Nano Intro Stage

Organization: Museum of Science, Boston

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General Description

Stage Presentation

Designed to introduce visitors to nanotechnology, and answer the questions: “How is it New,” “What Can It Do?” and “Do I care?”

Program Objectives

Big idea: Nanotechnology is about using new tools, new materials and new ideas to do stuff on a small scale that can tackle some big problems.

Learning goals:
As a result of participating in this program, visitors will be able to:
1. Identify that nano is about making new and different materials
2. Identify some of the problems that nano might help solve

NISE Network Main Messages:

[X] 1. Nanoscale effects occur in many places. Some are natural, everyday occurrences; others are the result of cutting-edge research.
[X] 2. Many materials exhibit startling properties at the nanoscale.
[X] 3. Nanotechnology means working at small size scales, manipulating materials to exhibit new properties.
[ ] 4. Nanoscale research is a people story.
[X] 5. No one knows what nanoscale research may discover, or how it may be applied.
[X] 6. How will nano affect you?

Nano Intro Stage

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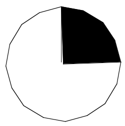
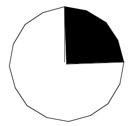
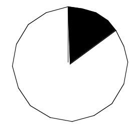
Time Required

Set-up	Program	Clean Up
		
15 minutes	15 minutes	10 minutes

Background Information

Definition of terms

Nano is the scientific term meaning one-billionth (1/1,000,000,000) It comes from a Greek word meaning “dwarf.”

A *nanometer* is one one-billionth of a meter. One inch equals 25.4 million nanometers. A sheet of paper is about 100,000 nanometers thick. A human hair measures roughly 50,000 to 100,000 nanometers across. Your fingernails grow one nanometer every second.

(Other units can also be divided by one billion. A single blink of an eye is about one-billionth of a year. An eyeblink is to a year what a nanometer is to a yardstick.)

Nanoscale refers to measurements of 1 – 100 nanometers. A virus is about 70 nm long. A cell membrane is about 9 nm thick. Ten hydrogen atoms are about 1 nm.

At the nanoscale, many common materials exhibit unusual properties, such as remarkably lower resistance to electricity, or faster chemical reactions.

Nanotechnology is the manipulation of material at the nanoscale to take advantage of these properties. This often means working with individual molecules.

Nanoscience, nanoengineering and other such terms refer to those activities applied to the nanoscale. “Nano,” by itself, is often used as short-hand to refer to any or all of these activities.

Program-specific background

The Metric System: The meter is the fundamental unit of measure in the metric

system, which is the system of measurement used by all scientists, and by most people in almost every other country on earth. A nanometer is a thousandth of a micrometer, which is a thousandth of a millimeter, which is a thousandth of a meter. You can read up on this on wikipedia:
http://en.wikipedia.org/wiki/Metric_system

Atoms & Molecules: Everything is made of atoms, and atoms get together with one another to make molecules. There are lots of different models that people use to represent atoms, none of them is exactly correct. The properties of materials are the result of the way the atoms are arranged in the molecule.

New Materials: The two materials explicitly mentioned in this program are Carbon Nanotubes and quantum dots. You can read a bunch about both of these materials on wikipedia too.

New Tools: The ability to accurately characterize and manipulate matter on a very small scale is enabled by the emergence of some new tools called Scanning Probe Microscopes. These microscopes work by “feeling” things rather than “looking” at them, and they operate by moving a very fine tip back and forth over a surface. They have enabled us both to image things on the nanoscale, and in some cases, to manipulate them as well. Examples of scanning probe microscopes include the Scanning Tunneling Microscope, and the Atomic Force Microscope. You can try reading the wikipedia articles on these, but they are VERY technical, so you might want to just stick to the basics.

New Ideas: Recent discoveries in biology have changed the way we think about how very small things can work. Many of the very small structures that make cells run appear to function in a very mechanical way; like tiny machines. This has led us to believe (for the first time) that maybe humans could build tiny things that behave like machines as well.

Application-Desalination: One of the exciting possible applications of nano is filters that take salt out of ocean water so people can drink it. This is important as the population grows, and as climate change shrinks the available supply of fresh water. There are several research efforts at this underway, one interesting one is being done at UCLA:
http://nanotechnologytoday.blogspot.com/2006/11/nanotech-water-desalination-membrane.html You may be able to find some research going on in your area as well.

