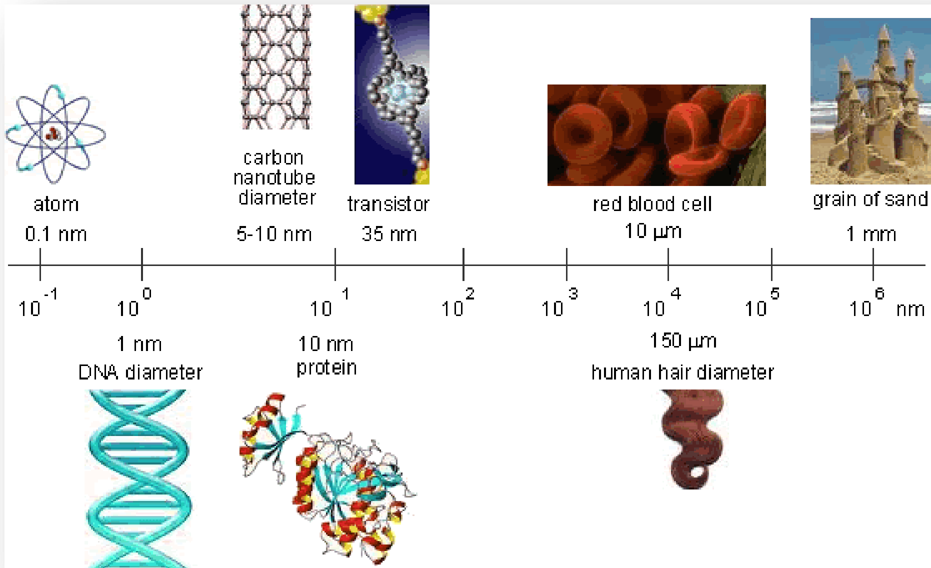
# EPICS®

## EPICS Program

## Introduction into Nanotechnology

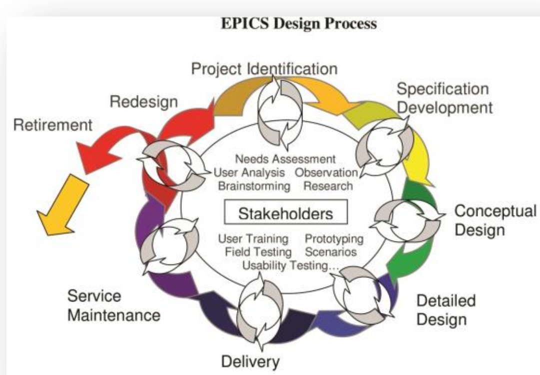



***Overview:*** As a part of the EPICS program/project discovery, teacher need background knowledge that will help them determine potential project within their community. One of the project identification categories is creating projects that educate younger students. In this workshop, the teachers will learn about NANO technology as a potential project for their students.

***Session Goal:***
The EPICS Teacher Participants will explore the emerging field of nanotechnology that will include scale, uses of nanotechnology, and careers in nanotechnology and hands on exploration of application of nanotechnology in the world and how it can be incorporated into projects with EPICS.

***Essential Questions:***

- What is Nano technology and how can I explain it to my students?
- How would Nano technology be incorporated into an EPICS project?
- What are some resources that I can use with my students?



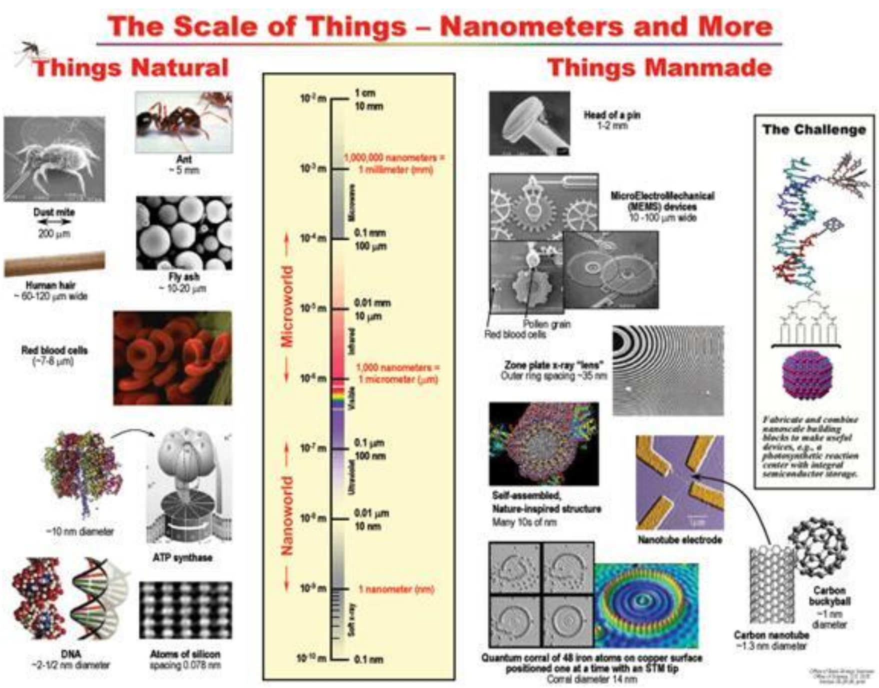
# *An Introduction to Nanotechnology*

Compiled by Earl Boysen of Hawk's Perch Technical Writing, LLC and UnderstandingNano.com.

