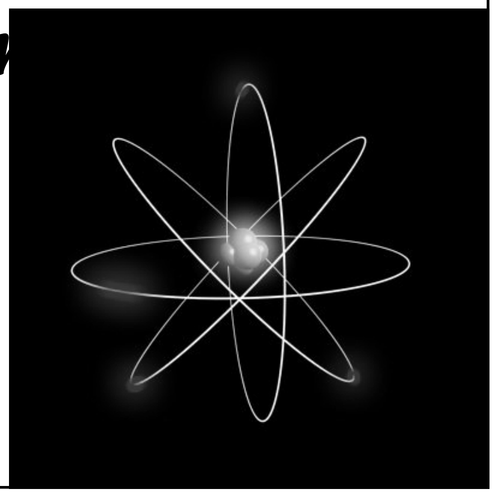
# Sunshine State Standards

- The Nature of matter:
  - Standard 1: The student understands that all matter has observable, measurable properties (SC.A.1.2).
    - Determines that the properties of materials can be compared and measured (SC.A.1.2.1) (See Extra Content)
    - Knows that common materials can be changed from one state to another by heating and cooling (SC.A.1.2.2).
    - Knows that the weight of an object always equals the sum of its parts (SC.A.1.2.3).
    - Knows that different materials are made by physically combining substances and that different objects can be made by combining different materials (SC.A.1.2.4).
    - Knows that materials made by chemically combining two or more substances may have different properties (SC.A.1.2.5).
  - Standard 2: The student understands the basic principles of atomic theory (SC.A.2.2).
    - Knows that materials may be made of parts too small to be seen without magnification (SC.A.2.2.1).

# Grade Level Expectations

- Knows that matter is conserved during heating and cooling.
- Knows that different materials can be physically combined to produce different substances.
- Knows that materials made by chemically combining two or more substances have properties that differ from the original materials.
- Knows the difference between physical and chemical changes.
- Knows that materials may be made of parts too small to be seen without magnification.
- Uses metric tools to determine the density and volume of materials.
- Knows the differences and similarities between mixtures and solutions.

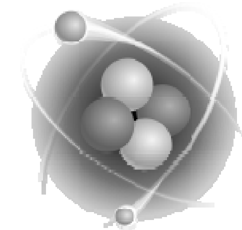
# Changes In Matter



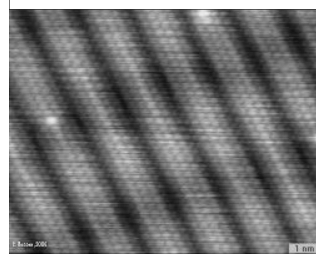
## Section 1:
## *What is Matter Made Of?*

# *What is Matter Made Of?*

- In general, matter is what 'stuff' is made up of. Everything you see (and can't see) around you is made up of matter: your book, the desk, and even the **air**.
- All matter has volume, but not all volume has matter. Think of a vacuum! We can measure a volume of space for instance, but it might not contain any matter at all!
- Matter is made up of small particles that are called **atoms**.

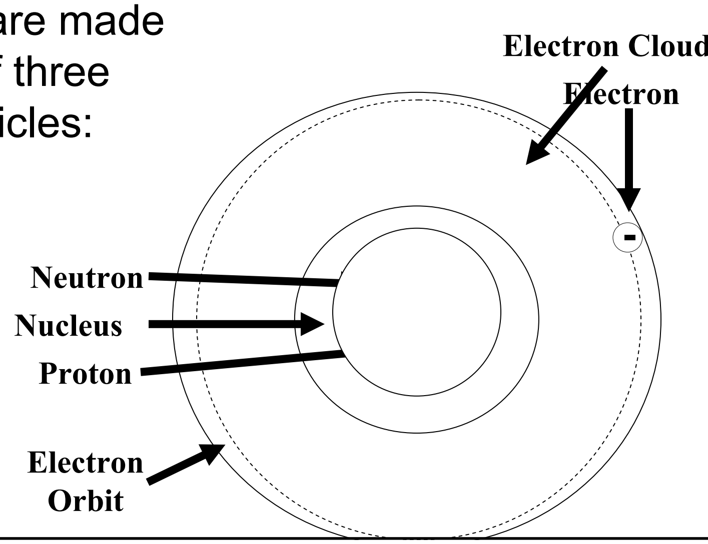


Electron Microscope Image of Individual Gold Atoms



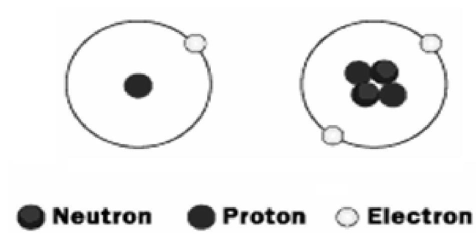
# *So Then What Is An Atom?*

Atoms are made up of three particles:



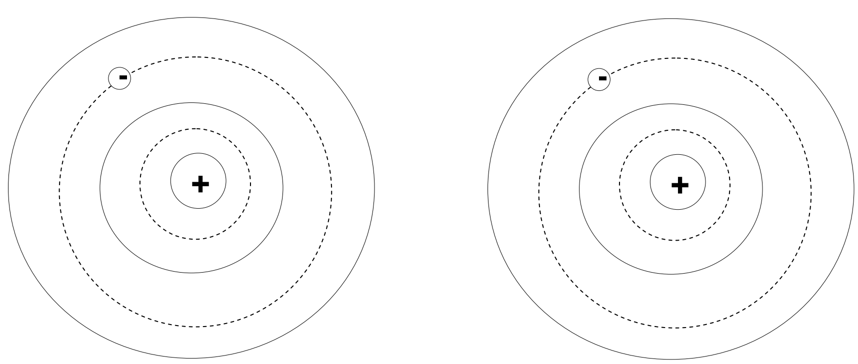
# The Electron Orbital

- Electrons move around the nucleus in an **orbital**, like the planets move around the sun!
- Atoms like for their orbitals to be full.
- Atoms often share electrons so that all of the atoms can have full orbitals!



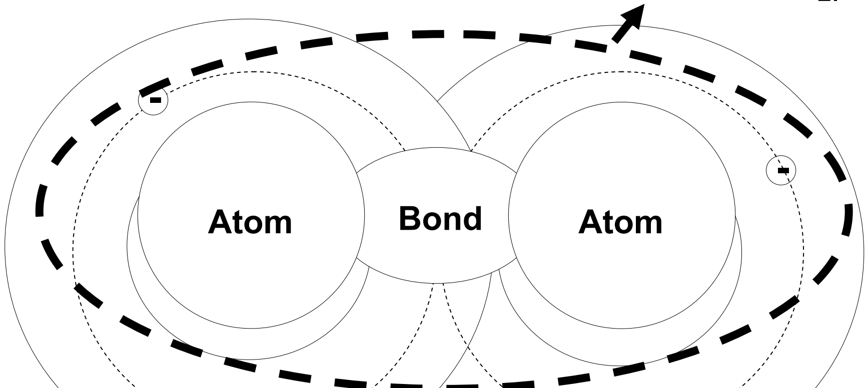

# Chemical Bonds

Here we have two hydrogen atoms. Each atom has 1 proton and 1 electron. To be stable, each orbital needs 2 electrons.



# Chemical Bonds

To two hydrogen atoms share their electrons to form a chemical bond and form the molecule $H_2$.

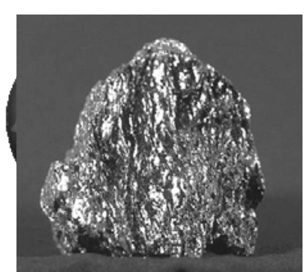



A **molecule** is a particle that contains two or more atoms linked by chemical **bonds**.

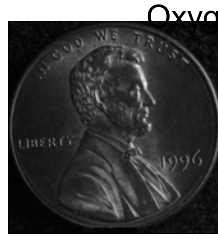
# Elements

- There are many different atoms, each with a different number of protons and different properties. Each type of atom is called an element.

Hydrogen (H)
Helium (He)
Oxygen (O)



Iron (Fe)



Copper (Cu)

Chlorine (Cl)

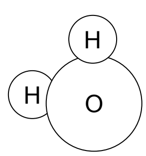
# *Common Elements:*

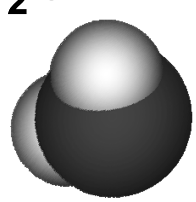
| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H | | | | | | | | | | | | | | | | | 2 He |
| 3 Li | 4 Be | | | | | | | | | | | 5 B | 6 C | 7 N | 8 O | 9 F | 10 Ne |
| 11 Na | 12 Mg | | | | | | | | | | | 13 Al | 14 Si | 15 P | 16 S | 17 Cl | 18 Ar |
| 19 K | 20 Ca | 21 Sc | 22 Ti | 23 V | 24 Cr | 25 Mn | 26 Fe | 27 Co | 28 Ni | 29 Cu | 30 Zn | 31 Ga | 32 Ge | 33 As | 34 Se | 35 Br | 36 Kr |
| 37 Rb | 38 Sr | 39 Y | 40 Zr | 41 Nb | 42 Mo | 43 Tc | 44 Ru | 45 Rh | 46 Pd | 47 Ag | 48 Cd | 49 In | 50 Sn | 51 Sb | 52 Te | 53 I | 54 Xe |
| 55 Cs | 56 Ba | 57 *La | 72 Hf | 73 Ta | 74 W | 75 Re | 76 Os | 77 Ir | 78 Pt | 79 Au | 80 Hg | 81 Tl | 82 Pb | 83 Bi | 84 Po | 85 At | 86 Rn |
| 87 Fr | 88 Ra | 89 +Ac | 104 Rf | 105 Ha | 106 Sg | 107 Ns | 108 Hs | 109 Mt | 110 110 | 111 111 | 112 112 | 113 113 | | | | | |
| | | 58 Ce | 59 Pr | 60 Nd | 61 Pm | 62 Sm | 63 Eu | 64 Gd | 65 Tb | 66 Dy | 67 Ho | 68 Er | 69 Tm | 70 Yb | 71 Lu | | |
| | | 90 Th | 91 Pa | 92 U | 93 Np | 94 Pu | 95 Am | 96 Cm | 97 Bk | 98 Cf | 99 Es | 100 Fm | 101 Md | 102 No | 103 Lr | | |

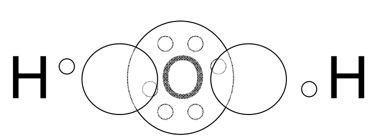
# *Let's Make Some Molecules*

What is Water?

**$H_2O$**






$H_2$=2 Hydrogen Atoms

O=1 Oxygen Atom

Hydrogen Wants 2 Electrons!

Oxygen Wants 8 Electrons!

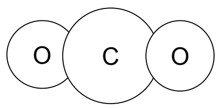
# *Let's Make Some Molecules*

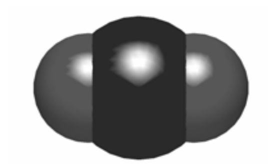
What is Carbon Dioxide?

C=1 Carbon Atom

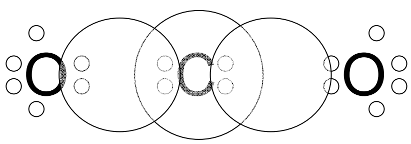
$O_2$=2 Oxygen Atoms

**$CO_2$**



Carbon and Oxygen Want 8 Electrons



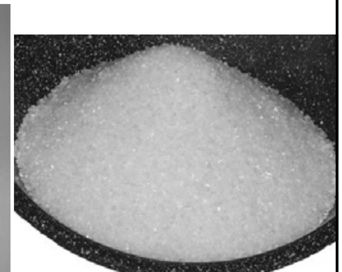

# *Let's Make Some Molecules*

What is Salt?

Na=1 Sodium Atom

Cl=1 Chlorine Atom

**NaCl**

# Activity 1 - Show Me A Million!

When students are talking about either very big or very small numbers it is hard for them to comprehend these orders of magnitude. In this activity the students are asked to calculate how much of a substance they would need to get one million pieces.

Materials Needed:

- Something to Count
  - M&Ms, Skittles, Cheerios, Bird Seed, Salt
- Cup
- Balance
- Calculator or Microsoft Excel

# Activity 1 - Show Me A Million!

Instructions:

- Students are split into groups of 3 to 5 students.
- Each group is given a different material to work with.
- Each student is asked to count out pieces of the material they are working with.
- The students then use a balance to determine the weight of a lot of pieces, and then calculate the weight of one piece. From the weight of one piece, the students can calculate the weight of one million pieces.
- Looking at the weight on the bag or box, students can determine how many containers of the substance they would need to have a million pieces.

Other Notes:

- This activity could be easily be adapted to find the density of the particles (using a measuring cup to measure volume).

