EXPLORE NANOTECHNOLOGY USING PAPER

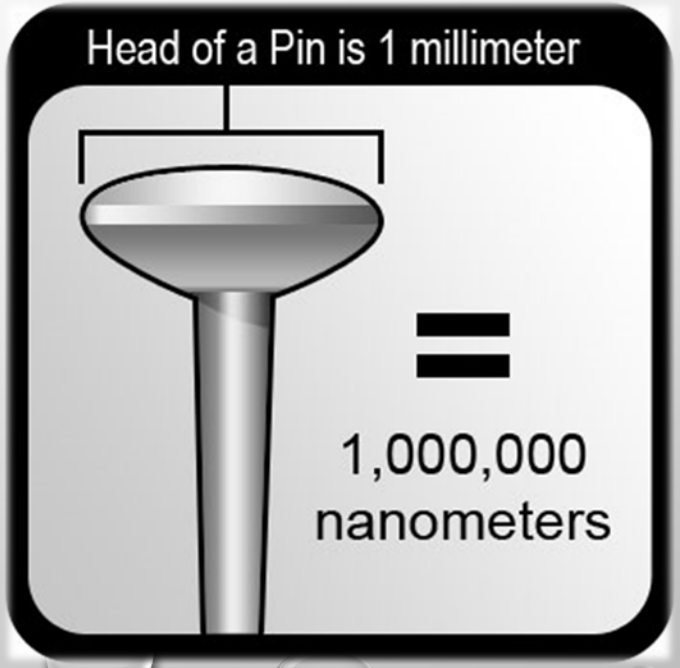
DAY 3

What is NANOTECHNOLOGY?

Nanotechnology is the science of studying materials at the "nano" scale, or the scale of individual atoms and molecules.

Just how small is the nanoscale?

A nanometer is one *billionth* of a meter. A typical push pin is about 1,000,000 nanometers wide---so a nanometer is *really* small!



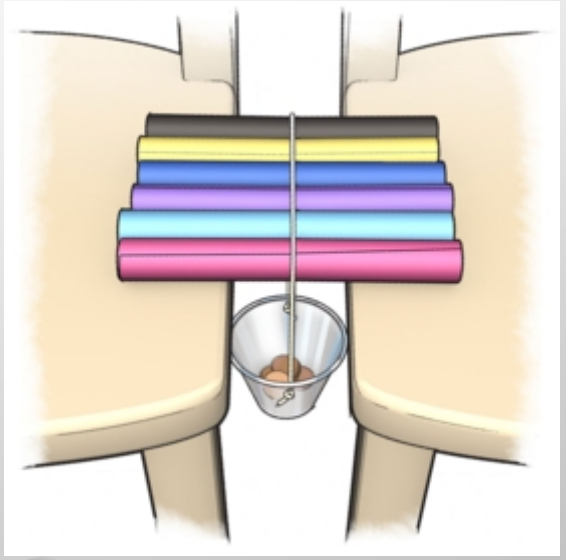
The structure of material at the nanoscale can dramatically change how it behaves.

For example, pencils contain graphite, which is made up of carbon atoms that are arranged in sheets and can easily rub off onto paper.

