Size and Scale: Activity 1

What's Nano?

Extreme Measures

We're Ebony and Jasmine. We just caught the Amazing Nano Brothers Juggling Show at the **Museum of Science** in Boston, Massachusetts, and it really got us thinking.

Our question:

How big is one billion and how small is one nanometer?

We searched the city of Boston from candy factories to Faneuil Hall for one billion of something. We finally reached it when we counted blades of grass on a football field. On our quest to see something one nanometer (one billionth of a meter) in size, we got some help from scientists at **Harvard University**. It turns out that things that are only nanometers in size are too small to see except with very powerful microscopes.

Nano Matters

A large barrier to understanding the nanoscale stems from misconceptions of size and scale. As soon as things become either too immense or too minute for us to visually comprehend, they tend to be grouped together and labeled "large" or "small." Atoms are the perfect example. Although they are the basis of all matter, atoms are difficult to visualize because their size is so unfamiliar. Scale ladders help kids recognize the order of magnitude of some benchmark objects and correctly arrange them in order of size. This exercise also increases familiarity with the metric system, the universal language used by scientists, and some common prefixes such as "micro" and "nano." The ultimate goal is for kids to get one step closer to wrapping their heads around the unimaginable.

Icebreaker

Make a human scale ladder.

20 minutes

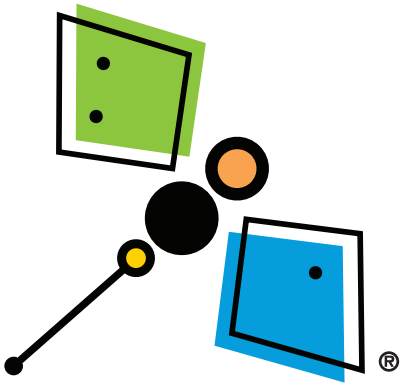
DragonflyTV Skill: Experimenting

Guide your kids as they

1) Print out the images from our website, write down the name of each object on a notecard or have the kids draw pictures of each object. (For object ideas, see the table on the following page.)
2) As a warm-up, have the children try to arrange themselves in order of height (tallest on one end and shortest on the other).
3) Now, give each child (or pair of children) a card with the name or image of an object. Tell them to communicate with other members of the group to see if they can arrange the objects they are holding in order of size (largest objects on one end and smallest on the other).
4) Can they predict which objects are macro-, micro-, nano-, and atomic scale?

You'll need:

- images from website (pbskidsgo.org/dragonflytv/show/whatsnano.html)
- notecards (optional)



Are you a nano-bit curious?

Here are some objects to consider. Choose objects that are appropriate for your audience. This is also a nice opportunity to teach the name and abbreviation for some common units of scientific measurement.

Object	Approximate Size	Scale
Atom	0.2 nm	Atomic
Width of DNA	2 nm	Nano
Virus	100 nm	Nano
Bacteria	1 µm (1000 nm)	Micro
Red blood cell	7 µm (7,000 nm)	Micro
Width of hair	100 µm (100,000 nm)	Micro
Dust	500 µm (500,000 nm)	Micro
Dime thickness	1 mm (1,000,000 nm)	Macro
Flea	2 mm (2,000,000 nm)	Macro
Ant	1 cm (100,000,000 nm)	Macro

Abbreviation	Prefix	Exponential	In Words...
cm	centi-	10^{-2}	hundredth
mm	milli-	10^{-3}	thousandth
µm	micro-	10^{-6}	millionth
nm	nano-	10^{-9}	billionth

Investigation

Sniff your way to one billionth.