Application-Alternative Energy: This is a BIG one. There are LOTS of places where nano and energy are working together. You can find more information in the NISE program Nano and Alternative Energies. The biggest applications are probably in electrical transmission and solar power production. One of the most promising commercial ventures is based in San Jose, CA, they are called NanoSolar: http://www.nanosolar.com/

Application-Medicine: This is a whole field unto itself. You can get a reasonable background by reading the wikipedia article on Nanomedicine: http://en.wikipedia.org/wiki/Nanomedicine. There are many therapies on the horizon, but be careful to make sure you have as much info as possible before mentioning one potential therapy in particular. Medical technologies take a LONG time to get approved, and you want to be sure not to give your visitors false hopes.

Application-Computers: Computers chips are nanoscale devices already. The transistors in a modern computer processor are only 50 nanometers across. Scientists now are trying to figure out to make them even smaller, which will probably mean making them out of something else, sometimes called going "beyond silicon." You can get a great intro to computer technology by reading the article on integrated circuits. http://en.wikipedia.org/wiki/Integrated_circuit

Materials

Powerpoint presentation

Set Up

Time: 5 minutes

Step 1:

Make sure your slides and projection equipment are working.

Review background information before you give the show for the first time.

Program Delivery

Time: 15 minutes

Safety:

No safety concerns.

Procedure and Discussion:

SLIDE 1:

Good [time of day] ladies and gentlemen, welcome to [wherever we are] my name is [whoever I am], and today I'd like to spend the next fifteen minutes or so talking to you about a word that's been much in the news lately….nanotechnology.

SLIDE 2:

In particular, I am going to try and answer three simple questions for you today. How Is Nanotechnology New? What can Nanotechnology Do? And Do you Care about Nanotechnology? You may not care about it now, but I'm hoping by the end that you will, at least a little.

SLIDE 3:

First and foremost, nanotechnology is a question of size. The "Nano" in nanotechnology comes from the unit of distance called the nanometer, or one one-billionth of a meter. A person is about a meter or two in size. One one-thousandth of that size is a millimeter, which is about the thickness of a credit card. One one-thousandth of that size is called a micrometer, which is about the thickness of a red blood cell. One one-thousandth of THAT size is called a nanometer, and that's about the thickness of one-strand of DNA, the material inside our cells that makes us who we are.

SLIDE 4:

The reason that size scale (sometimes called the Nanoscale) is so important, is that at that scale we are dealing with objects that are only a few atoms across. I'm sure most of you have heard of atoms before, they are the building blocks that everything in the universe is made of. You'll often see them drawn like this, but that's not the only way to draw them, or the only way to think of them. You could also draw them like this, with a very tiny nucleus at the middle, and a big cloud of electrons on the outside. I like to think of them like this, as tiny storms of energy, constantly swirling around. But however you think of them (or even if you never think of them) they're there, and everything is made of them.

SLIDE 5:

Atoms like to get together with one another, and make these things we call molecules, geometric arrangements of atoms. And it's the arrangement of those atoms that determine what the material is and how it behaves. Now that's not new science, we've known all about atoms and molecules for more than a hundred years. What's new is that we are gaining the ability to DO something about it.

SLIDE 6:

That’s the first thing that’s new about nanotechnology. The creation of new materials. Sometimes that means putting together new molecules, like the picture on the left, which is called a carbon nanotube. That’s a cylinder of carbon atoms, and it has some really cool properties, like being super strong and a good conductor. Other times, it just means breaking materials down into really small pieces, like the picture on the right. Those vials contain little particles of semiconductor, what we call quantum dots. What’s interesting is that all the vials contain the exact same material, the only difference is the size of the chunks. That changing size can create a changing property, in this case color. But that’s not the only thing that’s new.

SLIDE 7:

The second thing that’s new about nanotechnology is the development of some new tools for viewing and manipulating really small stuff. On the left is a picture of a thing called a Scanning Tunneling Microscope, a device that has been used to move individual atoms, one at a time. The device on the right is the tip of what’s called an Atomic Force Microscope, a tool that’s makes pictures of things by feeling its way around. These are just two of the many new tools that scientists have created for imaging and controlling things on a very small scale.

