*Grade 8*

# Nanotechnology

**Major Topic and SOL** Nanotechnology
Science SOL PS.1 a,c,l,n PS.3 b

**Length of Unit** 4 class periods (90 minutes each)

**Major Understanding**

Students will

- Define and describe the term Nano.
- Build an understanding and a mental visualization of one billion.
- Build an understanding and a mental visualization of one-billionth.
- Describe the geometry of a carbon nanotube and a buckyball.
- Understand the relationship between geometry of nanoscale objects and the behavior of the material.
- Develop an understanding of the unique properties of nanotechnology –engineered fabric.
- Apply concepts of adhesion and cohesion.

**Essential Questions**

- How could you describe something that is Nano?
- How could you describe a nanometer?
- What do you find unique about nanoshapes?

**Student Objectives**

Students will be able to:

- understand Nano in terms of size and scale.
- visualize the order of numerical properties of objects from the nanoscale to visible scale using exponents and decimals.
- develop an understanding of how small a nanometer is in comparison to common objects.
- model how nanotechnology-engineering applies to our everyday lives.

*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

| **Bloom's Taxonomy Skills** | **21st Century Learning Skills** |
|---|---|
| • Creating<br>• Evaluating<br>• Analyzing<br>• Applying<br>• Understanding<br>• Remembering | • Critical Thinking<br>• Problem Solving<br>• Communication<br>• Creativity & Innovation<br>• Collaboration<br>• Information & Media<br>• Contextual Learning<br>• Research |

**Assessment Evidence**

*Performance Tasks*

- Students will write a short essay describing the size of nano and how it relates to our lives today.

*Other Evidence*

- Story, illustration, discussion (written or oral) and/or
- presentation based on rubric
- Class Participation
- Teacher Observations
- Writing assignments
- Laboratory assignments/reports
- Group Work
- Quizzes
- Tests
- Rubrics

**Lesson 1: That's Huge!** (1-90 minute period)

**Technology** Computer, Internet

**Internet Resources**

- Reading: www.newsfactor.com/perl/story/15100.html

**Supplies/Materials**

Each group will need:

- Triple beam balance

- 1 small cup with 3 Tbsp of raw sugar
- Ruler
- Meter stick
- Golf ball
- 25 sheets of plain white paper
- Stop watch
- Tweezers
- Calculator
- Student sheets 1-5
- Article – " Nanotech: A Billion Computers in a Drop of Water" for background reading: www.newsfactor.com/perl/story/15100.html

For engagement activity:

- One gallon jar or jug filled with salt

**5E Lesson Plan**

***Engage:***

- Show students: http://learn.genetics.utah.edu/content/begin/cells/scale/ or a similar website in order to help visualize the nano scale in terms of actual size.
- Then show students a one-gallon jar filled with salt. Ask the students, *How many grains of salt are in the jar?* Have them record their answers on paper and set it aside. Student's responses may vary from 10,000 to one trillion.
- Record some of the responses on the board and tell the students to remember their guesses. You will reveal the answer at the end of the class.
- As a transition into discussing one billion, ask the students to describe a billion in their own words. Then write 1,000 on the board and ask the students *How many times larger than 1,000 is a billion?* The correct answer is a million and you can write on the board 1,000 x 1,000,000 = and then ask them how many zeros one billion should have.
- Write the answer 1,000,000,000 on the board. Then ask students how would one billion be written in exponential form? The correct answer is $1 \times 10^9$.

**Explore:**

- Have students complete the *Cutting It Down* to Nano activity.
- After they have completed that, explain to the students that they will be working in groups of four (be sure to assign roles of manager, reporter, and recorder) to solve some mysteries about the concept of a billion. There are five activities they will need to complete, and some of the activities will require them to move around the classroom. Students need about 25-30 minutes to complete the activities. Pass out the packet of activities, *Nanotechnology Unit Lesson 1 Student Sheet 1*.


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

- Circulate the room throughout the activities to check on their progress. Some groups may need additional assistance, depending on their mathematics and problem-solving skills.

**Explain:**

- Review the activities after the students have finished. Start with *Student Sheet 1*. Ask the students, *How big would a container need to be in order to hold one billion golf balls?* The correct answer is a box 50m (160 ft) on a side. This is equivalent to the volume of approximately 400 classrooms that measure 10m x 10m x 3m.
- Ask each student to place a golf ball in the palm of his or her hand, and tell the students it is one-billionth the size of the container.
- Continue reviewing the remaining activities. Encourage students to try visualizing the size or amount of one billion and to compare that size to one-billionth.

**Elaborate:**

- Ask students to get out their paper from the beginning of class. Give them a chance to change their initial estimate of the number of grains of salt in the jar. Write on the board: 1 Pinch = 1 Cup =
- Ask students, How many grains of salt are in a pinch? The correct answer is about 1,000 grains. Write 1,000 grains on the board beside 1 Pinch.
- Next ask the students to estimate how many grains are in a cup. The correct answer is 1,000,000 grains. Write 1,000,000 on the board next to 1 Cup. Now write on the board 16 cups = 1 gallon and ask the students to calculate how many grains of salt are in the one gallon jar. The correct answer is 16 x 1,000,000 = 16,000,000 grains of salt.
- Ask the students if this is an exact answer. Discuss with the students that the answer is an approximation and how it would be almost impossible to count every grain of salt.