Nanotechnology is defined as the study and use of structures between 1 nanometer and 100 nanometers in size. To give you an idea of how small that is, it would take eight hundred 100 nanometer particles side by side to match the width of a human hair. While this is the most common definition of nanotechnology researchers with various focuses have slightly different definitions. For a summary of these different definitions see [Definitions of Nanotechnology](),

## Introduction to Nanotechnology: Looking At Nanoparticles

Scientists have been studying and working with nanoparticles for centuries, but the effectiveness of their work has been hampered by their inability to see the structure of nanoparticles. In recent decades the development of microscopes capable of displaying particles as small as atoms has allowed scientists to see what they are working with.




The following illustration titled "The Scale of Things", created by the U. S. Department of Energy, provides a comparison of various objects to help you begin to envision exactly how small a nanometer is. The chart starts with objects that can be seen by the unaided eye, such as an ant, at the top of the chart, and progresses to objects about a nanometer or less in size, such as the ATP molecule used in humans to store energy from food.

Now that you have an idea of how small a scale nanotechnologists work with, consider the challenge they face. Think about how difficult it is for many of us to insert thread through the eye of a needle. Such an image helps you imagine the problem scientists have working with nanoparticles that can be as much as one millionth the size of the thread. Only through the use of powerful microscopes can they hope to 'see' and manipulate these nano-sized particles.

# Introduction to Nanotechnology Applications

The ability to see nano-sized materials has opened up a world of possibilities in a variety of industries and scientific endeavors. Because nanotechnology is essentially a set of techniques that allow manipulation of properties at a very small scale, it can have many applications, such as the ones listed below.

**Drug delivery.** Today, most harmful side effects of treatments such as chemotherapy are a result of drug delivery methods that don't pinpoint their intended target cells accurately. Researchers at Harvard and MIT have been able to attach special RNA strands, measuring about 10 nm in diameter, to nanoparticles and fill the nanoparticles with a chemotherapy drug. These RNA strands are attracted to cancer cells. When the nanoparticle encounters a cancer cell it adheres to it and releases the drug into the cancer cell. This directed method of drug delivery has great potential for treating cancer patients while producing less side harmful affects than those produced by conventional chemotherapy.

**Fabrics.** The properties of familiar materials are being changed by manufacturers who are adding nano-sized components to conventional materials to improve performance. For example, some clothing manufacturers are making water and stain repellent clothing using nano-sized whiskers in the fabric that cause water to bead up on the surface.

**Reactivity of Materials**. The properties of many conventional materials change when formed as nano-sized particles (nanoparticles). This is generally because nanoparticles have a greater surface area per weight than larger particles; they are therefore more reactive to some other molecules. For example studies have show that nanoparticles of iron can be effective in the cleanup of chemicals in groundwater because they react more efficiently to those chemicals than larger iron particles.

**Strength of Materials**. Nano-sized particles of carbon, (for example nanotubes and bucky balls) are extremely strong. Nanotubes and bucky balls are composed of only carbon and their strength comes from special characteristics of the bonds between carbon atoms. One proposed application that illustrates the strength of nanosized particles of carbon is the manufacture of t-shirt weight bullet proof vests made out of carbon nanotubes.

**Micro/Nano ElectroMechanical Systems**. The ability to create gears, mirrors, sensor elements, as well as electronic circuitry in silicon surfaces allows the manufacture of miniature sensors such as those used to activate the airbags in your car. This technique is called MEMS (Micro-ElectroMechanical Systems). The MEMS technique results in close integration of the mechanical mechanism with the necessary electronic circuit on a single silicon chip, similar to the method used to produce computer chips. Using MEMS to produce a device reduces both the cost and size of the product, compared to similar devices made with conventional methods. MEMS is a stepping stone to NEMS or Nano-ElectroMechanical Systems. NEMS products are being made by a few companies, and will take over as the standard once manufacturers make the investment in the equipment needed to produce nano-sized features.

**Molecular Manufacturing**. If you're a Star Trek fan, you remember the replicator, a device that could produce anything from a space age guitar to a cup of Earl Grey tea. Your favorite character just programmed the replicator, and whatever he or she wanted appeared. Researchers are working on developing a method called molecular manufacturing that may someday make the Star Trek replicator a reality. The gadget these folks envision is called a molecular fabricator;

this device would use tiny manipulators to position atoms and molecules to build an object as complex as a desktop computer. Researchers believe that raw materials can be used to reproduce almost any inanimate object using this method.

# The Nanotechnology Debate

There are many different points of view about the nanotechnology. These differences start with the definition of nanotechnology. Some define it as any activity that involves manipulating materials between one nanometer and 100 nanometers. However the original definition of nanotechnology involved building machines at the molecular scale and involves the manipulation of materials on an atomic (about two-tenths of a nanometer) scale.

The debate continues with varying opinions about exactly what nanotechnology can achieve. Some researchers believe nanotechnology can be used to significantly extend the human lifespan or produce replicator-like devices that can create almost anything from simple raw materials. Others see nanotechnology only as a tool to help us do what we do now, but faster or better.

The third major area of debate concerns the timeframe of nanotechnology-related advances. Will nanotechnology have a significant impact on our day-to-day lives in a decade or two, or will many of these promised advances take considerably longer to become realities?

Finally, all the opinions about what nanotechnology can help us achieve echo with ethical challenges. If nanotechnology helps us to increase our lifespans or produce manufactured goods from inexpensive raw materials, what is the moral imperative about making such technology available to all? Is there sufficient understanding or regulation of nanotech based materials to minimize possible harm to us or our environment?