*Our World on Different Orders of Magnitude:*
*http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/*

# Section 2:
# *Physical Changes In Matter*

## *Three States of Matter*

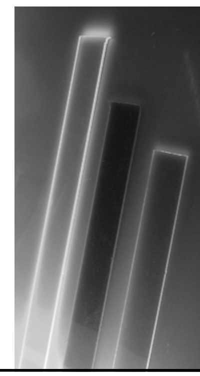
- There are three states of matter:
  - *Solid*
  - *Liquid*
  - *Gas*

Here, we can see the three states of water.



# *Solids*

- Solids keep their own shapes, and have closely packed molecules.
- Examples: Metals, Wood, Plastics

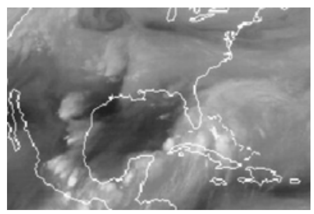


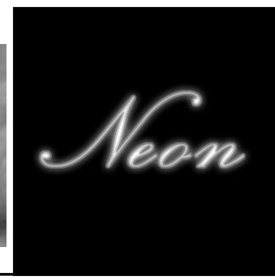
# *Liquids*

- Liquids take the shape of the container they are in and they can't escape from it. The molecules in a liquid are able to flow freely past each other.

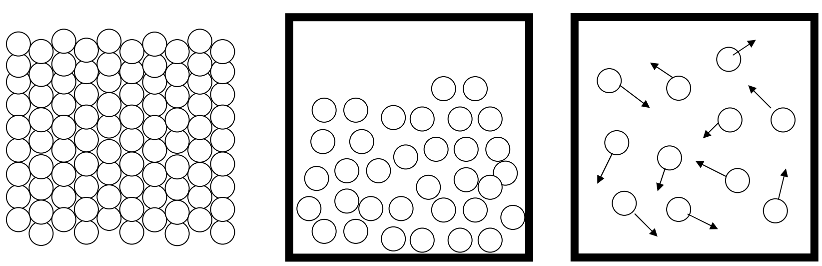

## *Gas*

- Gases take the form of the container they are in, but can escape if the container is not sealed. The molecules in gasses are constantly bouncing back and forth and move faster than water.






## *States of Matter: An Atomic Perspective*

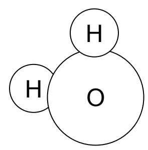


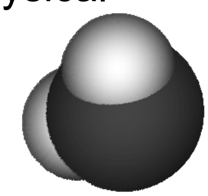
**Solid** **Liquid** **Gas**

*http://www.harcourtschool.com/activity/states_of_matter/*

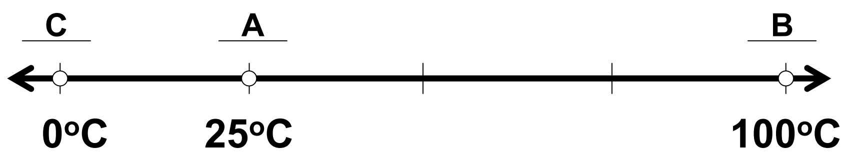
# *Physical Changes*

- A Physical Change is any change in a substance that does not change the chemical bonds of that substance.
- Water, $H_2O$, does not change it's structure when it goes from a solid to a liquid to a gas. Therefore, these are physical changes.



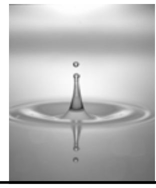



# *How Do We Change The State of Matter?*



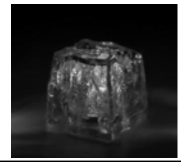

**Temperature Changes Cause Changes in States of Matter**

**A**

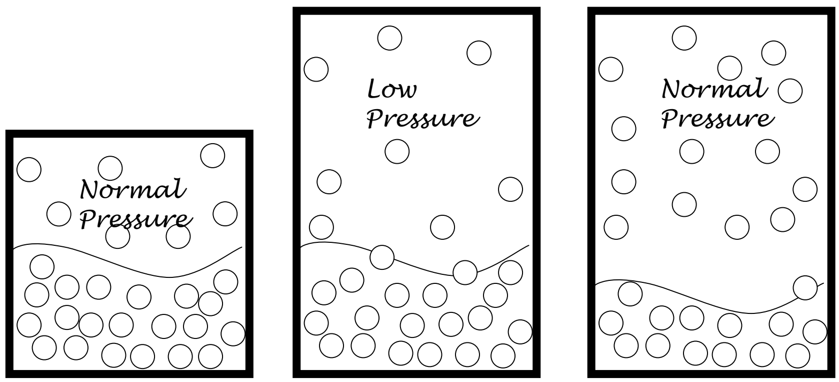


**B**

**C**



# How Do We Change The State of Matter?

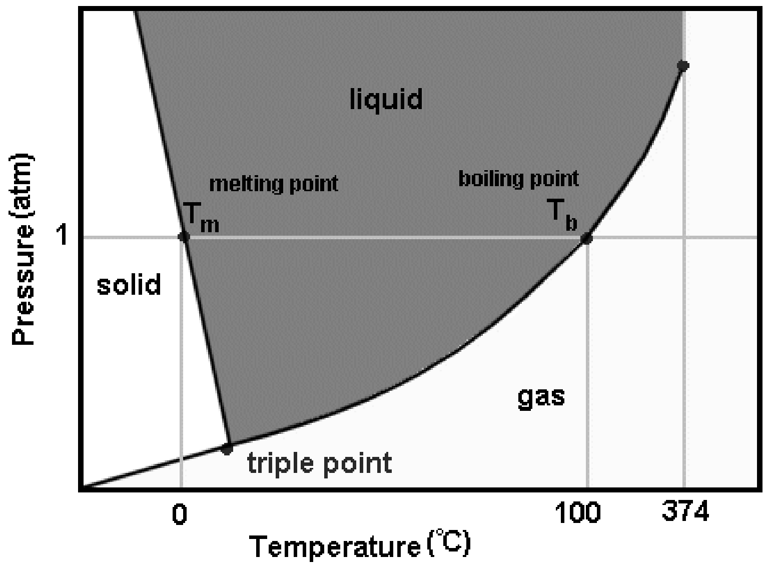



**Pressure Changes Cause Changes in States of Matter**

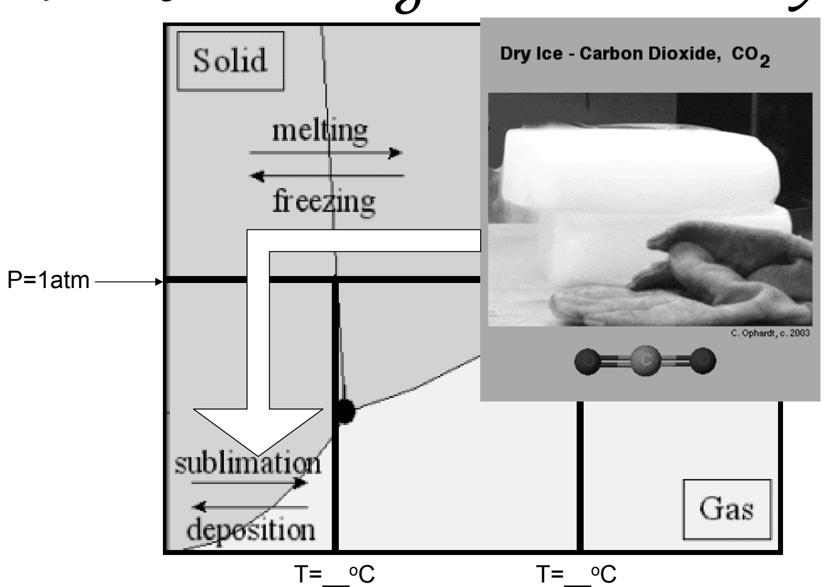
# Activity 2 – Pressure & States of Matter

- Let's look at how pressure changes effect water!
- First, use a 10ml syringe to pick up 1 ml of water. Make sure there is no air!!!.
- Cap the syringe with the caps provided.
- Turn the syringe so that the tip is facing upwards
- Pull down on the plunger quickly.

# Phase Diagrams

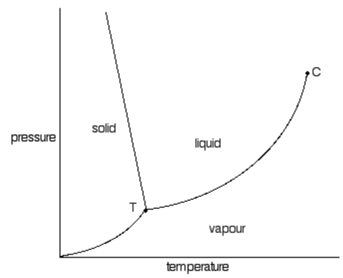



# Phase Change Vocabulary

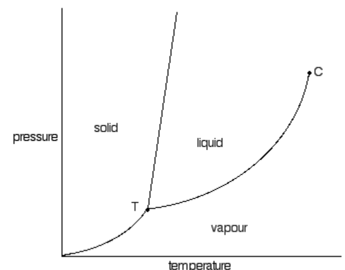


# Activity 3 – Pressure & States of Matter

- Mix 1 part corn starch to 1 part water in a cup.
- This mixture forms a 'Non-Newtonian' fluid. This means the viscosity (or how thick the fluid is) changes when pressure on the fluid changes. The fluid changes from a watery substance to a harder substance when pressure is applied.



*Water*



*Most Materials*

# PVA Slime Experiment

# Experiment Notes

Before The Experiment

- Prepare a 4% by weight Poly Vinyl Alcohol (PVA) solution. This can be done by dissolving 40 grams of PVA powder in one liter of hot water (not boiling). This is best done on a stove top in an OLD pot that can be disposed following this step or used for future PVA preparations. Powder PVA can be purchased online from class room chemical suppliers, such as www.thechemistrystore.com or www.postapplescientific.com . 4% PVA solutions can also be purchased online, but is far cheaper to prepare the solution your self.
- Prepare a 4% by weight borax solution by dissolving 40 grams of borax powder in one liter of warm water. This water will need to be warm to dissolve all the borax, but will not need stove top preparation. Borax powder can be purchased in most grocery stores on the laundry detergent isle.
- The experiment can be easily performed if an 'assembly line' is formed by the students. The PVA solution should be loaded into wash bottles (plastic squirt bottles) that allow the students to dispense and measure the PVA in graduated cylinders. After measuring the solution into graduated cylinders, the students should pore it into small disposable cups.
- The teacher should add 2 drops of food coloring to the solution. If more is used the dye will leak from the polymer gel and will stain anything it touches (hands, clothing, ect…). Students should use pop-sickle sticks to mix the solution.
- The teacher will have to add the borax SLOWLY until the proper consistency is achieved. This is done easily by dispensing the borax solution from a small wash bottle into the students cups while they are stirring. Approximately 1 to 2 ml of borax solution is required for every 10 ml of PVA solution. If there is too little borax, the slime will not set up, and if there is too much borax the slime will dissolve in the extra water.

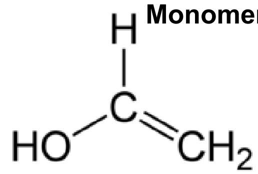
# Experiment Notes

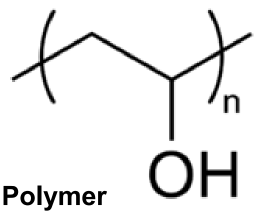
- Topics To Review Before The Experiment:
  - States of Matter
    - Solid, Liquid, Gas, Plasma
    - Amorphous Solids: Glass, Slime, Cotton Candy, Styrofoam
    - All this year we have discussed solid materials have a crystalline structure. Amorphous solids are solids that have no definite crystalline structure to support the solid.
  - Chemical and Physical Changes
  - Chemical and Physical Properties
  - Chemical and Physical Interactions
- Can you mix to liquids and make a solid?

# Poly-vinyl What?

- Polyvinyl Alcohol (PVA) is a polymer.
- A polymer is a long chain of individual unit molecules which have been linked together.
- The root poly means many and the root mono means one!
- A monomer is one unit.
- A polymer is many units.
- PVA is a common component in glues.

**Monomer**

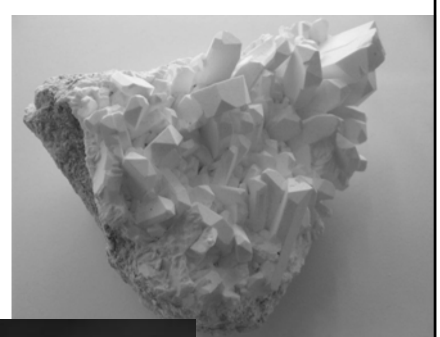


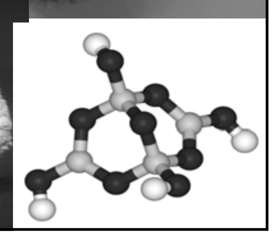




**Polymer**

# Borax

- Borax is more common than you might think. You can find it in things like:
  - Detergents (soaps)
  - Cosmetics
  - Enamel (Glazes)
- In it's natural form Sodium tetraborate Decahydrate.