**Evaluate:**

- Lastly, ask students to complete a checkout ticket of the following questions (have students write these questions and their answers to them on a sheet of paper that they can turn into you before they leave the classroom. It's their ticket out!), *How big would a container need to be in order to hold one billion grains of salt?* It is estimated that one billion grains of salt would fill a bathtub! Ask them to imagine a bathtub full of salt and to also imagine one tiny grain of salt. Ask students, *What fraction is a single grain of salt of the full bathtub?* This will give them a mental reference point that may help them later when conceptualizing the size of a nanometer.
- Use the rubric, *Grading Rubric Nanotechnology Unit Lesson 1: That's Huge*.


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

**Lesson 2: One in a Billion!** (1-90 minute period)

**Technology** N/A

**Internet Resources** N/A

**Supplies/Materials**

Each group will need:

- White paper
- 1 ml dropper
- Food coloring
- 200 ml of water
- Rinse cup of water
- 9 small cups (clear of white) or beakers
- 1 ml mouthwash
- 2 graduated cylinders (10 ml)
- Student sheets 1 and 2

**5E Lesson Plan**

***Engage:***

- Begin the activity by asking students, which is number is larger: one billion or one million? Then ask, which quantity is bigger: one part per million or on part per billion? Then ask students, would you prefer to have a concentration of toxic substance in your drinking water at one part per billion or one part per million? Please explain why. Listen to their responses to get an understanding of their prior knowledge. Ask the students to give you some examples of "things" that could represent one billion. Write the responses on the board.
- Once you have written down five to six examples of one billion, draw a line beside it to make a two-column chart and write One-Billionth at the top of the new column.
- Tell the students: Many people have a difficult time understanding very large numbers and very small numbers. In the last activity you learned about very large numbers, numbers in the billions. Today we are going to travel to the opposite end of the spectrum and learn about very, very small numbers. After the activity we will complete the chart by filling in examples of one billionth.

**Explore:**

- Have students work in pairs. Each pair should have 9 small cups or beakers placed on a blank white piece of paper to help them see the color change.

Explain that they will need to perform a series of dilutions, each larger by a power of ten. This is referred to as a serial dilution.

- Distribute *Nanotechnology Unit Lesson 2 Student Sheet 1, One in a Billion*. You may need to get them started by doing cups 1 and 2 as a class. You may also need to help them calculate the concentration for these cups.

**Explain:**

- Ask students to discuss the results of their investigation. Discuss with students that "parts per billion" typically is used when working with extremely small amounts. Nanotechnology is a field that works at this tiny unit.
- Discuss that a nanometer is one-billionth the size of a meter. The students could no longer see the food coloring at a certain solution level, however the pigment was still present. We cannot see objects that are at the nanoscale, but they do exist.

**Elaborate:**

- Distribute 1 ml of mouthwash to each group, nine clean cups (or beakers), and *Nanotechnology Unit Lesson 2 Student Sheet 2.* Students will use smell in this investigation as well as color as they make serial dilutions. Students are able to detect the presence of mouthwash by smell even after they can no longer see it. This provides an opportunity to discuss how things at the Nano scale are present even though they can't be seen.

**Evaluate:**

- *Nanotechnology Unit Lesson 2 Student Sheet 2* will evaluate students on this lesson.
- In addition, use *Grading Rubric Nanotechnology Unit Lesson 2: One in a Billion Lesson* rubric.

**Lesson 3: Nano Shapes** (1-90 minute period)

**Technology** computers, internet

**Internet Resources** N/A

**Supplies/Materials**

For each student:

- Copies of the *Build a Buckyball* pattern

**5E Lesson Plan**

***Engage:***

- Ask the students, *What are something's that are made of carbon? Have you ever heard of carbon?* You may have carbon graphite in your pencil or a ring or earrings with a diamond, a very hard form of carbon. It is the arrangement of carbon atoms that result in different forms from soft (graphite) to hard (diamond).
- Brainstorm all the different types of carbon that you may have encountered.

**Explore:**

- You can make a buckyball by connecting the carbon atoms in a distinctive pattern. Each buckyball is composed of 60 carbon atoms and is called C60 for short. The official geometric pattern is truncated icosahedrons. The ball has 32 faces including 20 regular hexagons and 12 pentagons. The hexagon has six equal sides and angles are equal. The pentagon has five equal sides and angles. When all the sides are the same length it is called "regular" hexagon or pentagon.
- Build a buckyball by cutting out the C60 pattern and taping the sides together. The sides are labeled with a letter so that you know to make side A on one face with side A on the corresponding face.
- Experiment with enlarging the buckyball pattern to make larger models. Copying the pattern on card stock will make it easier to fold and tape. Your finished buckyball should look just like a mini soccer ball.

**Explain:**

- Encourage students to examine the pattern and identify where the carbon atoms would be located and where the covalent bonds are found. Ask them, Are all the faces composed of a hexagon? Count the vertices to see if there are really sixty carbon atoms in the model.

**Elaborate:**

- Have students research on the internet geodesic domes and how they are used.