SLIDE 8:

The third thing that’s new about nanotechnology is the development of some new ideas about what’s possible. The picture on the left here is of a structure called ATP synthase. It’s the thing inside your cells that makes the fuel that cells burn. And it turns out that it works a lot like a motor or a generator, the green part on the top rotates around and pumps out the fuel. This was a big surprise when scientists found it, because it showed that tiny things like the parts of a cell can work in the same way big things like machines work, and that led people to think about things in a different way. A similar thing is happening with DNA. DNA is a series of little molecules called bases, and there’s only four of them. And every organism, from mushrooms to mastodons, has a unique code made up of these bases. That’s not all that different from the way computers work, using large sequences of a small number of different units. So for the first time people who think about how computers work are talking to people who think about how DNA works, and that’s new too.

SLIDE 9:

And the most important idea is really the simplest one. Small things behave differently than big things. You can see in this picture that the tiny beads of water are standing up like balls on this leaf. Now that doesn't happen with buckets of water, just with tiny drops. Small things behave differently than big things. And that's important, because we are using the behavior of small things to tackle some really big problems. I'm going to tell you about just a few examples.

SLIDE 10:

One of the biggest problems in the world is water. There are lots of places on earth where people don't have enough fresh water. Now there's plenty of water on earth, but we can't drink most of it, because it' salty. There's s group of engineers trying to use some of these new materials to make cheaper and more effective filters to take the salt out of water, so that someday we might be able to build a simple filter, where you pour seawater in the top, and drinking water comes out the bottom, that would be a really big deal.

SLIDE 11:

There's also a lot of people using these new technologies to tackle the problem of alternative energies. One approach is to try and make better solar panels, which take energy from the sun and turn it into electricity. We have panels that do this today, and they work really well, but they cost too much to make. If we could make them cheaper, a lot more people would be able to use them. Another approach is to try and find better ways of moving electricity from place to place. Right now the wires we use for moving power are lose a lot of their power along the way. If we could find a material that did a better job, we wouldn't have to make as much power in the first place, and that would be a really big deal, too.

SLIDE 12:

Nanotechnology is also playing a big role in the way we diagnose and treat disease. The important functions of living things all happen on a really small scale, and if we can better understand exactly how those things occur, we might be able to make new kinds of medicines. People are using new materials to try and improve things like the MRI, which can take pictures of the inside of people's bodies, and are using tiny pieces of gold to try and detect and treat diseases like cancer.

SLIDE 13:

People are also working on super small size scales to try and change the way we process information, too. The switches inside a modern computer chip are already nanosized, and people are trying to make them even smaller. The fastest computers in the world, like this one, at NASA, still take up a whole big room, and we use them to try and simulate really tricky problems, like how burning fossil fuels warms up the planet. The smaller we can make the computer chips, the better we can try and model those problems, which helps us think of solutions before it's too late. Some people are even trying to make computer chips in a totally different way, ones that use light instead of electricity, so they might use very little power. That would be a really big deal, too.

SLIDE 14:

So that's some of the things that nanotechnology may be able to do. It can change the way we use resources, like water and energy, the way we practice medicine, and the way we process information. And that's just the things we know about now. There are probably lots of other things that we haven't thought of yet, and the next generation of scientists (and I'm hoping some of you will be part of it) will probably be smarter than we are, and hopefully will think of some stuff we haven't yet.

SLIDE 15:

Now I'm sure that all sounds pretty good, and it might be, but some of it might also turn out to be bad. There are a lot of good examples of this in history, where technology we though would be good turned out to be bad. The ancient Romans where the first people to have indoor plumbing, which was good, but they made their pipes out of lead, which is poisonous, and lots of people died or went crazy, which was bad. In the 1950s, there was a drug called Thalidomide, which was supposed to help pregnant women with morning sickness (sounded good) but it caused lots of serious birth defects (very bad). Asbestos was a material used as an insulator and a fire-proofer (again, good) but the people who worked with it developed a serious lung cancer (bad.)

SLIDE 16:

So is nanotechnology good, or bad? Well, the answer is, neither, or probably both. It's like any technology. Take fire. Campfires are good, fires in your fireplace are good. Forest fires are bad, as are fires that burn your house down. Some sometimes it's good and sometimes it's bad. But it gets even trickier. Recently we've learned that maybe forest fires AREN"T bad, that they're actually better for the forest. So sometimes it's good, and sometimes it's bad. And sometimes the part you thought was bad turns out to be good, and vice versa. And I think this is probably the answer to the question: "Do you care?" Because you ought to. We all ought to, because it's hard to figure out what's good and what's bad. I care about fire, because I want to use fire in my house, but I want to be the one decide where in my house it's used, and how.