Only time will tell how nanotechnology will affect our lives, but browsing through the topics on the navigation bar above or on our Nanotechnology Applications page will help you understand the possibilities and anticipate the future.

# Nanotechnology Web sites

Purdue University Nano Hub- http://nanohub.org/

Try NANO- http://www.trynano.org/lesson_plans.html

http://www.oknano.com/NanoforStudents.html

## At a Glance

**Essential Question:** What is nanotechnology and at what size is the technology applicable?

### Standards

**NGSS Science Standards Gr. 5**

5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.

**Mathematics**

Geometric Measurement: understand concepts of volume and relate volume to multiplication and to addition.
3. Recognize volume as an attribute of solid figures and understand concepts of volume measurement.

### Materials

- Powers of 10 card game set: Cards with recognizable objects of varying size will include the size as a power of 10 (in meters).

### Overview

The purpose of this lesson is to introduce nanotechnology and tie it to the concept of scaling, or the size relationship between different things. The main topic of the lesson will be how small nanoparticles are compared to everything else we see and experience. This is the first lesson in a series of introductory nanotechnology lessons that puts things into perspective in terms of scaling.

### Major Concepts

- A nanometer is one billionth of a meter.
- Objects can be described as being some quantity multiplied by the size of another object. This is scale, or how objects relate to each other in length, width, height, or volume.
- The logarithmic scale
- Things function differently at such small sizes.
- Atoms are on the scale of nanometers and are in everything we see around us.

### Objectives

Students will:

- Demonstrate understanding of a nanometer
- Demonstrate an understanding of just how small things on the nanoscale are and that they cannot be seen using the naked eye
- Make the connection between atoms, cells, and nanometers

## Lesson Preparation

### Preparation

- **Print Nano cards for teams of 4**
- **Student Sheet**

## Activity 1: Preparation for the Class

Explanation of what a nanometer is.

A nanometer is 1 x 10^-9 meters, or .000000001 meters.

Some comparisons:

A sheet of paper is about 100,000 nanometers thick, or .0001 meters.

A strand of human DNA is 2.5 nanometers in diameter (40,000 times smaller than the thickness of a piece of paper)

There are 25,400,000 nanometers in one inch

A human hair is approximately 80,000- 100,000 nanometers wide

A single gold atom is about 0.33 nanometers in diameter (about 5 times larger than a carbon atom)

On a comparative scale, if the diameter of a marble was one nanometer, then diameter of the Earth would be about one meter

One nanometer is about as long as your fingernail grows in one second

Define “nanotechnology” and introduce the concept of scale:

Nanotechnology is use of particles on the scale of 1 to 100 nanometers to create a desired function. It uses particles on this scale to create larger structures with the desired functionality.

Define Standards:

Things on the nanoscale are too small to be seen.

Nanoparticles are 3D things that have volume. Nanoparticles can also be combined into essentially 2D planes.

## *Activity 2: Powers of 10 Game*

Teams of students (about 4 per team) should be given the set of cards.
They will put them in order from smallest to largest based on their own knowledge of scaling.
They will then use the worksheet to write down what they think the value (either in length, diameter, or height as specified) is of the object.
The cards will range from a nanoparticles (or atom) to something seemingly infinitely large like the universe.
Students will then turn the cards over and observe the actual size of the object in terms of meters as a power of ten.
This will demonstrate to them the size relationship between objects and that things can be unimaginably large or small.
The teacher should then create a log scale line that encompasses all of the objects.
The line should start at -11 and go to +26 with evenly spaced intervals at every integer.
These numbers signify 10^(x) and the size value of each object will fit somewhere in between each of these intervals.
Have the students come up to the board and write down where each object would be placed on the log scale.
This will show them that things that are vastly different in size can be expressed using a scale that is more practical to comprehend and display.

## Activity 3: *Wrap Up*

Students will be given a post-lesson worksheet with the following questions:

- What is a "nanometer"?
- How we can observe nanotechnology?
- How big is an atom?
- What is nanotechnology?
- Put a list of things in order from smallest to largest (objects from the powers of 10 card game)

**Resources:**


1. United States Nanotechnology Initiative. "What's So Special about the Nanoscale?" Nano.gov. 3/9/2015. http://www.nano.gov/nanotech-101/special
2. Nanoscale Science Education. "Scale and Scaling." North Carolina State University. 3/9/2015. http://www.ncsu.edu/project/scienceEd/scale.html
3. Scaleofuniverse.com

# Nanotechnology Lesson 1: Introduction to Scale

**Essential Question:** What is nanotechnology and at what size is the technology applicable?

**Unpacking the Standards:**

**What is a "nanometer"?**

______________________________________________

______________________________________________

**What is nanotechnology?** ______________________

______________________________________________

______________________________________________

______________________________________________

**How can we observe nanotechnology?**

______________________________________________

______________________________________________

**How big is an atom?** __________________________

______________________________________________

______________________________________________

______________________________________________



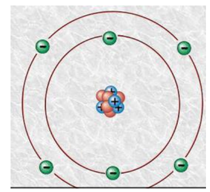


Name _______________________ Date _________ Period _____

**Put the following things in order from smallest to largest**

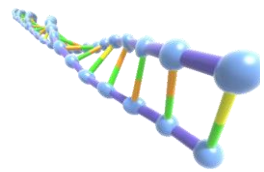
Human Blood Cell

Ranking in Size



A Carbon Atom

Ranking in Size



DNA

Ranking in Size

Nanometer- one billionth of a meter.