**Evaluate:**

- Assess students' understanding of nanogeometry by asking them to respond in groups or individually in writing to these questions:
  1. What unique properties do nanotubes have?
  2. How are buckyballs and nanotubes being used in new products and manufacturing?
  3. What aspects of geometry of the nanotube contribute to the unique properties of this molecule?
  4. Are nanotubes found only in laboratories or are they found in nature?
- Show your students several types of three-dimensional icosahedron shapes and ask them to identify which is not an accurate representation of buckyballs.
- Use the grading rubric, *Lesson 3 Nano Shapes*.


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

**Lesson 4: Nano Fabric** (1-90 minute period)

**Technology** N/A

**Internet Resources** N/A

**Supplies/Materials**

Each group will need:

- Piece of nano fabric
- Piece of untreated fabric
- Apron or old shirt
- 7 small cups
- 6 droppers
- Paper towels
- 2 small craft sticks
- Permanent marker
- Timer
- Student Sheet 1

Staining agents:

- Grape juice
- Orange juice
- Ketchup
- Mustard
- Oil
- Milk
- Cream
- Teacher needs:
- Pool noodle
- Pipe cleaners
- Pencil
- Balloon or ball

**5E Lesson Plan**

***Engage:***

- Open by asking: How many of you have to do laundry? Who would like to reduce the amount of laundry you have to do?
- Explain that you have purchased some fabric that has been treated through a secret process to make it stain resistant. You want to find out if it really works.

- Discuss with them that in order to have a controlled scientific experiment you must have a control variable. The control variable is a piece of untreated regular fabric.
- Explain that they are going to work in groups to test the fabrics using the staining agents and to see if they can predict which materials stain and which do not.

**Explore:**

- Students should wear aprons and safety goggles for this lab. Pass out *Nanotechnology Unit Lesson 4 Sheet 1* to each group of students.
- Before testing the fabric the students should make a prediction of what they think will happen with a written hypothesis on Student Sheet 1. Instruct the students to follow the procedures on Student Sheet 1. They should record their observations in Table 1.
- Once the students have make observations they should analyze their observations and complete the conclusions section of the lab. Discuss the results with the class.

**Explain:**

- Using background information provided, explain nanotechnology and how this fabric works. Model a cotton fiber by cutting a pool noodle so that it is about 1 foot long.
- Create the Nano whisker by wrapping pipe clearers around a pencil or other round object so that they appear to be coiled. Insert the nanowhisker into the cotton fiber so that they cover the entire cotton fiber. A blown-up balloon or ball could represent a water molecule. Place the balloon or ball up to the nanowhiskers to show that there is very little contact between the surface of the water molecule and the nanowhisker. This reduces friction between the two surfaces allowing liquids to roll off the surface. It also prevents the liquids from coming into contact with the actual cotton fiber. The liquid sits on the nanowhiskers.

**Elaborate:**

- Have students brainstorm about other ways to test the fabric. What might reduce the effectiveness of the treated fabric?

**Evaluate:**

- Check for understanding:
  1. In your own words describe the structure of a cotton fiber that has been treated with nanotechnology to make it stain resistant.
  2. How does this structure prevent some staining agents from staining the fabric?
  3. Why did some of the staining agents we tested actually stain the fabric?


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

4. Why is this treated fabric beneficial?
5. From the results you have seen of the various experiments what are your ideas on how the structure of the treated cotton fiber could be modified to improve effectiveness?
6. Can you think of other useful ways this concept could be applied?