1-1/2 hours

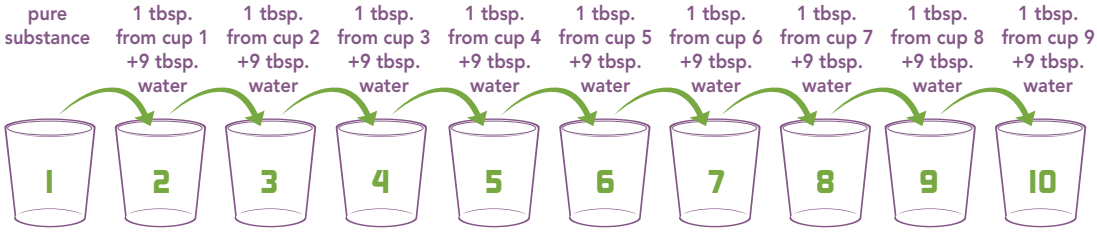
Guide your kids as they

1) Break up kids into groups and have them label the jars 1–10. (The advantage of using jars with lids over cups is to keep them closed as long as possible to trap the scent inside.)
2) Assign each group one strong scented liquid, which they should keep a secret.
3) Place 2 tablespoons of the scented liquid in cup 1.
4) Fill cup 2 with 1 tablespoon of the liquid in cup 1 plus 9 tablespoons water. Stir.
5) Fill cup 3 with 1 tablespoon of the diluted liquid in cup 2 plus 9 tablespoons water. Stir.
6) Continue in this manner until all 10 cups are filled. To reference this serial dilution in another way, please see the image below or the table on the following page.
7) The kids must now switch groups and try to guess the identity of the liquids used. Use a white piece of paper as a backdrop. How far can they see the color? Now have the kids smell each cup, beginning with cup 10. How far can they smell the scent? Can they identify the scented liquid?

You'll need:

- 10 jars with lids (or clear cups) per group
- tablespoon measuring spoon
- strong scented liquids such as: imitation vanilla, mouthwash, peppermint extract and perfume
- water
- white paper

Adapted from: Jones, M. Gail, Falvo, Michael R., Taylor, Amy R., Broadwell, Bethany P. "One in a Billion." In Nanoscale Science Activities for Grades 6–12, pp. 19–25. Arlington, VA: NSTA Press.



DFTV Adult Tip

Another approach is to have the kids mark the jars with a code and create a "key" so they know which jar is which. Then, challenge another group of kids to put the jars in order from strongest to weakest and see how accurate they are. When does it become too hard to distinguish with human senses?

DFTV Science Helper

Practice using scientific tools. Complete the dilutions using a graduated cylinder instead of a tablespoon. Just add 1 mL of scented liquid to 9 mL of water or 10 mL of scented liquid to 90 mL of water (depending on the size of your graduated cylinder) and continue in the same manner.

Serial Dilution "Recipe"

Cup	Add	Water
1	2 tablespoons scented liquid	None
2	1 tablespoon from cup 1	9 tablespoons
3	1 tablespoon from cup 2	9 tablespoons
4	1 tablespoon from cup 3	9 tablespoons
5	1 tablespoon from cup 4	9 tablespoons
6	1 tablespoon from cup 5	9 tablespoons
7	1 tablespoon from cup 6	9 tablespoons
8	1 tablespoon from cup 7	9 tablespoons
9	1 tablespoon from cup 8	9 tablespoons
10	1 tablespoon from cup 9	9 tablespoons

nano

View the "Hey, Wait a Nanosecond!" segment from show 701: Size and Scale as a jumping off point for a group discussion on what your students know about nanotechnology.

Are you a nano-bit curious?

"Nano" is a prefix that means one billionth. Although it may seem unimaginable, you just completed a serial dilution and reached one billionth of something. With each step, you diluted the scented solution by 10 (moving the decimal point one place to the left). Cup 10 contains one part per billion of vanilla, for example. That's one part vanilla for every 999,999,999 parts water. The nose is more sensitive than eyes and can detect some scents down to parts per million (cup 7). Yet, even the nose has trouble with parts per billion (cup 10). A few analogies: one part per billion can be equated to one blade of grass on an entire football field or one second in a span of 32 years. No doubt about it—we're talking small stuff! Parts per million and parts per billion are often used in science to address contaminants in water (e.g., the drinking water contained 2 parts per million of copper and 1 part per billion of lead). Even though this ratio is quite small, it can have large affects on health.

DFTV Kids Synthesize
Data and Analysis

Use this table as a guide for your students. You can even create a similar table with missing values for them to complete.

Cup	Decimal	Fraction (scented liquid/total liquid)
1	1	1/1
2	0.1	1/10
3	0.01	1/100
4	0.001	1/1,000 (one thousandth)
5	0.0001	1/10,000
6	0.00001	1/100,000
7	0.000001	1/1,000,000 (one millionth)
8	0.0000001	1/10,000,000
9	0.00000001	1/100,000,000
10	0.000000001	1/1,000,000,000 (one billionth)

Keep Exploring!

If appropriate and safe, put your sense of taste to the test, too! How far can you taste the vanilla or mouthwash?