Nanometer

Ranking in Size

**What are carbon nanotubes and why are they useful?**

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

## 2.0 Nanotechnology and Surface Area to Volume Ratio

### At a Glance

**Essential Question:** How does surface area and volume ratio impact the way that materials react to their environment based on size?

### Standards

**NGSS Science Standards Gr. 5**

5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.

5-PS1-2 Measurement and graphing

**Mathematics**

5.NF(number and operations-fraction),

5.MD(Measurement and Data)

### Materials

- Paper cube cutouts (1 large, 2 medium, 4 small sized)
- Alka-Seltzer (2 pills (1 package) per activity)
- Cups (2 per activity)
- Measuring cups
- Water
- Stopwatches

### Overview

This section of the course will discuss about the effects of the change in materials due to variations in surface area and volume. The main goal of this section is to provide understanding of how chemical reactions occur faster when a larger surface area of the material is covered.

### Major Concepts

- Calculating Surface Area of a cube
- Calculating Volume of a cube
- Ratio of volumes between two different cubes
- Surface area to volume ratio
- Limits to infinity and zero

### Objectives

Students will:

- be able to calculate surface area to volume ratio, and should understand the underlying concepts behind it such as the fact that if the same shape of material gets smaller, the ratio increases.
- Explain a chemical reaction and how they can change how fast chemical reactions occur due to manipulating the surface area of reactants.

### Lesson Preparation

### Preparation

- Print cube cards or present students with two different sizes of cubes. Examples might be dice and children's blocks or math manipulatives.
- Student Observation Sheet

## Procedure

### Activity 1: Introduction and review surface area and volume of shapes

The goal of this activity is to review how to calculate surface area and volume of cubes.

**Procedure:**

**Note to Teacher:** If you are having the students construct their own shapes, they will need to cut out and assemble the cubes to use with this activity. If you are using dice or blocks, pass out the blocks.

#### Review Volume

**Create a definition of Volume**- Have the students discuss volume. What is it and why do we need to know volume.

Volume is the amount of space a 3D object takes up. It is measured in cubic units.

**Review the Formula for Volume:**
Volume=length x width x height.

- Pass out the cubes
- Measure the length of the edges of each cube
- Calculate the volumes and surface area.
- Check students understand
- Discuss the calculations

It is vital they know how to do this in order to understand the next activities.

#### Review Calculating Ratios and Fractions

***For a Great lesson, use Surface Area to Volume Ratios in Nano Science***
***http://www.community.nsee.us/lessons/Apples_to_Atoms/AtoAch5.pdf***

### *Activity 2: Introduction to surface area/volume ratio*

Goal: to teach them how surface area to volume ratio increases as the length of cubes decreases.

**Procedure:**

- To show how this works, we use the cube cutouts that they made in the first activity. The cutout will consist of 3 sets of cubes.
    - The first set will have 1 really large cube, the second will consist of 2 medium sized cubes, and the 3rd will be the 4 smallest cubes.
    - Have the students find the volume and surface area of the large cube and then calculate the ratio between the two.
    - Next, have the students measure the volume and surface area of both medium cubes. The students will then add the two volumes and the two surface areas together, and then calculate the ratio of the combined surface area to volume ratio.
    - Repeat this process for the four smallest cubes.
    - Have the students compare these ratios to see as one large box is divided into sections the amount of surface area becomes larger while the volume remains the same.

## Activity 3: Comparing the Chemical reaction of Alka-Seltzer based on surface area

**(Warning: Alka-Seltzer contains the active ingredient Aspirin)**

In this activity we shall apply the concept of limits to infinity and zero towards surface area/volume ratio in a real life experiment.

### Procedure

Using Seltzer, which fizz when touching water, we shall have the students take 2 Seltzer tables and 2 clear plastic cups.

- First of all ask the students to leave the first Seltzer tablet intact
- Crush the second Seltzer tablet. A suggestion is keeping the second tablet in the foil packet after taking out the first and having the students crush the table with their shoe.
- Measure ½ cup of water and pour the water into each of the two cups.
- Make sure that the students have their observation sheets ready to record
- Make sure that you have each member of the team assigned a job for the experiment.

### Discussion:

- Which one they think will dissolve the fastest and which tablet will fizz the most?
- Have them write down their predictions

#### Dissolving of the full tablet of Seltzer

- Have the students fill the container with ½ cup of water
- have the students drop the tablet into the cup
- The students will time how long it takes the table to dissolve.
- Write the observation on the student sheet

#### Dissolving of the crushed seltzer table

- fill the second container with ½ cup of water
- Add the powder into the cup.
- Time how long it takes the second container of seltzer to dissolve.

- Write down their Observe.

### Discussion

How fast did the second container dissolve compare to the first container?

**Note To teacher:** They should observe the quick and vigorous fizz versus the slow fizz of the complete tablet. Even though it's the same amount of Seltzer, the powder from the crushed tablet has a larger surface area to volume ratio, and since the surface area is larger, it has a faster reaction time than the complete tablet.