- Use *Grading Rubric Nanotechnology Unit Lesson 4: Nanofabric*

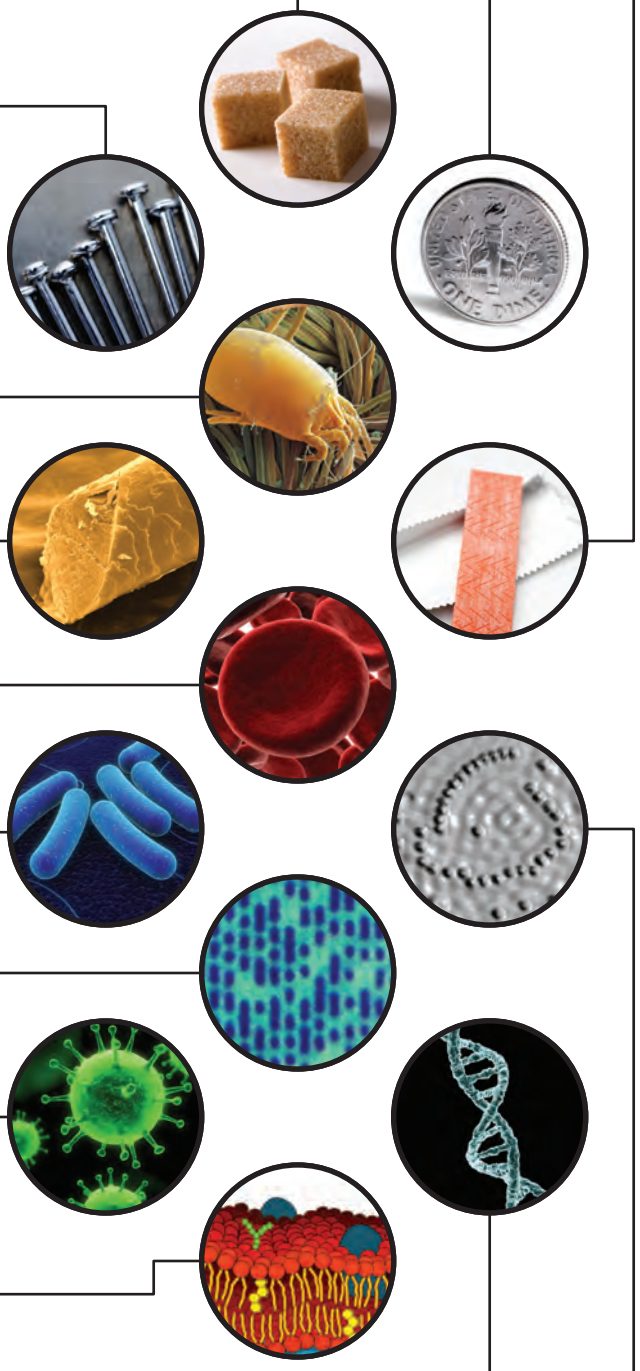
Grade 8

# CUTTING IT DOWN TO NANO

Cut paper strips in half. Tape onto worksheet. Repeat.

number of cuts

| | |
|---|---|
| 0 | 150,000,000 nanometers: **pencil** |
| 1 | 75,000,000 nanometers: **stick of gum** |
| 2 | 37,500,000 nanometers |
| 3 | 18,750,000 nanometers: **diameter of a dime** |
| 4 | 9,375,000 nanometers: **sugar cube** |
| 5 | 4,688,000 nanometers |
| 6 | 2,344,000 nanometers: **head of a pin** |
| 7 | 1,172,000 nanometers |
| 8 | 586,000 nanometers |
| 9 | 293,000 nanometers: **dust mite** |
| 10 | 146,000 nanometers |
| 11 | 73,000 nanometers: **human hair** |
| 12 | 37,000 nanometers |
| 13 | 18,000 nanometers |
| 14 | 9,200 nanometers: **red blood cell** |
| 15 | 4,600 nanometers |
| 16 | 2,300 nanometers |
| 17 | 1,100 nanometers: **bacteria** |
| 18 | 570 nanometers: **width of pits on CD** |
| 19 | 290 nanometers |
| 20 | 140 nanometers |
| 21 | 70 nanometers: **virus** |
| 22 | 35 nanometers |
| 23 | 18 nanometers |
| 24 | 9 nanometers: **thickness of cell membrane** |
| 25 | 4.5 nanometers |
| 26 | 2.3 nanometers: **width of the helix of DNA** |
| 27 | 1.1 nanometers: **ten hydrogen atoms** |



*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

## What is a nanometer?

A nanometer is one billionth of a meter ($10^{-9}$ meters). This means that if you took a meter stick and cut it into one billion (1,000,000,000) equal pieces, each piece would be one nanometer wide. That's so small that a human hair is about 73,000 nanometers wide. Or, to think of it another way, a nanometer is to the size of a softball as the softball is to the size of the earth.

## What is nanotechnology?

Nanoscience is the study and manipulation of materials on the scale of a few to a few hundred nanometers (the "nanoscale"). Nanotechnology involves putting this into use to improve devices and products.

Nanoscale materials can have very different properties than at a larger scale – for example, nanoscale particles of gold actually appear red – and these unique properties can allow them to be used in new and special ways. Scientists have already used nanotechnology to develop stain-resistant pants, self-cleaning windows, and incredibly small computer parts.

## What is the purpose of this activity?

We know that a nanometer is really tiny (or really, really, REALLY tiny), but it's still hard to imagine just how small one billionth of a meter is. A nanometer isn't just tiny in the way that a grain of sand or a speck of dust is tiny – it's thousands of times smaller than that.

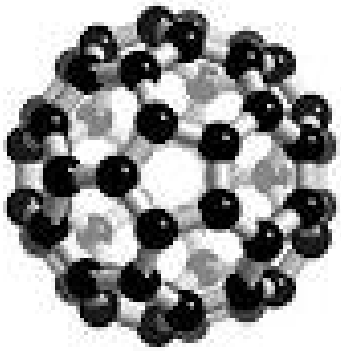
Look at the curve of your cut pieces of paper on the other side. Notice how much farther that curve extends before you could have a piece of paper that's one nanometer big. This can start to give you an idea of just how incredibly small the size scale that we're talking about is.

You may have also noticed how difficult it was to cut your piece of paper as it got smaller and smaller. The scissors, and our hands, are so big that they make extremely poor tools for cutting such a tiny piece of paper. Likewise, most traditional scientific tools are too big or lack the precision to be useful at the nanoscale. That's why scientists who work in nanotechnology have to use special tools to look at and manipulate materials that are just a few nanometers in size.

## Where can I get more information?

You can find lots more information about the nanoscale and nanotechnology at the "Exploring the Nanoworld" Web site, http://www.mrsec.wisc.edu/Edetc/ .


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*



Name _____
Date_____

Nanotechnology Unit
Lesson 1
Cutting it Down to Nano

**Materials**

- Paper strip (11 inches long)
- Scissors
- Ruler
- Calculator

**Process**

1. Fold the paper in half. Cut it. Record the new length in centimeters.
2. Repeat until you can't fold it in half anymore. Be sure you keep folding it the same way. Eventually, the width will be greater than the length.