# Section 3:
# *How Does Matter React Chemically?*

## *Vocabulary*

- Physical Property: Physical properties are traits that involve a substance by itself.
- Chemical Property: Chemical properties are properties that involve how a substance interacts with other substances.
- Chemical Change: A chemical change is a change that results in one or more new substances.
- Chemical Reaction: Another term for a chemical change is a chemical reaction.
- Compound: A compound is a substance made up of two or more different elements that have chemically combined.

# *Physical Properties*

Physical properties are traits that involve a substance by <u>itself</u>.

- Appearance
- Texture
- Color
- Odor
- Density

All of these things can describe an object by itself!

# *Chemical Properties*

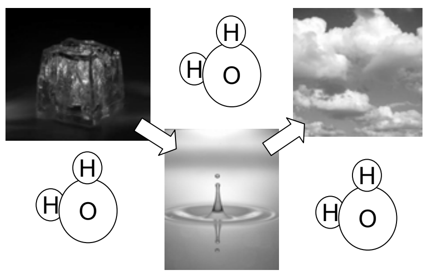
Chemical properties are properties that involve how a substance interacts with <u>other substances</u>.

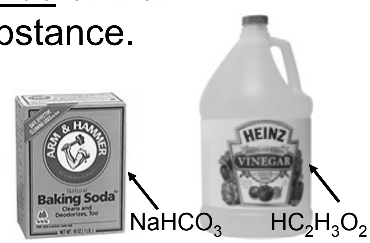
- Flammability
- Reactivity with Water and other Chemicals
- pH
- Toxicity

All of these properties describe how a substance interacts with one or more external things.

## Physical Change vs. Chemical Change

- A Physical Change is any change in a substance that does not change the chemical bonds of that substance.
- A Chemical Change is any change in a substance that changes the chemical bonds of that substance.




$NaHCO_3 + HC_2H_3O_2 \rightarrow NaC_2H_3O_2 + H_2CO_3$

$H_2CO_3 \rightarrow H_2O + CO_2$

## *Combustion Reaction*

**Fuel+ $O_2 \rightarrow CO_2 + H_2O$**

**Fuel: Methanol ($CH_3OH$)**

**Air: 21% Oxygen ($O_2$)**

## Combustion Reaction

**This reaction is not written correctly …**

$$CH_3OH + O_2 \rightarrow CO_2 + H_2O$$

Matter can not be created or destroyed!

**C: 1 + 0 = 1 + 0**

**H: 4 + 0 = 0 + 2** ← NOT Equal!!!

**O: 1 + 2 = 2 + 1**

## Combustion Reaction

$$CH_3OH + O_2 \rightarrow CO_2 + H_2O$$

**Becomes…**

$$2 \times CH_3OH + 3 \times O_2 \rightarrow$$

$$2 \times CO_2 + 4 \times H_2O$$

## *Combustion Reaction*

**$2 \times CH_3OH + 3 \times O_2 \rightarrow$**

**$2 \times CO_2 + 4 \times H_2O$**

**Let's see if this is equal!**

**C: 2 + 0 = 2 + 0**

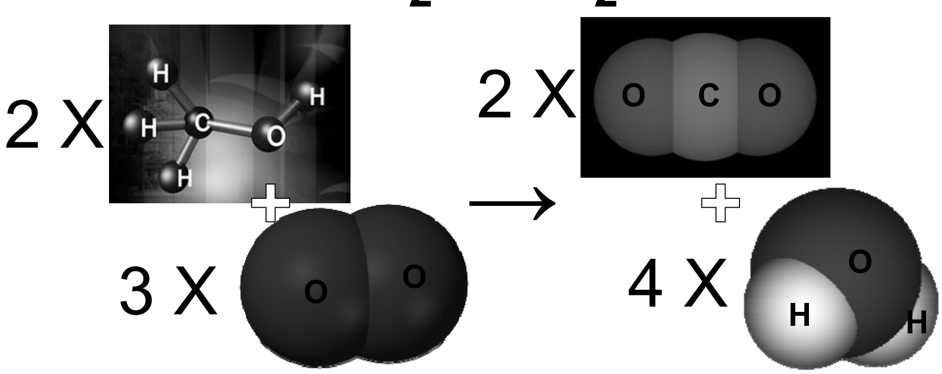
**H: 8 + 0 = 0 + 8**

**O: 2 + 6 = 4 + 4**

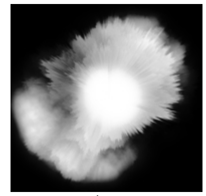
## *Combustion Reaction*

**$2CH_3OH + 3O_2 \rightarrow$**

**$2CO_2 + 4H_2O$**



# Experiment 2: Combustion



- Add 10 ml of Methanol to a 5 gallon water bottle.
- Spin the bottle several times to evenly distribute the fuel and allow a few moments for the gas to partially vaporize.
- Ignite with a match and stand back!!!

(You must wait ~30min between each combustion to allow $O_2$ to refill the bottle.)

# Experiment 2: Combustion

- What did you see?
- Did you see energy? If so, what types?
- Where do you think this energy came from?
- Was this a chemical reaction or a physical change?
- Where else might you see a combustion reaction occur?
- What products did you see after the reaction? Did you see any water or condensation on the inside of the bottle?
- A second match test is often used to confirm the absence of oxygen. In this test, a burning match is introduced into an environment with no remaining oxygen. If you performed a second match test on the bottle, do you think it would go out? Why?

# Experiment 2: Combustion

- Did you see energy? If so, what types?
  - Heat, Light, Movement (?), Sound
- Where do you think this energy came from?
  - Potential Energy stored in chemical bonds (chemical engegy, like in food we eat)
- Was this a chemical reaction or a physical change?
  - Chemical reaction. We broke some chemical bonds and formed new ones.
- Where else might you see a combustion reaction occur?
  - Combustion reactions occur all around us. A car uses a combustion reaction to turn gasoline into energy to move the car.
- What products did you see after the reaction? Did you see any water or condensation on the inside of the bottle?
  - As the bottle cools, water can be seen forming on the inside of the bottle and at the bottom of the bottle.
- A second match test is often used to confirm the absence of oxygen. In this test, a burning match is introduced into an environment with no remaining oxygen. If you performed a second match test on the bottle, do you think it would go out? Why?
  - The match would go out. This is because there is no oxygen left in the container (it was all used by the reaction). All that should be left is carbon dioxide and water vapor. Since a match can not burn in carbon dioxide it goes out.

# Nature of Matter Activity 1 - Show Me A Million

Name: ______________________________

Procedure:

1. Select what you want to count out a million of. Ideas include: Grains of sugar, grains of salt, bird seed, Cheerios, M&Ms, Skittles, peas, Red Hots, ect. (For this experiment we will use cheerios, but feel free to use what you like.)
2. Weigh out a cup on the balance and record the mass.
3. Count out at least 100 Cheerios into the cup. If you are using some thing smaller, like grains of salt, you might want to count out more to get an accurate result. (If you are counting grains of salt you might want to count out 1000 grains!) Record the number of Cheerios you count out.
4. Weigh the cup again with the added Cheerios and record the mass.
5. Subtract the value recorded in step 2 from the value recorded in step 4 to find the mass of just the Cheerios and record the value.
6. Divide the mass of all the Cheerios you counted out (Your answer from step 5) by the number of Cheerios you counted out (100) and record the value. This is the mass of a single Cheerio.
7. Multiply your answer from step 6 by 1,000,000 and record the value. This is the weight of one million Cheerios.
8. Now look at the mass of the Cheerios in the box and record the value.
9. Divide the number from step 7 by the number in step 8 to determine how many boxes of Cheerios you would need to have one million Cheerios.
10. If a box of Cheerios cost $3.50, how much would one million Cheerios cost?
11. Now repeat steps 7 through 10, but instead of multiplying by 1,000,000 you will multiply by $6x10^{23}$ (That is 6 with twenty three zeros following it!). By using this number you will be calculating the cost of 1 mole of Cheerios. As a comparison, one mole of water molecules weighs about 18g (the weight of about 18 paper clips). How much money would it cost to buy one mole of Cheerios?

    Note: Some calculators can not handle this many digits. To get around this problem, you can use a scientific calculator that can show exponents or a Microsoft Excel spreadsheet on the computer.

**Data Table for One Million:**

| Step: | Number: | Description: |
|---|---|---|
| 2 | | Weight of Cup |
| 3 | | Number of Particles |
| 4 | | Weight of Cup & Particles |
| 5 | | Weight of Particles |
| 6 | | Mass Per Particle |
| 7 | | Mass of One Million Particles |
| 8 | | Mass in One Box of Particles |
| 9 | | Number of Boxes Needed |
| 10 | | Cost of One Million Particles |

**Data Table for One Mole:**

| Step: | Number: | Description: |
|---|---|---|
| 7 | | Mass of One Mole of Particles |
| 8 | | Mass in One Box of Particles |
| 9 | | Number of Boxes Needed |
| 10 | | Cost of One Mole of Particles |

# Nature of Matter: Activity 2 – Pressure and States of Matter

1. Name: ______________________________

2. Hypothesis: Pressure has an effect on the state of matter.

3. Experimental Procedure:
   a. Use a 10ml syringe to pick up 1ml of water. Make sure there is no air!!!
   b. Cap the syringe with the caps provided.
   c. Turn the syringe so that the tip is facing upwards.
   d. Pull down on the plunger quickly.

4. Observations:
   **a.** What do you see before you pull down the plunger: __________________

   ________________________________________

   ________________________________________

   ________________________________________

   **b.** What do you see while you pull down the plunger: __________________

   ________________________________________

   ________________________________________

   ________________________________________

   **c.** What do you see after you pull down the plunger: __________________

   ________________________________________

   ________________________________________

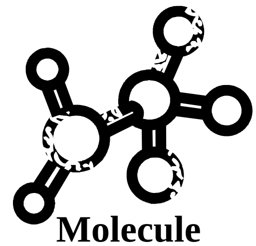
   **d.** Do you think our hypothesis is correct? Why? __________________

   ________________________________________

   ________________________________________

   ________________________________________

# The Nature of Matter-What is Matter Made Of (Section 1)



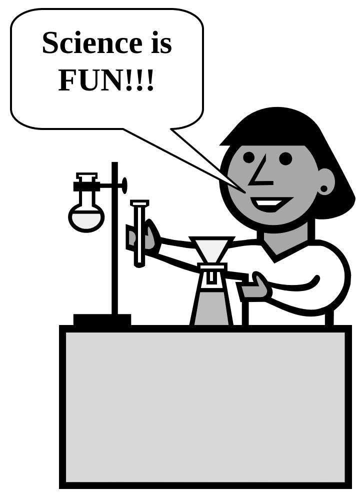

1) Name: ______________________________

2) Is ‘air’ matter? __________

3) Matter is made up of small particles called __________.

4) Which is not a particle found in an atom? __________
   a. Neutron
   b. Proton
   c. Electron Cloud
   d. Electron

5) Draw a picture of an atom. Label the following:
   a. Electron Cloud
   b. Nucleus




6) Electrons move around the nucleus in an __________.

7) How many protons does a hydrogen atom have? __________

8) A __________ is a particle that contains two or more atoms linked by chemical

   __________.

9) Atoms with different numbers of protons are called __________.

10) Name one element and an application for that element:

   Element: ___________________________

   Use: ______________________________________________________________

# The Nature of Matter-Physical Changes in Matter (Section 2)

1) Name: ______________________________

2) Clouds are an example of water in what state of matter? __________

3) Classify the following materials:

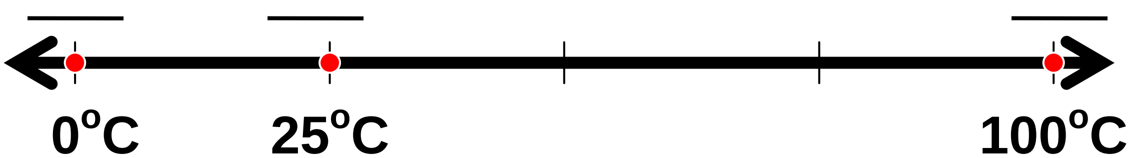
   a. Solid    b. Liquid    c. Gas

   1) Rocks: _____
   2) Water: _____
   3) Clouds: _____
   4) Oil: _____
   5) Steam: _____
   6) Your Book: _____
   7) Air: _____
   8) Orange Juice: _____

4) Which state of matter has molecules tightly packed? __________

   a. Solid    b. Liquid    c. Gas

5) Match the pictures on the temperature number line below:




A

B

C

6) What sate of matter is water when pressure is 1atm and temperature is 374°C?

7) Dew on the grass in the morning is an example of ________________.

8) Do the chemical bonds in a molecule change during a physical change? _____

## The Nature of Matter-How Does Matter React Chemically? (Section 3)

1) Name: ______________________________

2) Physical properties are traits that involve a substance by ____________________.