### Activity 3: *Wrap Up*

- Ask the students how to calculate Area, Volume, and Surface Area. Feel free to ask a student to demonstrate if they would like.
- Have the students complete the Question Worksheet.
- Questions on the worksheet will include:
  - As a particle gets smaller, what happens to its surface area to volume ratio?
  - What would happen if you took an Alka-Seltzer tablet and continued to break it into smaller pieces? How would the reaction with water change as the pieces got smaller and smaller?
  - How would you describe infinity?
  - Why is the surface area/volume ratio important in nanotechnology?

**Resources:**


1. United States Nanotechnology Initiative. "What's So Special about the Nanoscale?" Nano.gov. 3/9/2015. http://www.nano.gov/nanotech-101/special
2. Nanoscale Science Education. "Scale and Scaling." North Carolina State University. 3/9/2015. http://www.ncsu.edu/project/scienceEd/scale.html
3. ***http://www.community.nsee.us/lessons/Apples_to_Atoms/AtoAch5.pdf***

# Nanotechnology Lesson 2: Surface Area to Volume Ratio

**Essential Question:** How does surface area and volume ratio impact the way that materials react to their environment based on size?

**Unpacking the Standards:**

**Surface Area related to the Chemical Reaction of Seltzer**

**Make a Prediction: Which cup will have the fastest reaction time, the crushed seltzer tablet or the whole?**

______________________________________________

______________________________________________

**Cup 1- Full Seltzer Table Observation:**

**Time:** ________________________________________

**Cup 2- Crushed Seltzer Tablet Observation:**

**Time:** ________________________________________

**How did surface area make a difference in this experiment?**

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________





Name ______________________ Date _________ Period _____

## Reflection:

How does this information help you understand how different materials function at the Nano scale?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

As a particle gets smaller and smaller, what happens to its surface area to volume ratio?

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

What would happen if you took a Seltzer tablet and continued to break it into smaller pieces? How would the reaction with water change as the pieces got smaller and smaller?

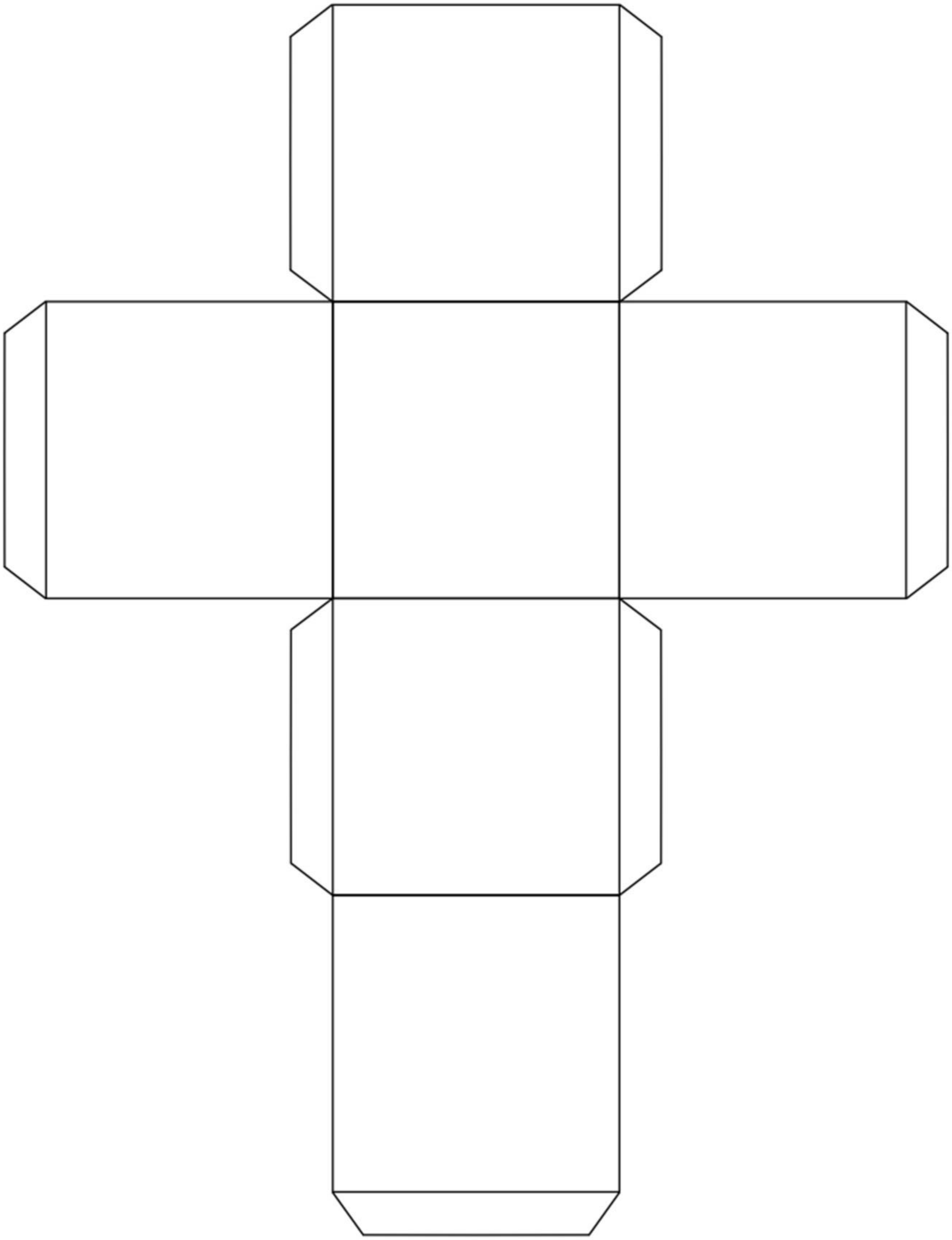
______________________________________________