**Challenge Questions**

1. Convert the lengths of the paper to millimeters, and record in the table. (Hint: 1 centimeters is 10 millimeters)

2. Convert the lengths of the paper to micrometers, and record in the table. (Hint: 1 millimeter is 1000 micrometers)

3. Convert the lengths of the paper to nanometers, and record in the table. (Hint: 1 micrometer is 1000 nanometers)

4. Compare your pieces of paper to other items on the nanoscale. (See addition scale sheet).

5. How close was your smallest piece of paper to the nanoscale?

6. How many times were you able to cut the paper?

7. Why did you have to stop cutting?

8. Can macroscale objects, like scissors, be used at the nanoscale?

*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

9. Can you think of a way to cut the paper even smaller?

**Fill in the table below.**

| Number of Cuts | Length (cm) | Converted to Millimeters (mm) | Converted to Micrometers (μm) | Converted to Nanometes (nm) |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

Name_____

# Grading Rubric
# Nanotechnology Unit Lesson 1: That's Huge

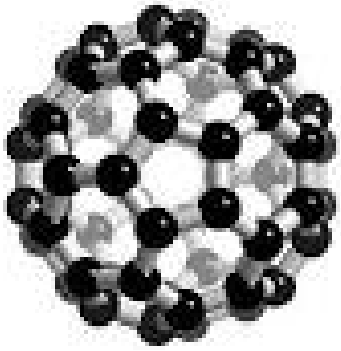
| | **Beginning**<br><br>**1** | **Developing**<br><br>**2** | **Accomplished**<br><br>**3** | **Exemplary**<br><br>**4** | **Score** |
|---|---|---|---|---|---|
| Participation in 1st class discussion and Brainstorming Activity<br><br>10% of grade for the Lesson | Contributes very little the brainstorming session and is not respectful of others when they are speaking. | Contributes some to the class discussion and is respectful of others when they speak. | Contributes to the class discussion and is respectful of others when they speak. | Contributes a great deal to the discussion and is very respectful of others when they are speaking. | |
| Cutting it Down to Nano<br><br>15% of grade for the Lesson | Completed the activity, however, none of the challenge questions are reasonable and not in complete sentences. | Completed the activity and some challenge questions have reasonable answers and in complete sentences. | Completed the activity and most of the challenge questions have reasonable answers and are in complete sentences. | Completed the activity and answers to challenge questions are reasonable and in complete sentences. | |
| Student Sheets 1 – 5<br><br>55% of grade for the Lesson | Completed 1-2 activities' predictions, process questions, results and challenge questions. | Completed 3 activities' predictions, process questions, results and challenge questions. | Completed 4 activities' predictions, process questions, results and challenge questions. | Completed all 5 activities' predictions, process questions, results and challenge questions. | |

*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

| | | | | | |
|---|---|---|---|---|---|
| Participation in 2nd class discussion and Brainstorming Activity<br><br>10% of grade for the Lesson | Contributes very little the brainstorming session and is not respectful of others when they are speaking. | Contributes some to the class discussion and is respectful of others when they speak. | Contributes to the class discussion and is respectful of others when they speak. | Contributes a great deal to the discussion and is very respectful of others when they are speaking. | |
| Participation in 3rd class discussion and Brainstorming Activity<br><br>10% of grade for the Lesson | Contributes very little the brainstorming session and is not respectful of others when they are speaking. | Contributes some to the class discussion and is respectful of others when they speak. | Contributes to the class discussion and is respectful of others when they speak. | Contributes a great deal to the discussion and is very respectful of others when they are speaking. | |
| Total / Grade | | | | | |


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

*Grade 8*



Name _____
Date_____

Nanotechnology Unit
Lesson 2
Student Sheet 1
One in a Billion

**Problem**
At what concentration (which cup) will the solution appear colorless?

**Prediction (Write your hypothesis in the space below.)**

**Materials**
Each group will need:

- White paper
- 1 ml dropper
- Food coloring
- 200 ml of water
- Rinse cup of water
- 9 small cups (clear or white) or beakers
- 2 graduated cylinders (10 ml)

**Process**

3. Number the cups or beakers 1 – 9

4. Place white paper under the 9 cups or beakers.

5. Using a gradated cylinder, put 1 ml of food coloring and 9 ml of water in cup 1. Be sure to rinse the graduated cylinder with water each time. Swirl cup or beaker gently to mix solution.

6. In the results chart, describe the color of the solution in cup 1 and write 0.1 under concentration to represent a 10% solution.

7. In cup 2 add 1 ml of solution from cup 1 and 9 ml of water. Again, describe the color and calculate the concentration of the solution. Record results in the results chart.

8. In cup 3 add 1 ml of solution from cup 2 and 9 ml of water. Record results in chart.

9. Continue the dilution process as done above from cups 4- 9. Record results in chart.

**Results**

| Cup | Color | Concentration |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |

**Conclusion**

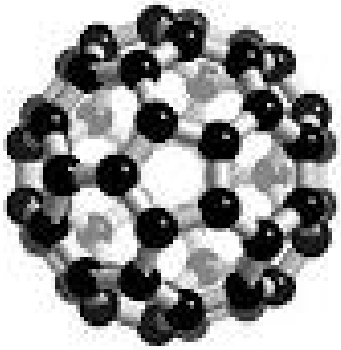
1. In which cup did the solution first appear colorless?

2. What is the concentration of food coloring in this cup?

3. Do you think there is any food coloring present in this cup of diluted solution even through you cannot see it? Explain.