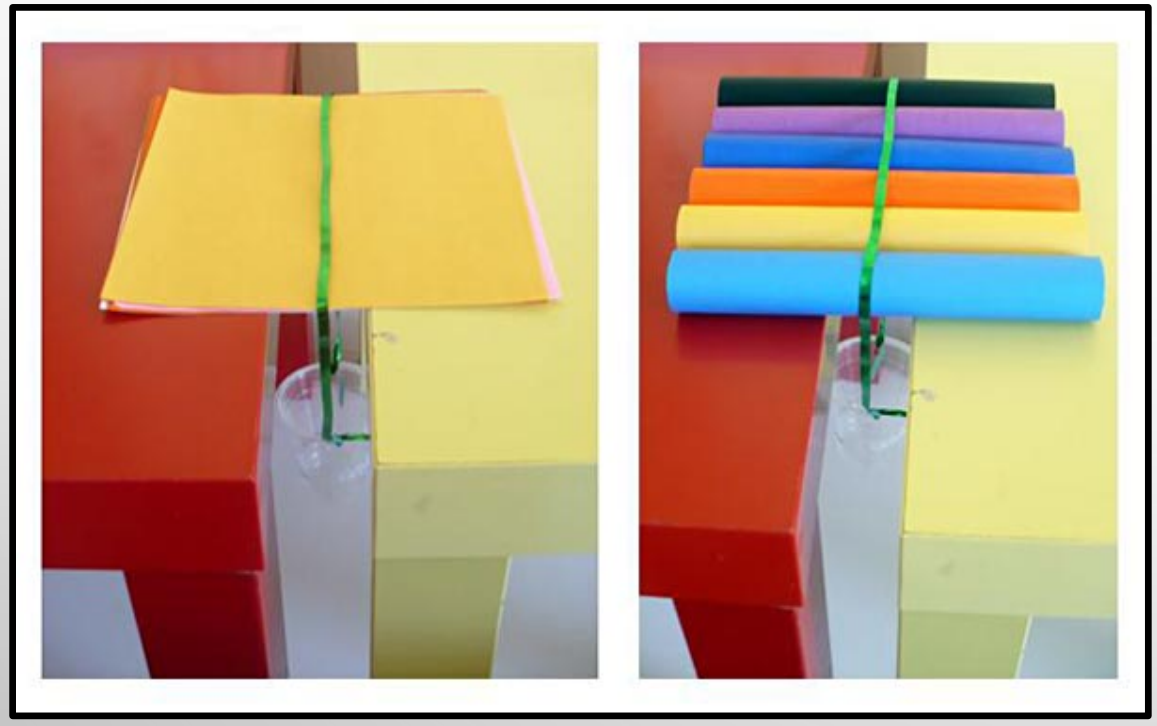
Carbon atoms, however, also make up some of the world's strongest materials---diamonds! In diamonds, carbon atoms are tightly packed together, making them so hard they can cut steel.

Scientists are working on another superstrong version of carbon atoms called ***carbon nanotubes***, which consist of sheets of carbon atoms rolled into tiny cylinders. Although this makes individual carbon nanotubes incredibly strong, mass-producing carbon nanotubes remains a challenge.

In this activity you'll compare the strength of paper that is *stacked in sheets* versus *rolled into tubes* to simulate the difference between flaky graphite and carbon nanotubes.



MATERIALS:



- ❑ 2 TABLES, CHAIRS OR DESKS OF EQUAL HEIGHT
- ❑ 12 PIECES OF PAPER
- ❑ SCOTCH TAPE OR RUBBER BANDS
- ❑ PLASTIC CUP
- ❑ STURDY STRING OR RIBBON
- ❑ HOLE PUNCH
- ❑ MANY COINS, ALL OF THE SAME TYPE (FOR EXAMPLE: ABOUT 250 PENNIES OR ABOUT 100 QUARTERS

PREPARATION:

- ✓Set up two identical tables, chairs or desks so they are next to one another, with a 2-3 inch gap in between.
- ✓Roll 6 of the pieces of paper into tubes about 1 inch in diameter. The other 6 will remain flat.
- ✓Use the hole punch to punch 2 holes on opposite sides of the cup, near the rim at the top. Cut a piece of string several feet long and tie one end of the string securely to each hole.

STEPS:

1. Stack 6 sheets of paper on top of one another so that they bridge the gap between your two tables. Center the sheets across the middle of the gap.

2. Hang the plastic cup from the sheets of paper so the string goes directly across the middle of the sheets (centered in the gap between the tables).

STEPS:

3. One by one, add pennies to the plastic cup until the paper falls. (Note: if the string breaks before the paper, retie the knot or use thicker string)

How many coins does it take to make the paper fall?
What happens to the paper?
Does it bend gradually or does it fold sharply in the middle?

STEPS:

4. Now, lay the 6 tubes of paper next to one another, with each one crossing the gap between the tables. Center the tubes across the middle of the gap. Make sure the tubes are pressed up against one another with no space in between. (You may need to hold the tubes together with tape or a rubber band.)

5. Hang the plastic cup from the tubes so the string goes around all 6 tubes and is centered in the gap between the tables. Tie the string ends in a knot.

Do the tubes sag at all under the weight of the plastic cup alone?

STEPS:

6. One by one, add your coins to the plastic cup until the tubes fall.

How many coins does it take to make the tubes fall?
What happens to the tubes?
Do they bend gradually?
Do they fold sharply in the middle?

- Which structure could hold more coins, the flat sheets of paper or the paper tubes?
- How do you think this relates to what you read about graphite and carbon nanotubes at the beginning of this lesson?
- Were the rolled sheets of paper stronger than the stacked sheets? If so, why?