Structure of Matter: Activity 1

Hockey Sticks

Stick To It

Nick and Jordan here. We love to play sports! Jordan just got a new hockey stick made with carbon nanotubes. We wanted to know more about carbon nanotubes, so we headed to the **Museum of Science** in Boston, Massachusetts. We learned that the structure of a nanotube determines its properties.

Our question:

How do carbon nanotube hockey sticks compare to wood and composite sticks?

We put our hockey sticks to the test on the ice. Then, with help from scientists at **Harvard University**, we compared the tensile strength of the sticks and used powerful microscopes to "see" the carbon nanotubes inside.

Nano Matters

At the nanoscale, the way in which atoms and molecules are arranged determines the particular properties of a material. Small changes at the nanoscale can have big effects on properties we observe at the macroscale. Because they are strong and lightweight, carbon nanotubes are being incorporated into a variety of composites and are making their way into sporting goods and other consumer products.

Icebreaker

Engineer a small bridge for a heavy load.

15 minutes

DragonflyTV Skill: Experimenting

Guide your kids as they

1) Place 2 cups upside down about 1" apart.
2) Peel off 2 Post-it notes and stack them as a flat bridge between the cups.
3) Place pennies one at a time on the middle of your Post-it note bridge. When the structure falls, count how many pennies you used.
4) Roll up 2 Post-it notes. Use a pen or pencil to make small tubes and the sticky ends of the Post-its to keep the tubes closed.
5) Place these tubes across the gap between the cups.
6) Carefully put pennies on the bridge one by one. Count how many pennies the bridge can hold before it bends and collapses.

Adapted from: Johnsen, Jill. Stronger Than Steel. Explore Magazine July/Aug./Sept. Issue (2006).

You'll need:

- Post-it notes
- pennies
- pen or pencil
- 2 cups

Are you a nano-bit curious?

Carbon molecules come in many forms and the way the atoms are arranged determines the properties of the material. With the Post-it notes, you modeled two types of carbon molecules: graphite and carbon nanotubes. In graphite, carbon atoms are arranged in a honeycomb pattern and stacked in sheets. It is very soft and breaks easily because the sheets can glide along one another. Carbon nanotubes (CNTs) are comprised of that same honeycomb sheet, but they are rolled into a tube. The strength greatly increases due to this structure. In fact, carbon nanotubes are about 50 times stronger than steel, but much lighter. To view illustrations of graphite and CNTs, see the **Image Gallery** on page 66.

Investigation

See what a difference materials make.

2 hours plus drying time and an additional hour for testing

You'll need:

- dirt or soil
- water
- flour
- sand
- measuring cups and spoons
- container to use as a mold (aluminum foil loaf pan or old juice or milk container)
- straw, wheat or dried grass of various thicknesses
- toothpicks
- bucket
- weights (books, rocks, water, etc.)
- notebook and pencil

Guide your kids as they

1) Brainstorm examples of composites. (A composite is a material made of 2 or more different components. Each component keeps its own identity, but adds a property to the final product that each piece alone would not have.) Examples include: fiberglass, concrete, Mylar balloons, skateboards, carbon nanotube hockey sticks.
2) Mud bricks are one of the earliest examples of composites. Provide your students with the supplies listed. Examine the properties of each material and record observations in a notebook. (For example, straw is strong when pulled, but is very weak when crumbled. A flour and water mixture is very sticky. Soil can be packed tightly, but crumbles easily.)
3) Challenge the kids to make the best mud brick that can pass the following tests using any of the materials provided. Make sure they record the recipe for each brick in their notebook.
   a) Roll the brick (end over end) 5 times. Does it crumble?
   b) Stack weights on top of the brick. How much can it hold?
   c) Submerge the brick in water for 30 seconds. Does it fall apart?
   d) Think of your own test! An example is a bending test. Place the brick across 2 desks. Tie a string to the handle of a bucket and wrap the opposite end around the brick. Slowly add water to the bucket, marking a line on the bucket when the brick breaks.
4) Share your results with the group. Why do you think straw and mud were both essential components of mud bricks used for housing?

DFTV Science Helper

Bricks must bake in the sun for 2–3 days prior to testing. If they are still damp when dumped out of the molds, let them dry more before running the investigation or briefly bake them in an oven.

nano

Watch the "Zoom Cab" feature from Show 706: Nanotechnology and Society to see a carbon fiber at the nanoscale.

Are you a nano-bit curious?

A carbon nanotube hockey stick is a composite, like a mud brick is. Carbon nanotubes, similar to the straw, have a lot of tensile strength. Think of a piece of paper. It has tensile strength because it can be pulled hard before it breaks, yet it crumbles easily. A cake of mud (used in most mud bricks) is similar to the soil and flour mixture you made. It can withstand a compression force (heavy weight on top), but not bending. If straw is embedded in the brick, it can resist both compression and bending. Scientists are excited about carbon nanotubes because they add tensile strength to various composites (e.g., hockey sticks, tennis rackets, golf clubs) without adding much weight.

DFTV Kids Synthesize
Data and Analysis

Here's an example data table that can help you record your observations. Adjust the table as necessary for your investigation.

	Roll test	Stack test	Submerge test	Your own test (bending, tearing, etc.)	What properties of the mixture made the brick behave this way?
Brick #1					
Brick #2					
Brick #3					

Keep Exploring!

Experiment with different types of soil. Try sifting the soil with various types of mesh screen to see if the size of the dirt particles affects how the brick behaves. How important is the identity of the "glue" holding the brick together? Experiment with gluten, powdered clay and plaster of Paris.

For additional ideas on how to expand this activity, see http://nasaexplores.nasa.gov/show_912_teacher_st.php?id=02122385811.