4. What is the concentration of cup 9? Explain your answer in your own words.


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*



Name _____
Date_____

Nanotechnology Unit
Lesson 2
Student Sheet 2

**Going Further**

Your challenge is to dilute mouthwash to the point that it is a "nano" percent solution. You will use the same process as you did for the first dilution investigation. In cup 1 add 1 ml of mouthwash and 9 ml of water. As you continue the dilution process for cups 2 – 9, record your observation of color and smell. Calculate and record the concentrations.

Prediction: At what point do you think you will no longer be able to smell the solution? (Write a hypothesis in the space below.)

| Cup | Color | Smell | Concentration |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |
| 9 | | | |

**Discussion**

1. In which cup did the solution first appear colorless?
2. In which cup did the solution first appear odorless?
3. Which cup holds the "nano" percent solution?
4. What is the actual percent solution of this mixture written in numerical format?
5. Explain how you made a "nano" percent solution.

*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

*Grade 8*

Name_____

# Grading Rubric
# Nanotechnology Unit Lesson 2: One in a Billion

| | **Beginning**<br><br>**1** | **Developing**<br><br>**2** | **Accomplished**<br><br>**3** | **Exemplary**<br><br>**4** | **Score** |
|---|---|---|---|---|---|
| Participation in 1st class discussion and Brainstorming Activity<br><br>15% of grade for the Lesson | Contributes very little the brainstorming session and is not respectful of others when they are speaking. | Contributes some to the class discussion and is respectful of others when they speak. | Contributes to the class discussion and is respectful of others when they speak. | Contributes a great deal to the discussion and is very respectful of others when they are speaking. | |
| One in a Billion Activity<br><br>35% of grade for the Lesson | Completes activity, however, does not record all the data. Answers are not reasonably and not in complete sentences. | Completes activity and records all data. Answers some conclusion questions reasonably and in complete sentences. | Completes activity and records all data. Answers most conclusion questions reasonably and in complete sentences. | Completes activity and records all data. Answers conclusion questions reasonably and in complete sentences. | |
| Participation in 2st class discussion an<br><br>15% of grade for the Lesson | Contributes very little the class discussion and is not respectful of others when they are speaking. | Contributes some to the class discussion and is respectful of others when they speak. | Contributes to the class discussion and is respectful of others when they speak. | Contributes a great deal to the discussion and is very respectful of others when they are speaking. | |

*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

| | | | | | |
|---|---|---|---|---|---|
| One in a Billion – Going Further Activity<br><br>35% of grade for the Lesson | Completes activity, however, does not record all the data. Answers are not reasonably and not in complete sentences. | Completes activity and records all data. Answers some discussion questions reasonably and in complete sentences. | Completes activity and records all data. Answers most discussion questions reasonably and in complete sentences. | Completes activity and records all data. Answers discussion questions reasonably and in complete sentences. | |
| Total / Grade | | | | | |


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

# Construction of the $C_{60}$ Fullerene Model

**Student Handout**

## Purpose

To construct a paper model of a $C_{60}$ molecule.

## Introduction

In the past decades, scientists discovered that other forms of carbon exist besides that of the diamond, graphite and amorphous carbon allotropes. These forms of carbon are collectively known as the Fullerenes or Buckyballs, after Buckminster Fuller, who invented the geodesic dome, which has a similar structure. The most investigated fullerene is the $C_{60}$ molecule. It has the same shape as a soccer ball. The formal name for this shape is ***truncated icosahedron***. It has 32 faces, of which 20 are regular hexagons and 12 are regular pentagons. These faces come together at 60 points, or vertices. There is a carbon atom at each of these vertices.

Three scientists spent much time in investigating $C_{60}$ and its related fullerenes. They were awarded the Nobel Prize in Chemistry in 1996. The discovery of the fullerenes paved the way for nanotechnology in which scientists actively engaged in various ways of joining molecules together to produce useful new materials other than the familiar plastics.

## Materials and Tools

Templates I and II, a pair of scissors, adhesive tape

## Tasks

1. Use a pair of scissors to cut out the shapes of template I. With the help of adhesive tape, join the two strips together to form a chain of 10 hexagons (Fig. 1). Stick the head and tail of the chain together to form a ring (Fig. 2).

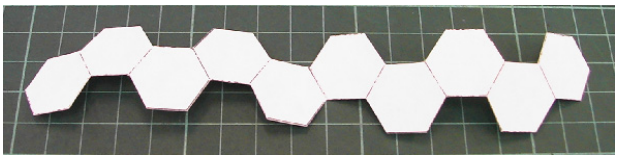


Fig. 1: Chain of 10 hexagons

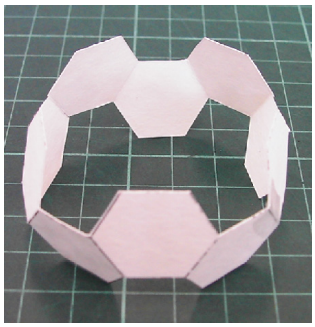


Fig. 2: A ring of 10 hexagons

2. Cut out the two shapes of template II. Complete two shapes each of which looks like Fig. 3.

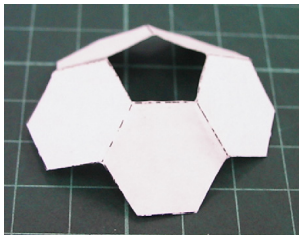


Fig. 3



*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

3. Create a hemisphere-like shape by joining the ring constructed in step (1) to one of the shape cut out in step (2) (see Fig. 4).