3) Chemical properties are properties that involve how a substance interacts with

   _____ ____________________.

4) A _________________ change is any change in a substance that does not

   _____________ the chemical bonds of that substance.

5) A _________________ change is any change in a substance that changes the

   __________________ ____________ of that substance.

6) Classify the following properties and changes:

   a. Physical Property
   b. Chemical Property
   c. Physical Change
   d. Chemical Change

   Gasoline is flammable: ________

   The apple juice is a liquid: ________

   The ice cube is melting: ________

   A log is burning in a bond fire: ________

   The bread is soft: ________

   Baking soda and vinegar are mixed to make a gas: ________

   An apple is cut in half: ________

   An apple is red: ________

   Mercury is poisonous to humans: ________

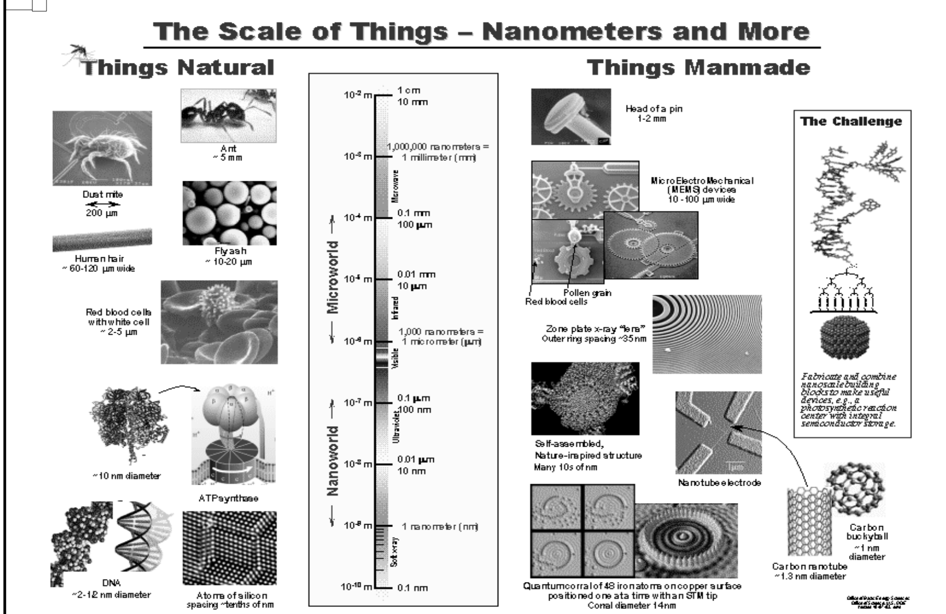
   Clouds condensing to make rain: ________

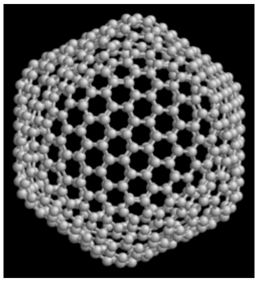
7) Air is ________% Oxygen, and ________% Nitrogen.

# Nanotechnology

## From Buckyballs To Nanowires

Mark Oliver Summer 2006 RET
Dr. S. Bhansali's Lab (BioMems/Microsystems)
Dr. N. Ramgir, Researcher



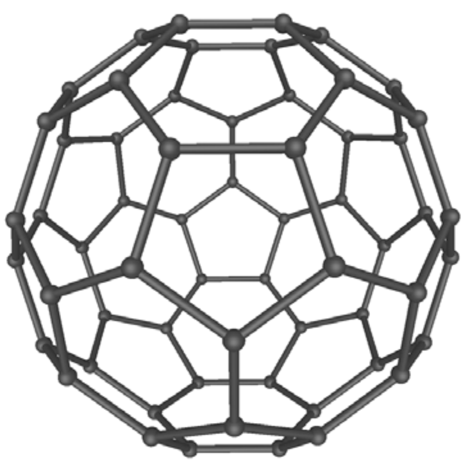


**The fullerenes are a recently-discovered family of carbon allotropes.**

**They are molecules composed entirely of carbon, in the form of a hollow sphere, ellipsoid, or tube.**

**Spherical fullerenes are sometimes called buckyballs, and cylindrical fullerenes are called buckytubes.**

**Fullerenes are similar in structure to graphite, which is composed of a sheet of linked hexagonal rings, but they contain pentagonal (or sometimes heptagonal) rings that prevent the sheet from being planar.**



**Buckminsterfullerene (C60) was named after Richard Buckminster Fuller, a noted architect who popularized the geodesic dome.**

**Since buckminsterfullerenes have a similar shape to that sort of dome, the name was thought to be appropriate.**

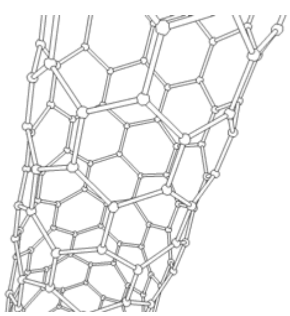
**As the discovery of the fullerene family came *after* buckminsterfullerene, the name was shortened to illustrate that the former is a type of the latter.**


Buckminster Fuller
(1895 –1983)
American visionary, designer, architect, inventor.

**Throughout his life, Fuller was concerned with the question of whether humanity has a chance to survive lastingly and successfully on planet Earth, and if so, how.**

**Considering himself an average individual without special monetary means or academic degree, he chose to devote his life to this question, trying to find out what an individual like him could do to improve humanity's condition that large organizations, governments, or private enterprises inherently could not do.**

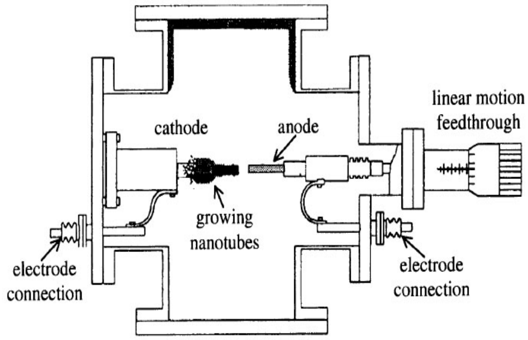
**He also created a large number of inventions, mostly in the fields of design and architecture, the best-known of which is the geodesic dome.**



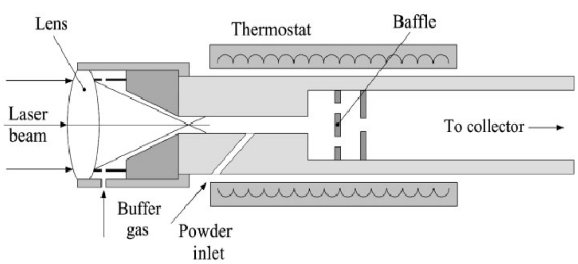
**Nanotubes** are cylindrical fullerenes.

These tubes of carbon are usually only a few nanometres wide, but they can range from less than a micrometer to a full meter in length.

Their unique molecular structure results in unique macroscopic properties, including high tensile strength, high electrical conductivity, high resistance to heat, and chemical inactivity



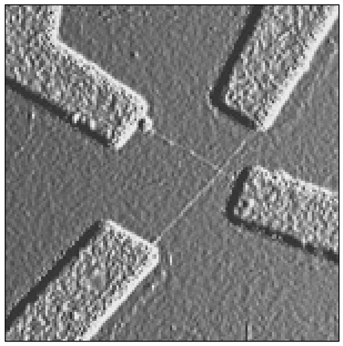

**An early method for generating single wall carbon nanotubes was the use of an electric arc between two graphite rods or electrodes.**

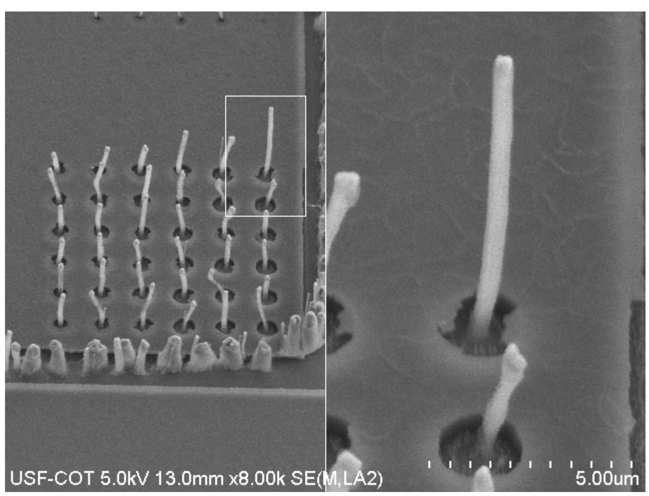



**The Laser Vaporization method focuses the beam of a laser onto a mixture of metallic catalyst and graphite particles to synthesize single wall carbon nanotubes**.

**Scanning electron microscopy of this material**

**Diameter of 1.4 nm.**






**These nanotubes were created using a Plasma-Enhanced Chemical Vapor Deposition reactor.**

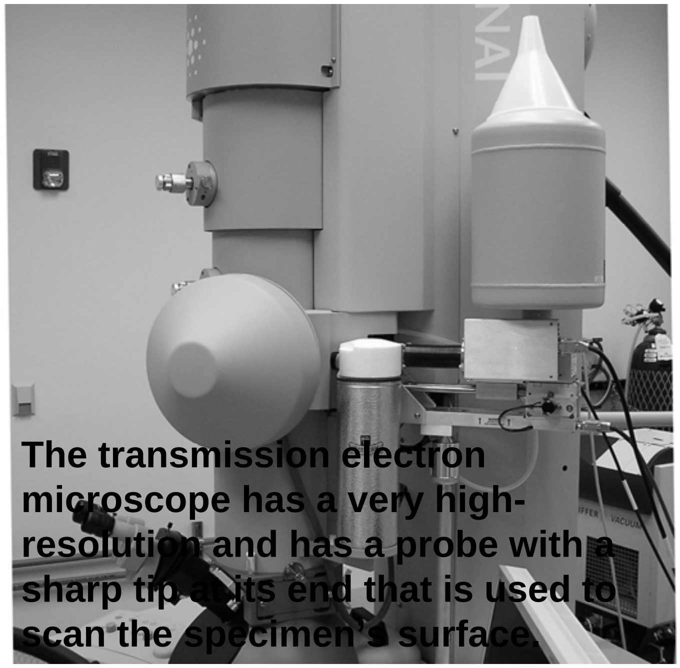
# Nanotechnology Research Center at USF

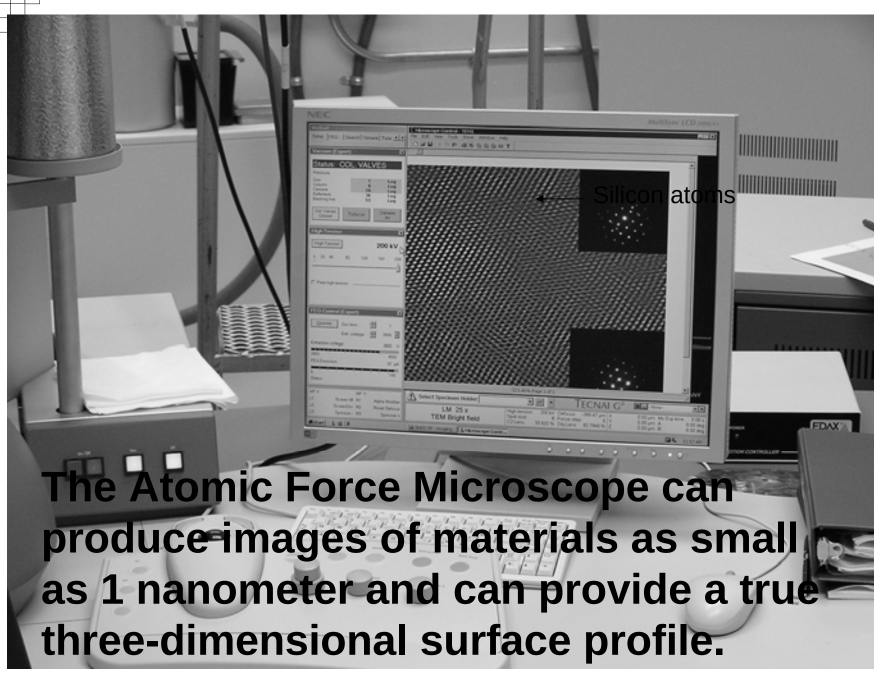
- **Brand new facility**
- **Cost $3 million**
- **Equipment $10 million**
- **Toolbox for researchers**

**Within the Clean Room, the first bay is used for Metal Deposition. A thin layer of gold (Au), Silver (Ag), or Platinum (Pt) is placed on a Silicon (Si) wafer.**

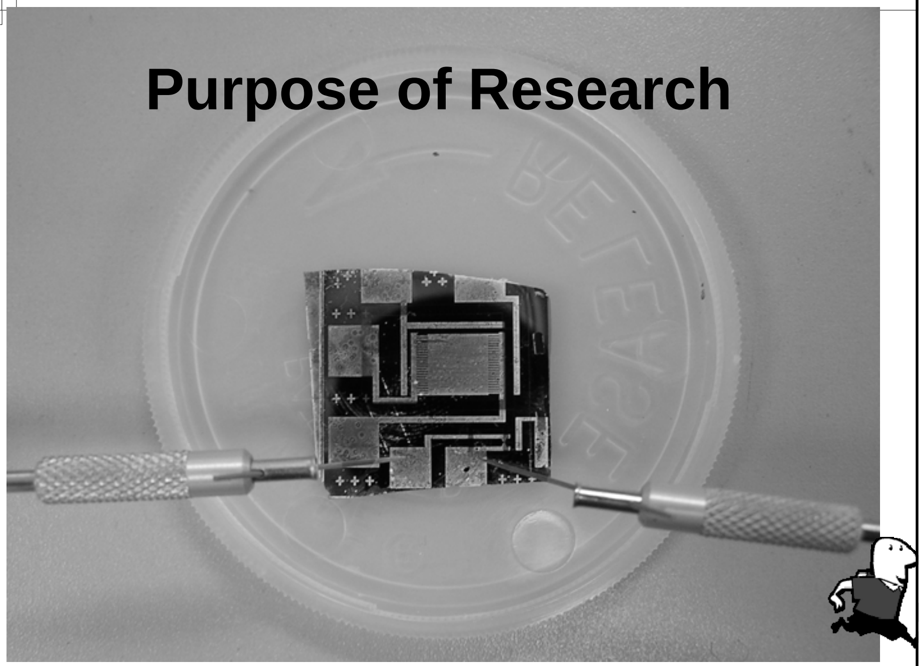
The second bay in the Clean Room is used for etching the surface of the disc.