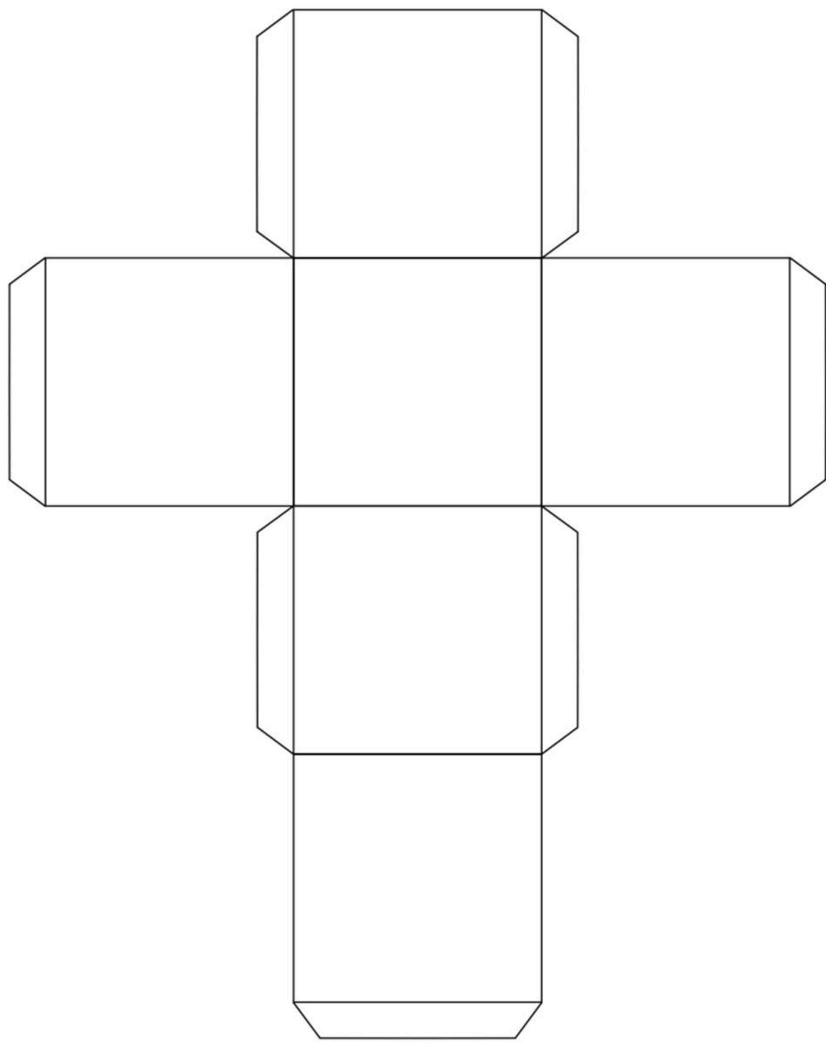
______________________________________________

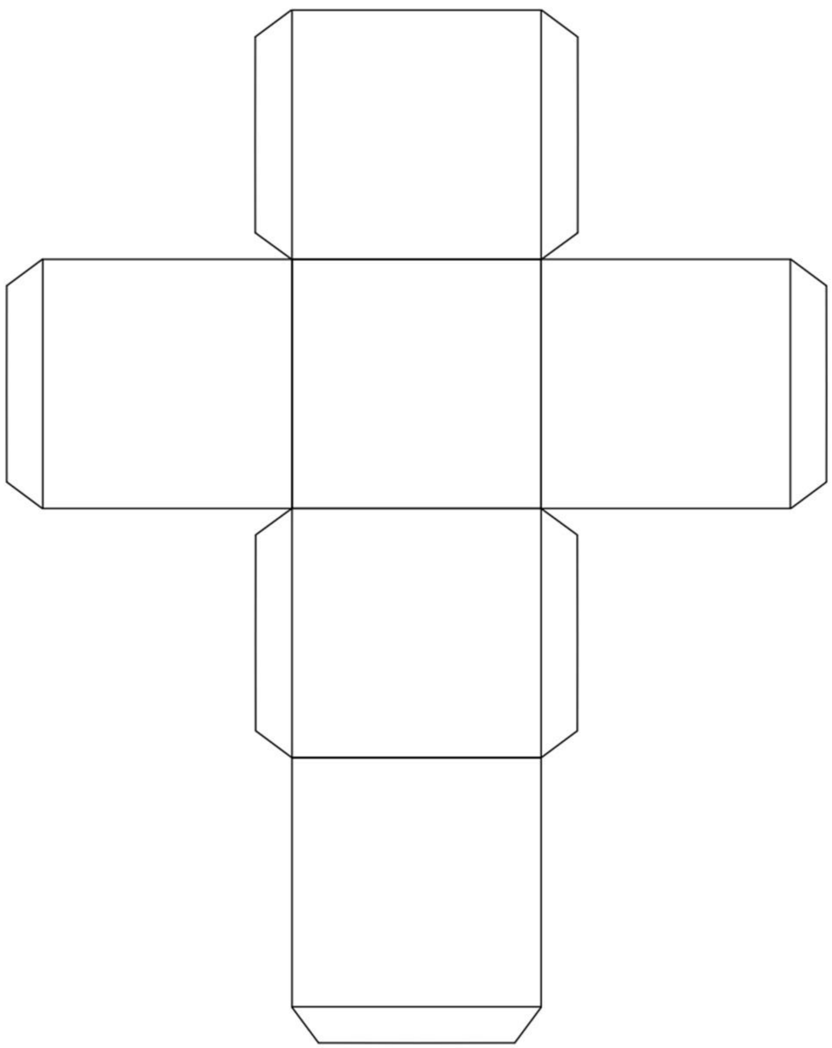
______________________________________________