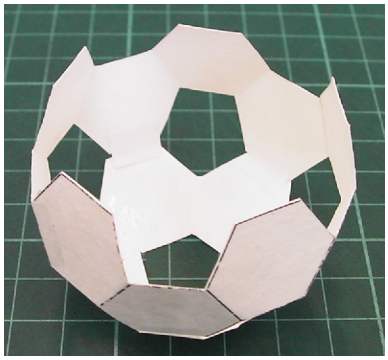


Fig. 4

4. Complete the model by joining in the remaining shape cut out in step (2) to the hemisphere.

**Questions for Discussions**

1. Describe in detail the appearance of the assembled sphere.

2. Explain why the sphere cannot be constructed entirely with hexagonal rings.

3. Does fullerene conduct electricity? Suggest an explanation in terms of the hybridization state of the carbon atoms.

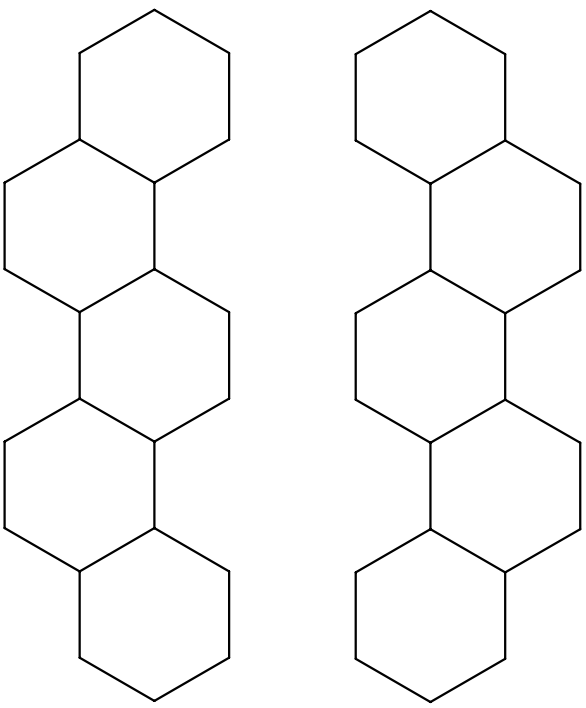
4. Based on the constructed model of $C_{60}$, suggest shapes of other fullerenes with more than 60 carbon atoms.