The third bay is used for optical lithography and requires special lighting.


The transmission electron microscope has a very high-resolution and has a probe with a sharp tip at its end that is used to scan the specimen's surface.

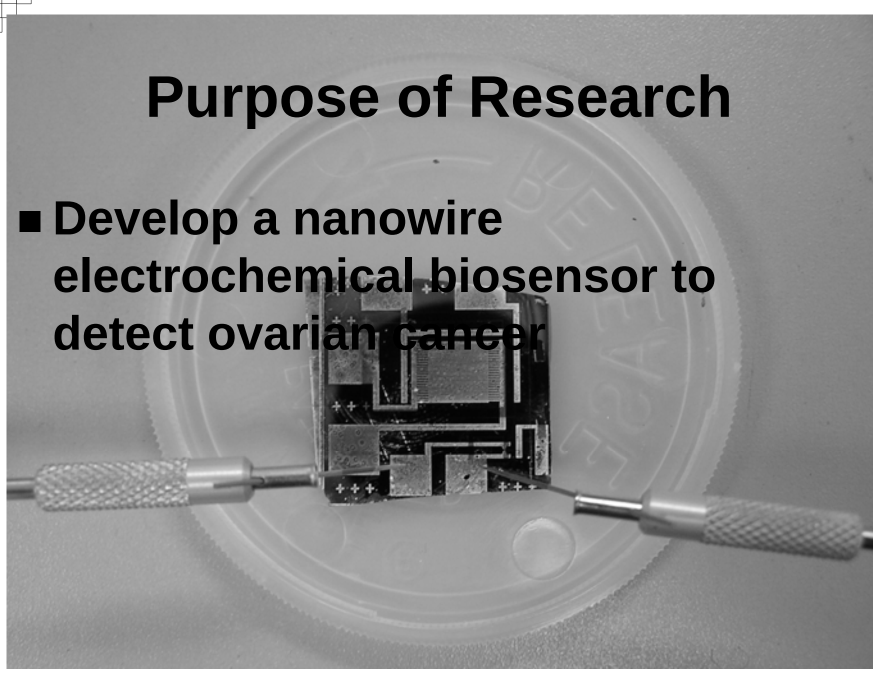

Silicon atoms
The Atomic Force Microscope can produce images of materials as small as 1 nanometer and can provide a true three-dimensional surface profile.

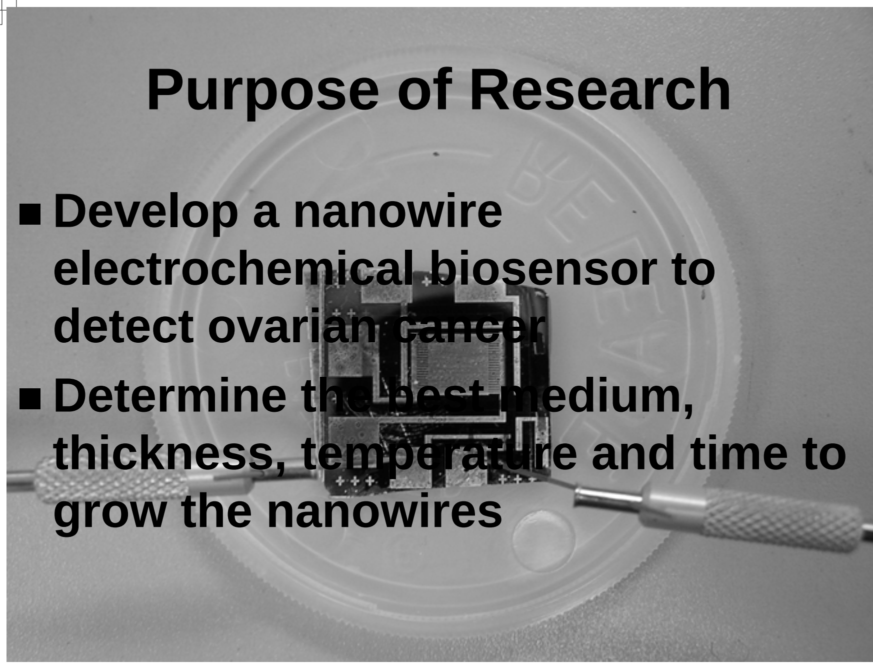
# Purpose of Research



# Purpose of Research

- Develop a nanowire electrochemical biosensor to detect ovarian cancer

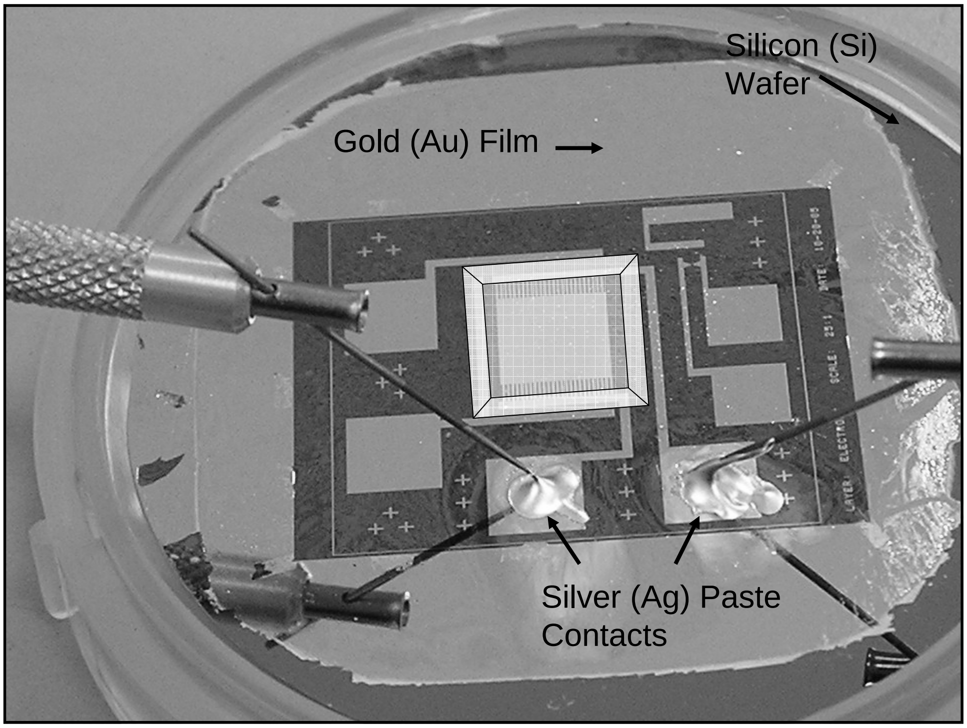


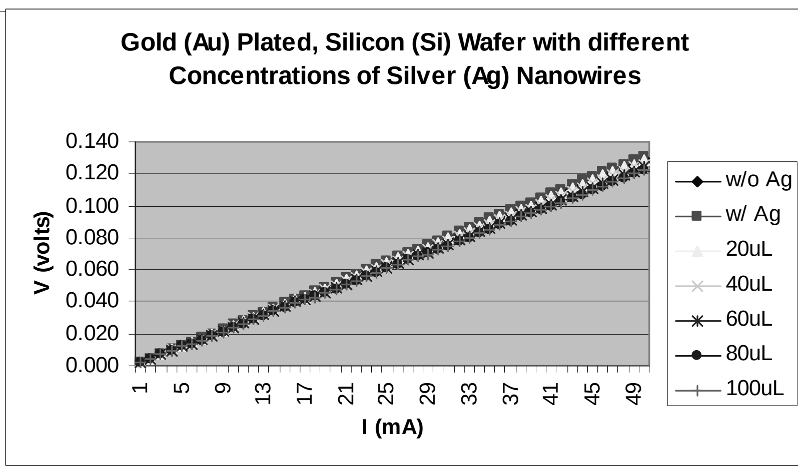


# Purpose of Research

- Develop a nanowire electrochemical biosensor to detect ovarian cancer
- Determine the best medium, thickness, temperature and time to grow the nanowires

Measuring the resistance after applying a solution containing Gold (Au) nanowires

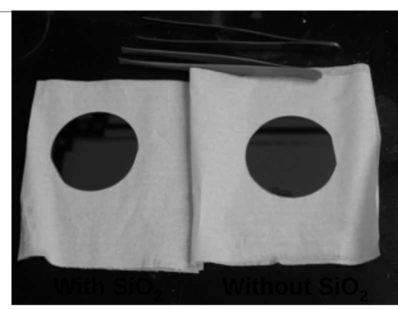


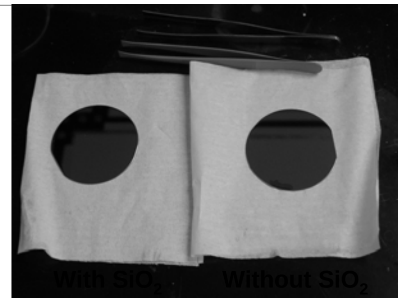

The data demonstrates that the application of Silver Nanowire solution in increasing amounts appears to be proportional as per Ohm's Law (V=IR). However, there was a slight increase in voltage at the higher current (I) levels as more nanowires were added.