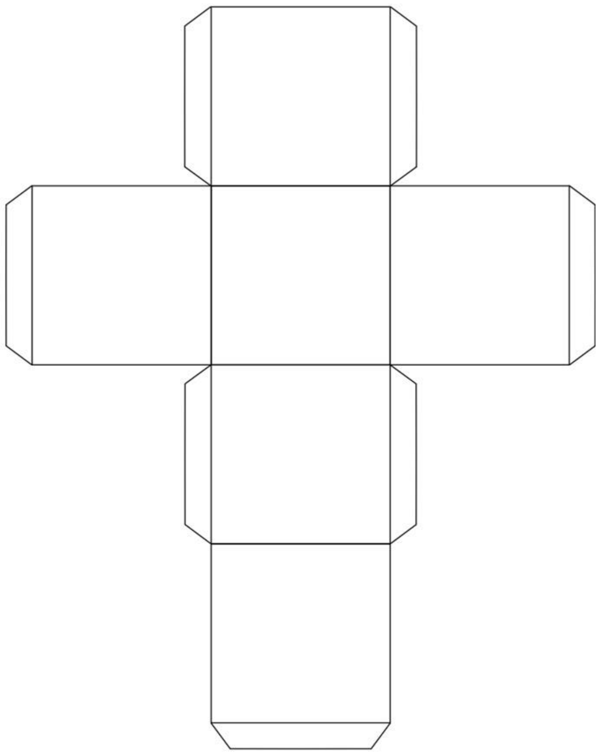
______________________________________________

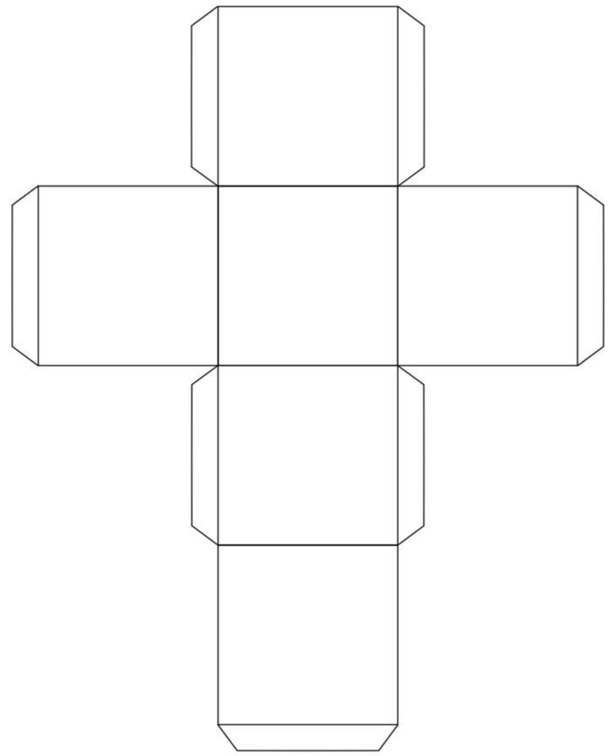
______________________________________________