SLIDE 17:

So that’s the broad strokes about nanotechnology. Those are the general answers to the three questions, how’s it new, what can it do, and do you care. But that’s not the whole story, not quite. Now I want you to close your eyes and let me tell you a story…

SLIDE 18:

What if I told you I had invented a marvelous machine, one that was going to change the world. This machine ran on nothing but solar power and a little bit of water, and it did an amazing thing. It took the energy from the sun, and packaged it into portable batteries that humans could use. What’s more, this machine sucked greenhouse gases out of the atmosphere, and it emitted perfectly pure oxygen for us to breathe. This machine could repair itself if it got damaged, and it was so smart it could even build more copies of itself to keep doing its job. Now imagine that I told you I had written all of the blueprints for this machine, all the instructions for how to make it, onto a tiny little chip, and all you had to do was put the chip into a vat with the right chemicals, and the first copy of the machine would assemble itself and start running, all on its own. You can open your eyes. Sounds like science fiction, right? Well it is, unless you’re willing to change your idea of what it means to be a machine…

SLIDE 19:

This is exactly what living things do all the time. The machine is a tree, the battery is an apple. The chip is a seed, and the vat of chemicals is the soil.

SLIDE 20:

This “machine” does just what I’ve described, it takes carbon dioxide out of the air, water from the soil, it releases oxygen, and it packages it’s energy into the apples, which we can eat, or feed to our animals, or make into alcohol to burn in our engines. The trees grow, and repair themselves, and can eventually grow into an orchard. Now we didn’t build that system, it evolved on its own over billions of years. But that doesn’t mean we couldn’t make something like it someday.

SLIDE 21:

If you think about it, this is what technology has been doing all along. The motorcycle has roughly the same shape, and does roughly the same job, as the horse. The same thing is true of the airplane and the bird. Now, you might argue that the motorcycle and the airplane aren’t as graceful as the horse or the bird, or as efficient, or as beautiful, and I’d agree, but they are rough approximations. They are technological imitations of biological systems. And someday we might be able to do the same thing on a small scale, to re-create through technology some of the marvelous feats accomplished by biology. Now, we certainly don't know how to do that today, and maybe we never will, but there's no reason to think it's impossible, and maybe some of you here today will have some good ideas that scientists haven't thought of yet.

SLIDE 22:

And so that's the short answer to my original question, and the thought I'd like to leave you with. What is nanotechnology? It's the future. And like the future, it's coming, whether you are ready for it or not. So think about what kind of future you want, because we will be a part of what kind of future we share. Thanks for coming, and….

SLIDE 23:

I'd be happy to answer any of your questions…

Tips and Troubleshooting:

Be prepared for questions to be shouted and interrupt you, you can push hard ones to the end by saying "Good question, we can talk about that when I'd finished."

Common Visitor Questions

How do we make carbon nanotubes now?

We do use self-assembly to make carbon nanotubes now, but we aren't able to make giant ropes or even wires yet.
Carbon nanotubes are made with fire under special conditions, or with templates that are the size of the nanotubes and carbon gas that condenses into nanotubes, the same way water vapor condenses into snowflakes.

Can This Cure Cancer?

Unlikely. Cancer is actually a bunch of different diseases, each of them have slightly different treatment. However, some nanotechnologies may offer possible treatments, but we need to make sure they are safe before we let people use them.

Going Further…

Here are some resources you can share with your visitors:

Pictures of particles of gold with different sizes resulting in different colors:

http://www.nanospectra.com/Nano-Scale%20Optics.htm

Clean Up

Time: 5 minutes

Turn everything off.

Universal Design

This program has been designed to be inclusive of visitors, including visitors of different ages, backgrounds, and different physical and cognitive abilities.

The following features of the program's design make it accessible:

[X] 1. Repeat and reinforce main ideas and concepts
Three different demonstrations repeat the idea that small things act differently.

[X] 2. Provide multiple entry points and multiple ways of engagement

[ ] 3. Provide physical and sensory access to all aspects of the program
Several demonstrations are hands-on and participatory.

To give an inclusive presentation of this program:

Be sure to verbally describe visual elements of the program.

This project was supported by the National Science Foundation under Grant No. ESI-0532536.