After being cleaned half of the discs have $SiO_2$ removed

After being cleaned half of the discs have $SiO_2$ removed

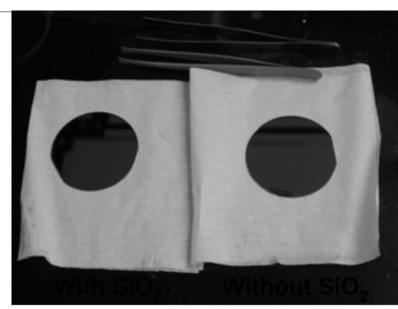



After being cleaned half of the
discs have $SiO_2$ removed


With $SiO_2$
Without $SiO_2$


Vacuum evaporator used to
apply Chromium & Gold


After being cleaned half of the
discs have $SiO_2$ removed

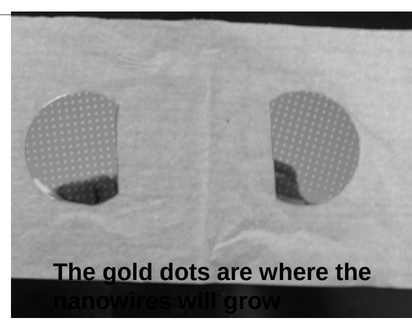

With $SiO_2$
Without $SiO_2$

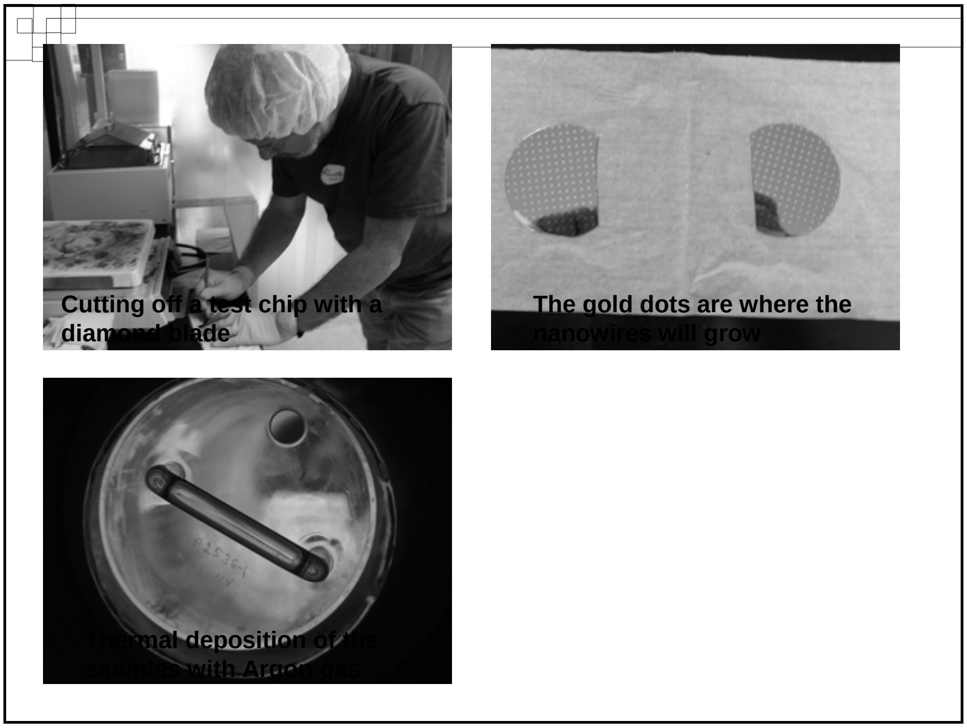

Vacuum evaporator used to
apply Chromium & Gold

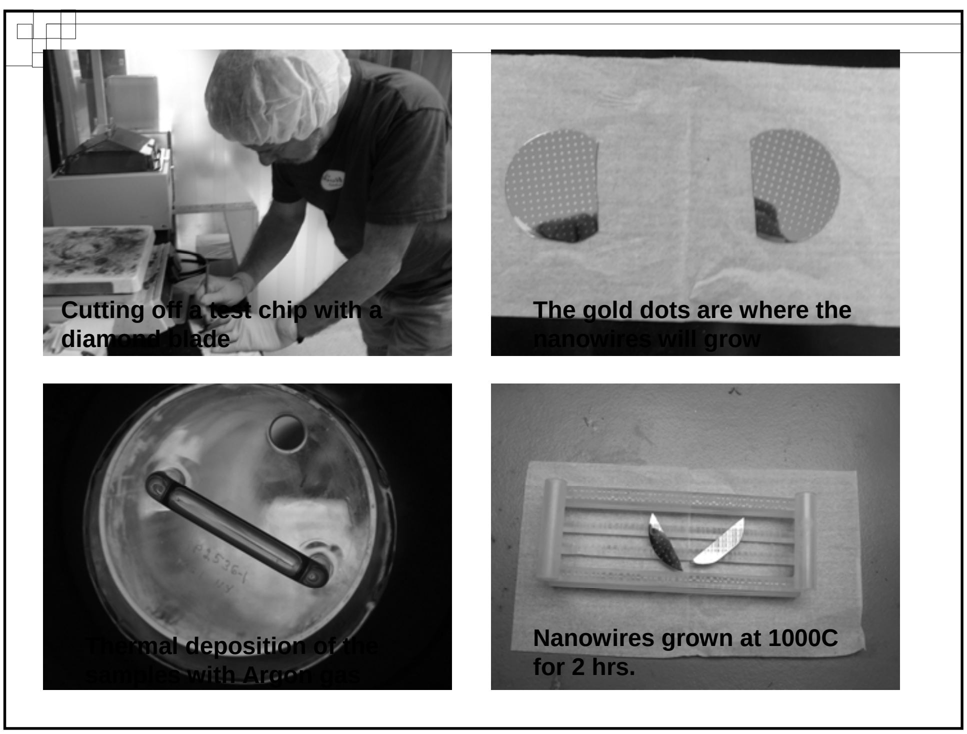

Liquid Nitrogen is used
to get a better vacuum

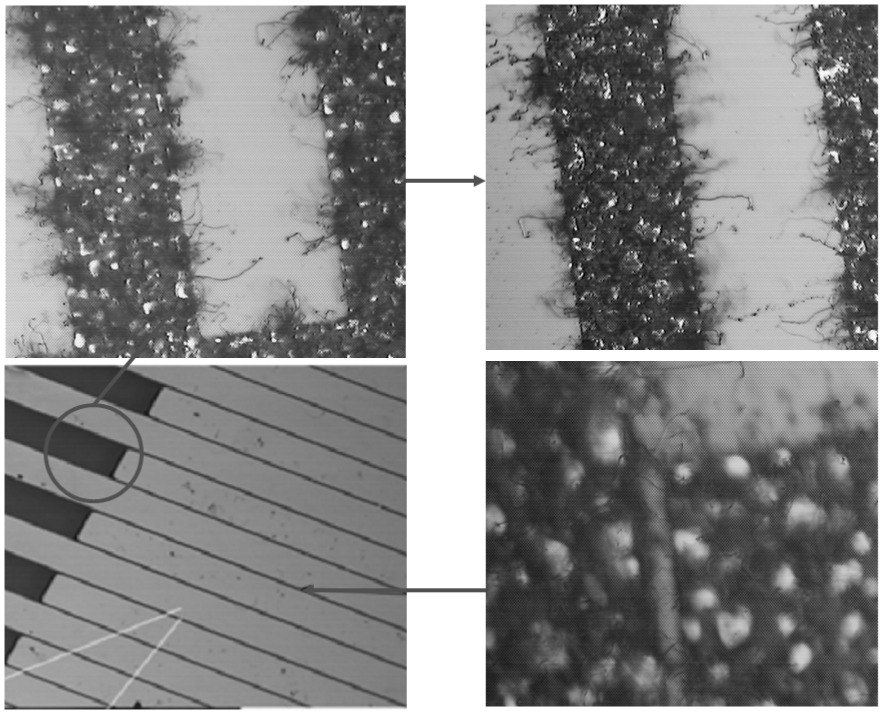

Cutting off a test chip with a diamond blade


Cutting off a test chip with a diamond blade


The gold dots are where the nanowires will grow


Cutting off a test chip with a diamond blade
The gold dots are where the nanowires will grow
Thermal deposition of the samples with Argon gas


Cutting off a test chip with a diamond blade
The gold dots are where the nanowires will grow
Thermal deposition of the samples with Argon gas
Nanowires grown at 1000C for 2 hrs.



# References


- *Design and Construction of Plasma Enhanced Chemical Vapor Deposition Reactor and Directed Assembly of Carbon Nanotubes,* Joshua David Schumacher (2003)
- http://en.wikipedia.org/wiki/Allotropes_of_carbon
- http://www.matmod.com/Nanometers.html

# Credits

This project was made possible through the support of The Department of Electrical Engineering at USF and NSF

Dr. Michael Kovac - Director, Nanomaterials & Nanomanufacturing Research Center

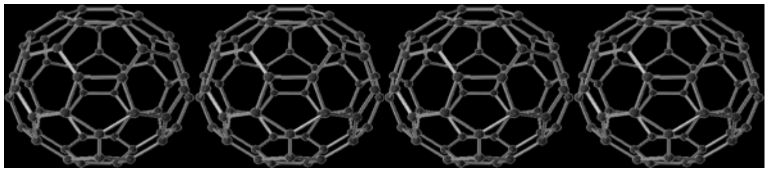
**Special Thanks to**

Dr. Shekhar Bhansali, - Assoc. Prof., BioMems/Microsystems

Mr. Bernard Batson – IGERT Program Coordinator

Dr. Niranjan Ramgir, - Post Doctoral Fellow

Mr. Eric Bunting – Engineering Student Bookman College



# Nanotechnology

**Jessica Weber – PhD student, STARS Fellow**

**Mark Oliver – Mentor Teacher, Tampa Palms Elem.**

April 19 2008 STARS Mentor Teacher Workshop

## Sunshine State Standards

- SC.A.1.2.4.2 The student knows the differences and similarities between mixtures and solutions.
- SC.A.2.2.1.5.1 The student knows that materials may be made of parts too small to be seen without magnification.
- SC.H.1.2.5: The student knows that a model of something is different from the real thing, but can be used to learn something about the real thing.
- SC.H.1.2.2.5.1 The student understands that scientists use different kinds of investigations (for example, observations of events in nature, controlled experiments) depending on the questions they are trying to answer.
- SC.H.3.2.3: The student knows that before a group of people builds something or tries something new, they should determine how it might affect other people.

2

# Outline

- Introduction
- The size of things
  - What's smaller than a pygmy shrew?
  - Activity: Ranking objects by size
- History of Nanotechnology
- Crystal Structure Examination
  - Activity: A Solution to a Problem
- Nano4Newbies Website Overview
  - Activity: Nano4Newbies Scavenger Hunt
- Small tools to build small things
  - Activity: Oven Mitt Challenge
  - Intro to AFM
  - "Mystery Box" Contour Mapping with Excel

3

# The Size of Things

- The Pygmy Shrew is the smallest mammal in the world
- It weighs only about 2 grams

http://en.wikipedia.org/wiki/Image:Etruscanpygmyshrew.JPG

4

# Vocabulary Guide

| *Vocabulary Word* | *I don't know this word* | *I have heard this word, but don't know what it means* | *My definition of this word before the lesson* | *My definition of this word after the lesson* |
|---|---|---|---|---|
| Atom | | | | |
| Bacteria | | | | |
| Cell | | | | |
| Electron | | | | |
| Molecule | | | | |
| Neutron | | | | |
| Nucleus | | | | |
| Proton | | | | |
| Protozoa | | | | |
| Pygmy Shrew | | | | |
| Quark | | | | |

5

# Ranking Objects by Relative Size

- Atom
- Cell
- Electron
- Elephant
- Molecule
- Neutron
- Proton
- Nucleus
- Pygmy Shrew
- Quark

***First Try:***

______ ______ ______ ______ ______ ______ ______ ______ ______ ______

Largest Smallest

***Second Try:***

______ ______ ______ ______ ______ ______ ______ ______ ______ ______

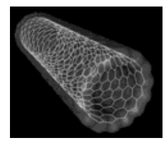
Largest Smallest

6

# History of Nanotechnology

- 30BC - 640AD Lycurgus Cup

- 1827 Photography



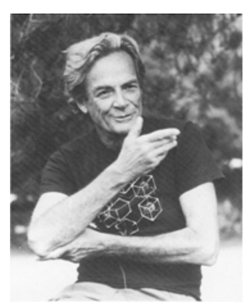
- 1953 DNA
- 1991 Carbon Nanotube

7

# Feynman's Vision

**There's Plenty of Room at the Bottom (1959)**

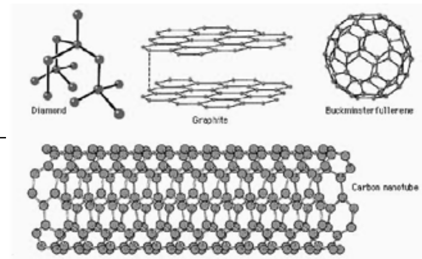
"As soon as I mention this, people tell me about miniaturization, and how far it has progressed today. They tell me about electric motors that are the size of the nail on your small finger. And there is a device on the market, they tell me, by which you can write the Lord's Prayer on the head of a pin. But that's nothing; that's the most primitive, halting step in the direction I intend to discuss. It is a staggeringly small world that is below. In the year 2000, when they look back at this age, they will wonder why it was not until the year 1960 that anybody began seriously to move in this direction."



***"Why cannot we write the entire 24 volumes of the Encyclopedia Brittanica on the head of a pin?"***

8

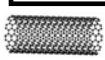
# The Big Deal




Carbon nanotubes are the strongest and most flexible material.

How many materials can you think of that would benefit from having carbon nanotubes added to them?

Their unique molecular structure results in unique macroscopic properties, including high tensile strength, high electrical conductivity, high resistance to heat, and chemical inactivity.



9

# Invitation to Learn

- Have students write what they think the following vocabulary words mean: atom, element, change of state, chemical change, compound, molecule, physical change, chemical reaction, nanotechnology.
- Have students read the Harcourt Science book p. 64-70
- Discuss the Science Up Close pictures (66-67) of the breaking apart of a charcoal briquette.
- Show the class the different ways carbon can be configured (carbon_offline_englesk_fullscreen Macromedia Projection Company)

10

# Activity: A Solution to the Problem

- Break students into small groups (2-4) equalized for their different learning styles to work on the following projects.
- Make allowances for any disabilities by adjusting time duration, performance criterion and administering alternative assessments.
- Have students record what they think the words mean on their *From Buckyballs to Nanotubes Vocabulary Sheet*
- Materials: iodized salt, kosher salt, sea salt, granulated sugar, powered sugar, brown sugar, iron fillings, rice, magnet, 6 measuring spoons, 6 plates, 6 plastic cups, water

11

# Procedure

- Using the iron fillings, rice, sugar, salt and magnet demonstrate the differences and similarities of mixtures and solutions. Then place a small amount of each kind of salt and each kind of sugar on its own plate.
- Compare and contrast each sample for color and texture. Record your observations.
- Compare and contrast the grain size of each sample. Record your observations.
- Place 40 ml of water in each of the six cups. Use a clean spoon to place a level tablespoon of each sample in its own cup. Stir. Record your observations.