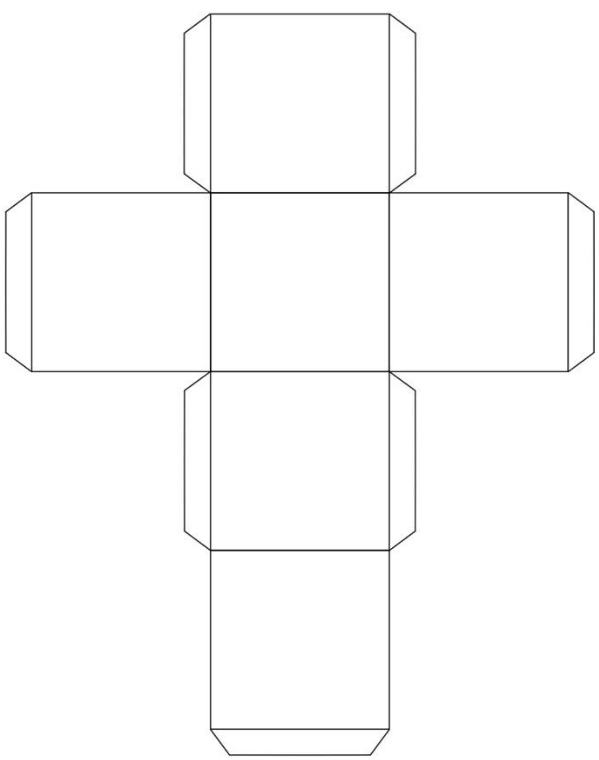


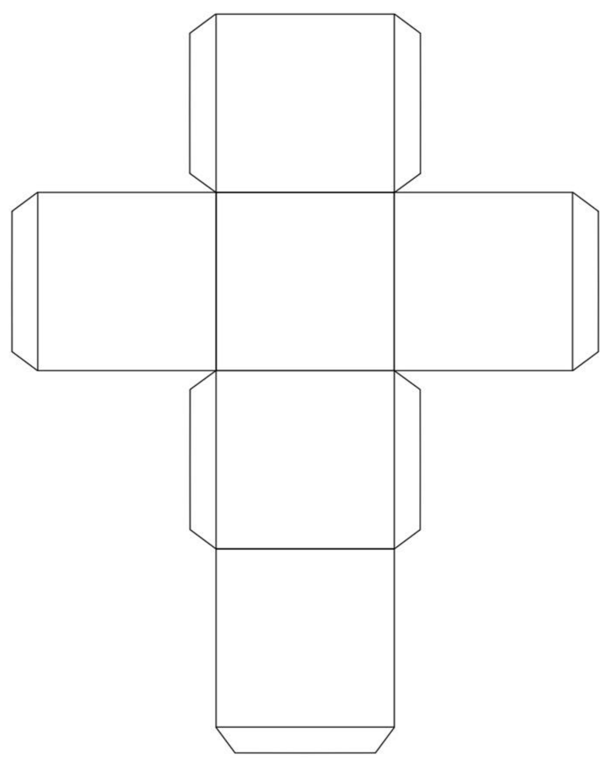


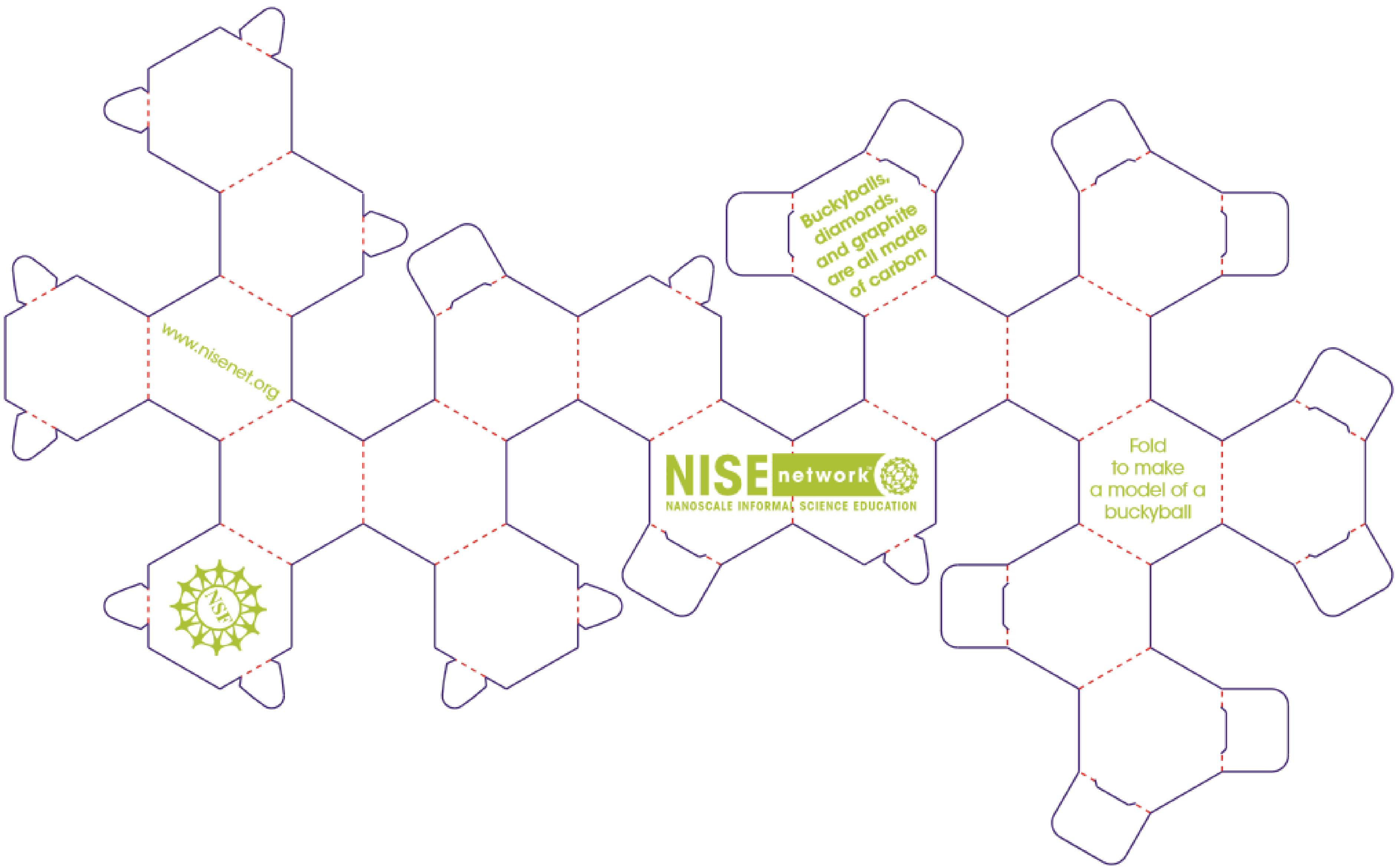











www.nisenet.org
Buckyballs, diamonds, and graphite are all made of carbon
NISE network
NANOSCALE INFORMAL SCIENCE EDUCATION
Fold to make a model of a buckyball