5. Suggest some applications of the fullerenes to illustrate its importance.

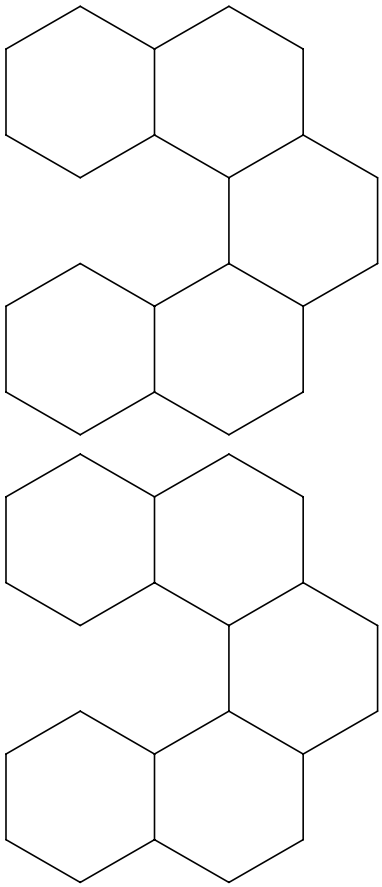


*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

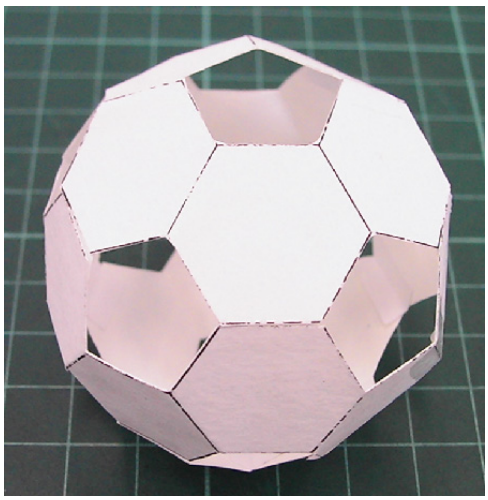
# Paper Model of Buckyball



Template I



Template II



A finished model of Buckminsterfullerene, $C_{60}$



*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

*Grade 8*

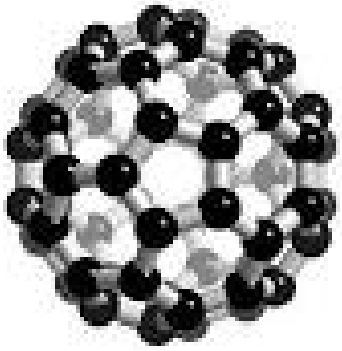
Name_____

# Grading Rubric
# Nanotechnology Unit Lesson 3: Nano Shapes

| | **Beginning**<br><br>**1** | **Developing**<br><br>**2** | **Accomplished**<br><br>**3** | **Exemplary**<br><br>**4** | **Score** |
|---|---|---|---|---|---|
| Participation in class discussion<br><br>20% of grade for the Lesson | Contributes very little the brainstorming session and is not respectful of others when they are speaking. | Contributes some to the class discussion and is respectful of others when they speak. | Contributes to the class discussion and is respectful of others when they speak. | Contributes a great deal to the discussion and is very respectful of others when they are speaking. | |
| Build your own Buckyball<br><br>30% of grade for the Lesson | Completes roughly half of the construction. | Completes more than half of the construction. | Completes all of the construction, however, the bucklyball will not stay together. | Completes all of the construction and the buckyball stays together. | |
| Evaluation questions<br><br>50% of grade for the Lesson | Not able to complete any of the evaluations questions. | Completes half of evaluation questions. | Completes all evaluation questions, however, some answers are not reasonable and/or are in complete sentences. | Completes all evaluation questions with reasonable answers and complete sentences. | |
| Total / Grade | | | | | |

*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

*Grade 8*



Name _____
Date_____

Nanotechnology Unit
Lesson 4
Student Sheet 1

# Fabric Comparison Test

**Problem Question:** Does fabric treated with nanotechnology resist stains from the following staining agents: mustard, ketchup, grape juice, orange juice, oil, milk, and cream?

Write a hypothesis of what you think will happen:

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

**Material**

- 10 cm x 15 cm piece of nanofabric
- 10 cm x 15 cm piece of untreated fabric
- Apron or old shirt
- 7 small cups
- 6 droppers
- Paper towels
- 2 small craft sticks
- Permanent marker
- Timer

**Staining Agents**

- Grape juice
- Orange juice
- Ketchup
- Mustard
- Oil
- Milk
- Cream

**Procedure**

1. Put on an old shirt or lab coat to protect your own clothes.
2. Divide into groups of 4 students.

*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

3. Place your two pieces of fabric flat on your desk. Label each with a marker so you don't get them confused in your data collection. The untreated fabric should be labeled "UF" and the treated fabric should be labeled "TF".

   Label the fabrics with the following abbreviations. Leave enough space between them to place the staining agent on the fabric above each label.

   GJ = Grape Juice

   OJ = Orange Juice

   K = Ketchup

   O = Oil

   Mi = Milk

   C = Cream

4. Put the staining agent in the cups on your desk.
5. Place two drops of grape juice on each piece of fabric above the GJ label. Do the same with the other staining agents so that they correspond with the correct label.
6. Let the staining agent sit for five minutes.
7. When the time is up, remove the staining agents with a damp paper towel.
8. Make observations of what you see on each piece of fabric and record those observations in your data table.

**Table 1. Data / Results**

| **Staining Agents** | **Fabric** | |
|---|---|---|
| | **Untreated Fabric (control)** | **Treated Fabric (experimental)** |
| **Grape Juice (GJ)** | | |


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

| | | |
|---|---|---|
| **Orange Juice (OJ)** | | |
| **Ketchup (K)** | | |
| **Mustard (M)** | | |
| **Milk (Mi)** | | |
| **Oil (O)** | | |
| **Cream (C)** | | |

**Conclusion**

1. Was your hypothesis proven or disproven? Explain.

2. What would you do to make this experiment better?

3. Would you buy fabric treated with nanotechnology? Why or why not?


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

4. How do you think nanotechnology-treated fabric works? You may draw a diagram to explain your ideas.

5. Are there other experiments you could try with nanofabric? What are they?


*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

*Grade 8*

Name_____

# Grading Rubric
# Nanotechnology Unit Lesson 4: Nanofabric

| | **Beginning**<br>**1** | **Developing**<br>**2** | **Accomplished**<br>**3** | **Exemplary**<br>**4** | **Score** |
|---|---|---|---|---|---|
| Participation in class discussion<br>10% of grade for the Lesson | Contributes very little the brainstorming session and is not respectful of others when they are speaking. | Contributes some to the class discussion and is respectful of others when they speak. | Contributes to the class discussion and is respectful of others when they speak. | Contributes a great deal to the discussion and is very respectful of others when they are speaking. | |
| Fabric Comparison Test<br>40% of grade for the Lesson | Completes the lab, however, does not record all data. Questions are not reasonable and are not answered in complete sentences. | Completes the lab and records all data. However, questions are not reasonable but are in complete sentences. | Completes the lab and records all the data. Most questions are reasonably answered and in complete sentences. | Completes the lab and records all data. All questions are reasonably answered and in complete sentences. | |
| Evaluation questions<br>40% of grade for the Lesson | Not able to complete any of the evaluations questions. | Completes half of evaluation questions. | Completes all evaluation questions, however, some answers are not reasonable and/or are in complete sentences. | Completes all evaluation questions with reasonable answers and complete sentences. | |
| Participation in class discussion<br>10% of grade for the Lesson | Contributes very little the brainstorming session and is not respectful of others when they are speaking. | Contributes some to the class discussion and is respectful of others when they speak. | Contributes to the class discussion and is respectful of others when they speak. | Contributes a great deal to the discussion and is very respectful of others when they are speaking. | |
| Total / Grade | | | | | |

*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*

*Lesson Contributed by: Lisa Fain*
*Funded through 2012 Mathematics and Science Partnership Grant, INSPIRS*