12

# Draw Conclusions

- Which samples – the light-colored ones or the darker-colored ones- mixed into the water more quickly?
- Which samples – the ones with larger grains or the ones with smaller grains - mixed into the water more quickly?
- What can you conclude about how color and grain size affect the speed in which a sample mixed into water?
- Predict where sugar cubes fit in your list.
- Test your prediction.

13

# Performance Tasks

Students will conduct the *Solution to the Problem* investigation.

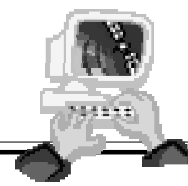
- Make a table to sequence the salt and sugar samples by how much of them mixed into water.
- Predict where a sugar cube will fit in the table. Explain their answer.
- Summarize the results of their investigation. How do they compare to their prediction?

14

# Alternative Assessments

Present the *Buckyballs to Nanowires* PowerPoint to the class and discuss how allotropes work.

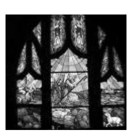
- Have the students in their small groups (2-3) build one of the different carbon allotropes out of toothpicks and miniature marshmallows. (buckyball, graphite, diamond, nanotube).
- In the computer lab, have the students research the way nanotechnology is changing the fields of engineering, biology, physics and chemistry. What are some of the benefits and possible harmful effects?
- Have the students put together a PowerPoint presentation based on their research and present it in class.



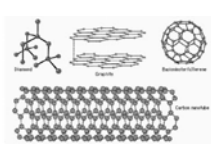
15

# Nano4Newbies

- “Nano Scavenger Hunt”
- 10 questions: 1 hour



**Question:** Even before the 1800’s, stained glass artists were users of nanotechnology. The ruby red color of some stained glass is due to the ______________ trapped inside the glass matrix.



**Question:** List two material properties that change at the nanoscale.

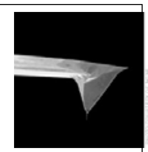
16

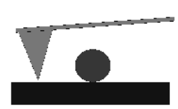
# Small Tools to Build and See Small Things

- Demo: Oven Mitt Challenge
  - Materials: Oven Mitts, toothpicks, and marshmallows or other round soft candies
  - Students will try to make atomic models while wearing oven mitts
- Take Home Message
  - As nanotechnology continues to progress, scientists and engineers need to use smaller tools in order to control things at the nanoscale

17

# Atomic Force Microscopy

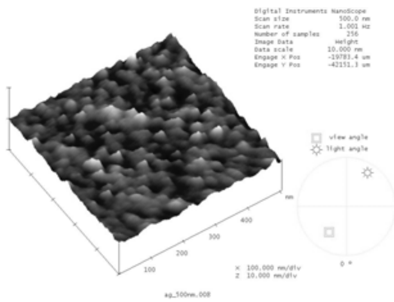


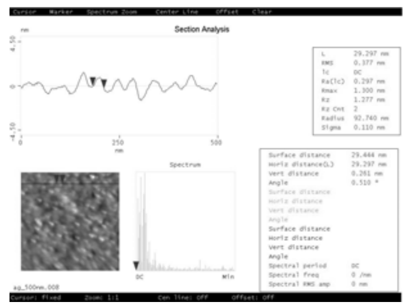


- AFM is a form of Scanning Probe Microscopy
- <u>How it works</u>
  - a very sharp tip is dragged across a sample surface and the change in the vertical position (denoted the "z" axis) reflects the topography of the surface. By collecting the height data for a succession of lines it is possible to form a three dimensional map of the suface features.

18

# AFM Image of Ag Nanoparticles

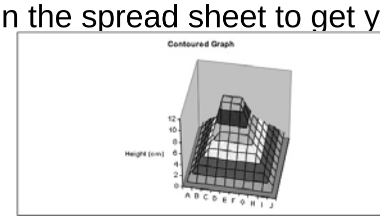





19

# Activity: AFM Mystery Black Box

- Make a “mystery landscape” in a shoebox
- Punch holes in a grid-like pattern in the lid
- Poke a stick in the holes (line by line) and measure how far it goes down in the box
- Enter your data in the spread sheet to get your “mystery landscape”!




20

# Resources

Physical versus Chemical Websites

- http://antoine.frostburg.edu/chem/senese/101/matter/faq/physical-chemical.shtml
- http://virtual.yosemite.cc.ca.us/lmaki/Chem150-99/chapters/chapter1/lessons/phys_chem/phy_c_1.htm
- http://stars.eng.usf.edu/Nature%20of%20Matter/Nature%20of%20Matter%202.1.ppt#285,27,Nanotechnology

Nanotechnology Websites

- http://nano.cancer.gov/resource_center/video_journey_wmv-high.asp
- http://www.csmonitor.com/2003/0318/p15s01-lecl.html
- http://www.emints.org/ethemes/resources/S00001564.shtml
- http://epics.ecn.purdue.edu/lspm/videos/kevin.asp
- http://mrsec.wisc.edu/Edetc/LEGO/PDFfiles/nanobook.PDF

21

Name ___________________

# What's Smaller Than a Pygmy Shrew? *Vocabulary Guide*

| ***Vocabulary Word*** | ***I don't know this word*** | ***I have heard this word, but don't know what it means*** | ***My definition of this word before the lesson*** | ***My definition of this word after the lesson*** |
|---|---|---|---|---|
| Atom | | | | |
| Bacteria | | | | |
| Cell | | | | |
| Electron | | | | |

| ***Vocabulary Word*** | ***I don't know this word*** | ***I have heard this word, but don't know what it means*** | ***My definition of this word before the lesson*** | ***My definition of this word after the lesson*** |
|---|---|---|---|---|
| Molecule | | | | |
| Neutron | | | | |
| Nucleus | | | | |
| Proton | | | | |
| Protozoa | | | | |
| Pygmy Shrew | | | | |
| Quark | | | | |

Name__________________

# What's Smaller Than a Pygmy Shrew: *Let's Rank Objects by Size*

Word List

| | | | | |
|---|---|---|---|---|
| Atom | Cell | Electron | Elephant | Molecule |
| Neutron | Proton | Nucleus | Pygmy Shrew | Quark |

First Try:

__________ __________ __________ __________ __________
Largest

__________ __________ __________ __________ __________
Smallest

Second Try:

__________ __________ __________ __________ __________
Largest

__________ __________ __________ __________ __________
Smallest

Mark.Oliver@sdhc.k12.fl.us Dr. Bhansali(bhansali@eng.usf.edu)

**Title: From Buckballs to Nanotubes** **Subject/Course: Science**
**Topic: What is Matter Made of? Grades: 5th Time Duration: 10 – 45min periods**

## Stage 1 - Desired Results

**Established Goals: SSS**
**SC.A.1.2.4.2 The student knows the differences and similarities between mixtures and solutions.**

**SC.A.2.2.1.5.1 The student knows that materials may be made of parts too small to be seen without magnification.**

**SC.H.1.2.5: The student knows that a model of something is different from the real thing, but can be used to learn something about the real thing.**

**SC.H.1.2.2.5.1 The student understands that scientists use different kinds of investigations (for example, observations of events in nature, controlled experiments) depending on the questions they are trying to answer.**

**SC.H.3.2.3: The student knows that before a group of people builds something or tries something new, they should determine how it might affect other people.**

**Understandings:**
*Students will understand that…the atom is the smallest particle of matter.*

*Students will know…that elements are substances made of just one kind of atom*

Essential Questions:
What is an atom?
What is the difference between a mixture and a solution?
Why do scientists use models?

*Students will be able to…compare the properties of materials, including how they dissolve in water.*

## Stage 2 – Assessment Evidence

**Performance Tasks:**

**Students will conduct the *Solution to the Problem* investigation**.
1. Make a table to sequence the salt and sugar samples by how much of them mixed into water.
2. Predict where a sugar cube will fit in the table. Explain their answer.
3. Summarize the results of their investigation. How do they compare to their prediction?

**Key Criteria**

**Student's PowerPoint presentation based on their research of nanotechnology:**

1. **How is it changing the fields of engineering, biology, physics and chemistry?**
2. **What are some of the benefits and possible harmful effects?**

**Other Evidence**

**Students will build three-dimensional models of one of the following allotropes of carbon atoms (buckyball, graphite, diamond, nanotube) and compare them with their known uses.**

## Stage 3 – Learning Plan

**Learning Activities**

**Introduction**

1. **Have students write what they think the following vocabulary words mean:** atom, element, change of state, chemical change, compound, molecule, physical change, chemical reaction, nanotechnology.

2. **Have students read the Harcourt Science book p. 64-70**

3. **Go over what the main idea of what an atom is from the following section:**

"More than 2000 years ago, a Greek thinker named Democritus had an idea about matter. Democritus said that all matter is made up of tiny particles, or bits. He said that different kinds of matter are made up of different kinds of particles. And he thought that these particles could not be broken down into smaller parts.

Democritus didn't experiment or test his ideas in any way. Still, it turns out that he was right. We now know that matter can be broken down only so far. If you divide something smaller and smaller, you end up with an atom. An atom is the smallest possible particle of a substance. A molecule is made up of two or more atoms joined together.

As you might guess, atoms and molecules are very small. They are really, really small. In fact, they are so small that you can't see them. Even with a regular microscope you couldn't see an atom or a molecule. Why not? Because single atoms and molecules are too small to reflect light! So there's no way you can see an atom or molecule at all unless you use a special microscope.

Democritus made up the word atom. It comes from a word that means "cannot be divided." Think about a tank of oxygen. You can divide all the oxygen into smaller and smaller parts. But when you get to an oxygen atom, you have to stop. If you break it up further, it won't be oxygen anymore."

4. **Discuss the Science Up Close pictures (66-67) of the breaking apart of a charcoal briquette.**

5. **Show the class the different ways carbon can be configured (carbon_offline_englesk_fullscreen Macromedia Projection Company)**

Break students into small groups (2-4) equalized for their different learning styles to work on the following projects. Make allowances for any disabilities by adjusting time duration, performance criterion and administering alternative assessments.

6. **Have students perform the following investigation: *A Solution to the Problem***

**Materials:** iodized salt, kosher salt, sea salt, granulated sugar, powered sugar, brown sugar, iron fillings, rice, magnet, 6 measuring spoons, 6 plates, 6 plastic cups, water

**Procedure:** Using the iron fillings, rice, sugar, salt and magnet demonstrate the differences and similarities of mixtures and solutions. Then place a small amount of each kind of salt and each kind of sugar on its own plate.

1. Compare and contrast each sample for color and texture. Record your observations.
2. Compare and contrast the grain size of each sample. Record your observations.
3. Place 40 ml of water in each of the six cups. Use a clean spoon to place a level tablespoon of each sample in its own cup. Stir. Record your observations.

**Draw Conclusions**

1. Which samples – the light-colored ones or the darker-colored ones- mixed into the water more quickly?
2. Which samples – the ones with larger grains or the ones with smaller grains - mixed into the water more quickly?
3. What can you conclude about how color and grain size affect the speed in which a sample mixed into water?

**Extension:** Predict where sugar cubes fit in your list. Test your prediction.

7. **Present the *Buckyballs to Nanowires* PowerPoint (part I & II) to the class and discuss how allotropes work.**

8. **Have the students in their small groups (4) build one of the different carbon allotropes out of toothpicks and miniature marshmallows. (buckyball, graphite, diamond, nanotube).**

9. **In the computer lab, have the students research the way nanotechnology is changing the fields of engineering, biology, physics and chemistry. What are some of the benefits and possible harmful effects?**

10. **Have the students put together a PowerPoint presentation based on their research.**

## Stage 4 – Resources

**From Buckyballs to Nanotubes Vocabulary Sheet**

Atomic Theory Websites

http://www.watertown.k12.wi.us/HS/Staff/Buescher/atomtime.asp

http://www.visionlearning.com/library/module_viewer.php?mid=50

http://dl.clackamas.edu/ch104-04/dalton's.htm

http://www.iun.edu/~cpanhd/periodictable.html

Physical versus Chemical Websites

http://antoine.frostburg.edu/chem/senese/101/matter/faq/physical-chemical.shtml

http://virtual.yosemite.cc.ca.us/lmaki/Chem150-99/chapters/chapter1/lessons/phys_chem/phy_c_1.htm

http://stars.eng.usf.edu/Nature%20of%20Matter/Nature%20of%20Matter%202.1.ppt#285,27,Nanotechnology

Nanotechnology Websites

http://nano.cancer.gov/resource_center/video_journey_wmv-high.asp

http://www.csmonitor.com/2003/0318/p15s01-lecl.html

http://www.emints.org/ethemes/resources/S00001564.shtml

http://epics.ecn.purdue.edu/lspm/videos/kevin.asp

http://mrsec.wisc.edu/Edetc/LEGO/PDFfiles/nanobook.PDF

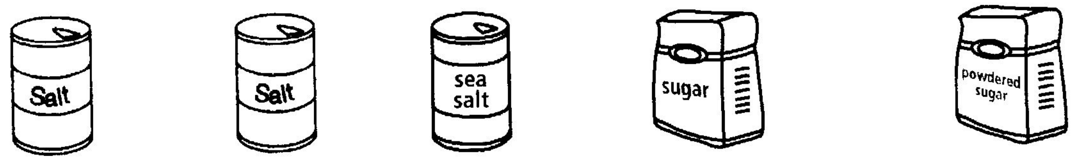
Name  ____________________

Date ____________________

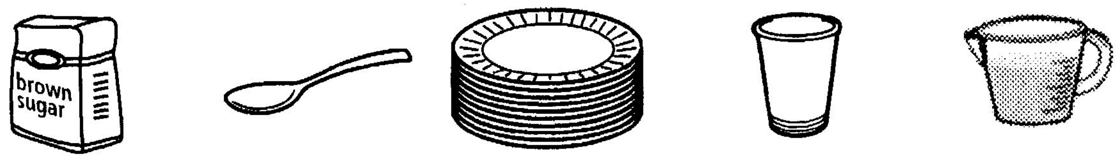


# A Solution to the Problem

## Materials




iodized salt | kosher salt | sea salt | granulated sugar | powdered sugar




brown sugar | 6 spoons | 6 plates | 6 plastic cups | water

## Procedure

1. Place a small amount of each kind of salt and each kind of sugar on its own plate.
2. **Compare and contrast** each sample for color and texture. **Record** your **observations.**
3. **Compare and contrast** the grain size of each sample. **Record** your **observations.**
4. Place the same amount of water in each of six cups. Use a clean spoon to place the same amount of each sample in its own cup. Stir. Use a table like this to **record** your **observations.**

| Sample | Color | Texture | Grain Size | Reaction in Water |
|---|---|---|---|---|
| Iodized salt | | | | |
| | | | | |

Name ______________________

Investigate Log

## Draw Conclusions

1. Which samples—the light-colored ones or the darker-colored ones—mixed into the water more quickly?

_______________________________________

_______________________________________

2. Which samples—the ones with larger grains or the ones with smaller grains—mixed into water more quickly?

_______________________________________

_______________________________________

**Inquiry Skill Tip**

When one factor or event has no effect on the other, you must **draw the conclusion** that there is no relationship between them.

3. **Inquiry Skill—*Draw Conclusions*** Scientists interpret data to **draw conclusions.** What can you conclude about color and grain size and the speed in which a sample mixed into water?

_______________________________________

_______________________________________

_______________________________________

_______________________________________

| Investigate Self-Assessment | Agree | Not Sure | Disagree |
|---|---|---|---|
| I observed the color, texture, and grain size of each type of salt and sugar. | | | |
| I followed safety rules by not tasting any of the materials used in this investigation. | | | |
| I **drew a conclusion** about how color and grain size affected the speed in which a sample mixed into water. | | | |
| | | | |

Name ______________________

Date ______________________

Investigate Log

# Investigate Further

**Sequence the samples by how much of them mixed into water. Predict where sugar cubes fit on your list. Test your prediction.**

**Materials**

- spoon
- plastic cup
- water
- sugar cube

1. Make a table to sequence the salt and sugar samples by how much of them mixed into water.

2. Predict where a sugar cube will fit in the table. Explain your answer.

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

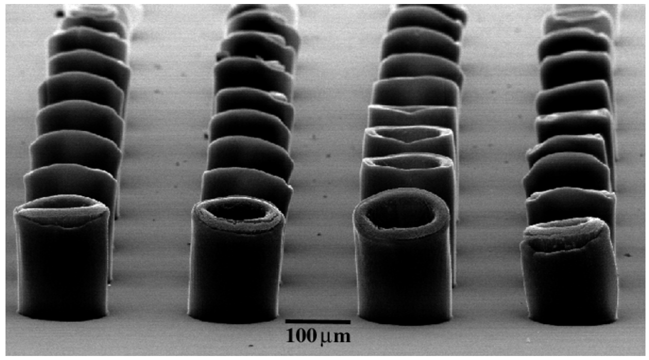
3. Summarize the results of your investigation. How do they compare to your prediction?

_______________________________________________

_______________________________________________

_______________________________________________

# Nano4Newbies Pre Test




1. “Nano” comes from the Latin word meaning

   ________________?

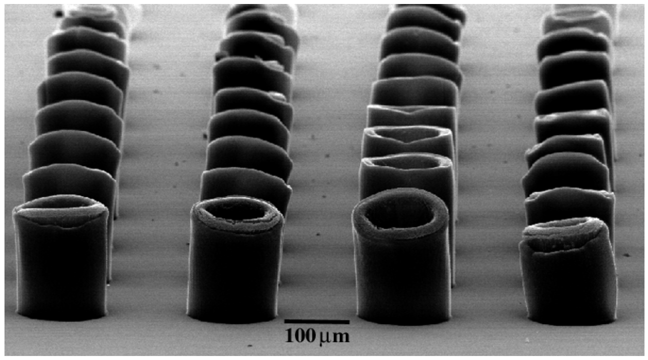
2. What type of nanoparticle could be added to money in the future in order to prevent counterfeiting of bills?

3. What is one material property that may change when the material is reduced to the nanoscale?

4. True or False: Can scientists already control individual atoms and molecules to build nanostructures?

5. What is one potential medical application of nanotechnology?

# Nano4Newbies Post Test




1. “Nano” comes from the Latin word meaning

   ________________?

2. What type of nanoparticle could be added to money in the future in order to prevent counterfeiting of bills?

3. What is one material property that may change when the material is reduced to the nanoscale?

4. True or False: Can scientists already control individual atoms and molecules to build nanostructures?

5. What is one potential medical application of nanotechnology?

Name:________________________

# Nano4Newbies Scavenger Hunt

## Directions: Answer the following questions by visiting the webpage links on Nano4Newbies.

1. A nanometer is a _________________of a millimeter. Answer Link under Main Page - Introduction.

2. Even before the 1800's, stained glass artists were early users of nanotechnology. The ruby red color of some stained glass is due to the _______________________________ trapped in the glass matrix.
   Answer Link under Main Page - History of Nano Timeline.

3. List two material properties that change at the nanoscale.
   _______________________________________________________
   Answer Link under Main Page - All Things Nano.

4. Nanotechnology has several potential applications that will affect our everyday lives. What is one medical application that may be used in the future?
   _______________________________________________________
   _______________________________________________________

Answer Link under Basic Definitions - Big Picture of Nanoscience.

5. Some companies are beginning to create "smart" fabrics. These companies are using nanotechnology to ______________ fabric fibers. Two things these "smart" fabrics can do are: ________________________________ and ________________________________________________________.

   Answer Link under All Things Nano → in the 21st century fabrics get 'smart'.

6. "Nano" comes from the Latin word meaning _____________________.

   Answer Link under Education - New Horizons for Learning.

7. Scientists can build a very small artificial nose. The device is called a _______________________________ and measures changes in odor by associating different odors to changes in _______________________.

   Answer Link under Multimedia - Nanooze → Articles → the Bionic Nose.

8. Counterfeiting currency could become much more difficult in the future. A _________________________________ is a nanoparticle that will shine a very specific color.

Adding combinations of these nanoparticles to money would make it very hard for forgers to fake.
Answer Link under Multimedia - Science museum/antenna → Safe and sound → Crime → Driving the forgers dotty.

9. Write a sentence about how nanotechnology works. What machine do scientists use?

____________________________________________

____________________________________________

____________________________________________

____________________________________________

Answer Link under Schools and Nanotechnology - Westwood Schools → How Does Nanotechnology Work.

10. Researchers are working on hydrogen nano fuel cells. How do these nanomaterials works?

____________________________________________

____________________________________________

____________________________________________

Answer Link under Schools and Nanotechnology - Westwood Schools → Examples of Nanotechnology Use.

# Nano4Newbies Scavenger Hunt

## Directions: Answer the following questions by visiting the webpage links on Nano4Newbies.

1. A nanometer is a millionth of a millimeter. Answer Link (under Introduction): http://nano4newbies.lib.usf.edu/index.php?option=com_content&task=view&id=25&Itemid=27
2. Even before the 1800's, stained glass artists were early users of nanotechnology. The ruby red color of some stained glass is due to the gold nanoparticles trapped in the glass matrix.
   Answer Link (under History of Nano): http://www.discovernano.northwestern.edu/whatis/History/HistoryPopup
3. List two material properties that change at the nanoscale. Electrical conductivity and mechanical strength
   Answer Link (under All Things Nano): http://www.earthsky.org/blog/50688/top-10-things-to-know-about-nanotechnology
4. Nanotechnology has several potential applications that will affect our everyday lives. What is one medical application that may be used in the future? Nanoparticles as a vehicle for gene and drug delivery. Answer Link (under Big Picture of Nanoscience): http://www.nanotechnology.com/docs/wtd015798.pdf
5. Some companies are beginning to create "smart" fabrics. These companies are using nanotechnology to coat fabric fibers. Two things these "smart" fabrics can do are: Resist stains and wick away moisture from the body.
   Answer Link (under All Things Nano → in the 20th century fabrics get 'smart'): http://www.earthsky.org/radioshows/51429/in-the-21st-century-fabrics-get-smart

6. "Nano" comes from the Latin word meaning dwarf. Answer Link (under New Horizons for Learning): http://www.newhorizons.org/strategies/technology/allen.htm
7. Scientists can build a very small artificial nose. The device is called a field effect transistor and measures changes in odor by associating different odors to changes in current. Answer Link (under Nanooze → Articles → the Bionic Nose): http://www.nanooze.org/english/articles/5senses_bionicnose.html
8. Counterfeiting currency could become much more difficult in the future. A quantum dot is a nanoparticle that will shine a very specific color. Adding combinations of these nanoparticles to money would make it very hard for forgers to fake. Answer Link (under Science museum/antenna → Safe and sound → Crime → Driving the forgers dotty): http://www.sciencemuseum.org.uk/antenna/nano/safeandsound/112.asp
9. Write a sentence about how nanotechnology works. What machine do scientists use? In nanotechnology scientists will be able to control individual atoms, which means they will be able to move atoms and molecules to specific places. Scientists will be able to do this by machines called assemblers. Answer Link (under Westwood Schools → How Does Nanotechnology Work): http://westwood.wikispaces.com/How+does+Nanotechnology+work%3F
10. Researchers are working on hydrogen nano fuel cells. How do these nanomaterials works? The nanomaterials will absorb hydrogen and release it only when needed. Answer Link (under Westwood Schools → Examples of Nanotechnology Use ): http://westwood.wikispaces.com/Examples+of+Nanotechnology+Use

# AFM Mystery Box Worksheet

**Names**

1
2
3
4

**Date**

**Box Height**

12 cm

***Measured Data***

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| **2** | 11 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 11 |
| **3** | 11 | 9 | 7 | 7 | 7 | 7 | 7 | 7 | 9 | 11 |
| **4** | 11 | 9 | 7 | 5 | 5 | 5 | 5 | 7 | 9 | 11 |
| **5** | 11 | 9 | 7 | 1 | 1 | 1 | 5 | 7 | 9 | 11 |
| **6** | 11 | 9 | 7 | 1 | 1 | 1 | 5 | 7 | 9 | 11 |
| **7** | 11 | 9 | 7 | 5 | 5 | 5 | 5 | 7 | 9 | 11 |
| **8** | 11 | 9 | 7 | 7 | 7 | 7 | 7 | 7 | 9 | 11 |
| **9** | 11 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 11 |
| **10** | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |

***Transformed Data***

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **2** | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| **3** | 1 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 3 | 1 |
| **4** | 1 | 3 | 5 | 7 | 7 | 7 | 7 | 5 | 3 | 1 |
| **5** | 1 | 3 | 5 | 11 | 11 | 11 | 7 | 5 | 3 | 1 |
| **6** | 1 | 3 | 5 | 11 | 11 | 11 | 7 | 5 | 3 | 1 |
| **7** | 1 | 3 | 5 | 7 | 7 | 7 | 7 | 5 | 3 | 1 |
| **8** | 1 | 3 | 5 | 5 | 5 | 5 | 5 | 5 | 3 | 1 |
| **9** | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 |
| **10** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |