



name: \_\_\_\_\_ date: \_\_\_\_\_ period: \_\_\_\_\_

## Let's Get Small

1. Nanotechnology is the science of the \_\_\_\_\_. A nanometer is equal to \_\_\_\_\_ of a meter.
2. Complete the following chart with the correct statistics.

	Measurement in nanometers
Width of a hydrogen atom	
Width of a sugar molecule	
Width of a virus particle	
Diameter of a red blood cell	
Width of a strand of hair	

3. Explain how nanotechnology will be or is already useful in the following:

a. Batteries:

b. Tennis racket:

c. Light bulbs/Solar Cells:

d. Hyalogen:

e. Drugs:

f. Computers:

g. Disinfectants:

## Let's Get Small

adapted from an article from "How Things Work"



### Introduction

Imagine having a cell phone or a GameBoy where the batteries last four or five weeks without recharging. Then, when you do need to recharge, it only takes two minutes. The display is brighter, larger and much sharper than any display today. And the computer inside it is so fast; it's like using a desktop computer today.

A cell phone like this may soon be possible, and it will all happen thanks to nanotechnology. Over the next several years, nanotechnology will probably be touching just about everything you buy or use on a daily basis.

Nanotechnology is the science of the super-small. The "nano" in nanotechnology comes from a measurement -- the nanometer -- that equals one one-billionth of a meter. A nanometer is so small that it is nearly impossible to imagine. But here is one way to think about it. The smallest single atom in our universe is a hydrogen atom. It is about a tenth of a nanometer across. One sugar molecule is about 10 hydrogen atoms wide, so it is about a nanometer wide. Remember, we're talking about a sugar molecule, not a grain of sugar. A virus particle is about 50 nanometers wide. A red blood cell in your blood has a diameter of about 5,000 nanometers. Now, look at a strand of hair on your arm. It has a diameter of about 75,000 nanometers. So if you had a way to do it, you could line up about 15 red blood cells across the end of a strand of hair. As you can see -- a nanometer is very, very, very small.

### Why is nanotechnology so important?

The reason why nanotechnology is so important is that, at the atomic level, molecules can behave differently than they do at our level. For example, we all know what gold looks like -- it is yellow, shiny, and metallic. But when you take just a few atoms of gold and deal with it at the nano level, it is nothing like that. For one thing, it can actually look pink.

By building things at the nano level, people are working with individual atoms or a handful of atoms and taking advantage of these different properties. The advantages can be huge. Let's take batteries as an example. A battery is full of chemicals that make electricity. The chemicals are normally powders or gels. But by forming the chemicals into nano-particles, the batteries work much better. This is because when you make the particles super-small, you increase the number of atoms that are exposed for the chemical reaction. Now, the reaction can happen much faster and/or more completely. Therefore, the battery can store more energy, and it can charge a lot faster. Today it might take two hours to charge a cell phone. In the future, it will only take two minutes.

### Nanotech in Computers

**Right now, microprocessors are already at the nano level. A typical wire on a modern microprocessor chip is only 90 nanometers across. Over the next 10 years or so, these wires will shrink down to 20 nanometers -- possibly even 10. At that level, there would actually be less than 50 silicon atoms across the width of the wire!**

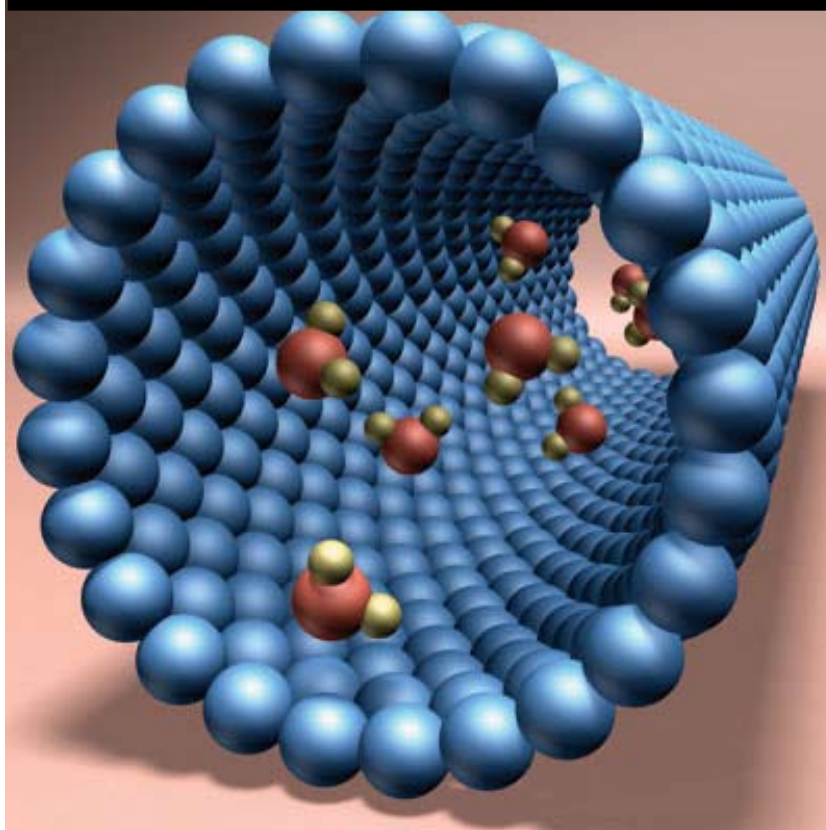


Image courtesy NASA  
Digital model of a carbon nanotube

### Other Uses for Nanotechnology

What else will scientists be able to do with nanotechnology? It really is amazing when you think about it. For example, you know that steel is strong. And you probably have used something like a graphite or **KEVLAR®** tennis racket that is even stronger and lighter than steel. Nanotechnology, in the form of **carbon nanotubes**, will create even stronger stuff -- possibly 100 times stronger than normal graphite with about the same weight. If you're wondering what a **carbon nanotube** is, imagine taking a sheet of carbon atoms just one atom thick. Then you roll it into the smallest tube possible. That is a **carbon nanotube**. It has a diameter of about 1.3 nanometers.

### Quantum Dot

Another type of nanotechnology is called a quantum dot. These dots are tiny -- only about 5 nanometers across. They contain a handful of atoms, and those atoms are chosen so that they are very good at absorbing or creating light. By using quantum dots, scientists will be able to make a completely new type of light bulb. They will also be able to create solar cells that are much cheaper than today's solar cells.

Speaking of solar cells, there is another way that nanotechnology should be able to help with sunlight. For many years, scientists have been trying to find a cheap way for sunlight to break water into hydrogen and oxygen. The resulting hydrogen would then be used to power fuel cells in cars and trucks. With luck, nanotechnology will crack that problem and make cheap hydrogen a reality.

### Medical uses of nanotechnology

There will even be nanotechnology inside your body. One of the most interesting ways to use nanotechnology is to make new drugs that can latch on to diseased cells. Let's say that there is a cancer tumor in your body. Right now, doctors give you a drug that can kill the tumor. That's called chemotherapy. The problem is that the drug flows throughout your body, and it kills lots of other things too. Some scientists believe it eventually will be possible to use nanotechnology to create special nanocages that contain drug molecules. These nanocaged drugs will attach only to tumor cells. That way, the tumor is the only thing killed by the drug.

**Teeny Tiny Machines** Although they aren't quite at the nano level yet, scientists are making machines at the micro level now. They have created tiny motors and gears, for example, and can use them to move things around. You actually have one of these micro-machines in your car right now. The airbag in your car needs to sense a collision. It uses a tiny weight, much smaller than a grain of salt, to do it. When the car collides with something, the tiny weight moves and a tiny capacitor senses the movement. Bam -- in less than a millisecond your airbag is popping out!



Photo courtesy Sandia National Laboratories  
Lauren Rohwer displays the two solid-state light-emitting devices using quantum dots her team has developed. One is blue and the other is white.

And then there is the world of computing, where nanotechnology should really shine. Computers have been made of silicon for many years, but now we are getting to the point where we can't make silicon computers much smaller. Nanotech will create a whole new kind of transistor that is smaller, faster and uses less power than any transistor seen today. That means computers will get a lot smaller and faster. And these computers will be able to have a lot more memory. Because of nanotechnology, video games, and lots of other applications, will keep getting better and better while computers become less and less expensive.

### How will scientists create such small technology?

How are scientists going to create these tiny particles and structures? It depends on what they are creating, and there are many ways to do it. For example, scientists recently discovered that you can create certain kinds of quantum dots inexpensively using a fairly normal chemical reaction. You can create long strands of carbon nanotubes with chemical reactions as well. Tiny nanomachines are often created by etching silicon in the same sort of way that engineers create computer chips. Sometime in the future, engineers probably will create machines that can arrange atoms one-by-one. It is possible to arrange the atoms one-by-one today, but it is very slow, and there are many kinks to work out of the process.

Not everything in nanotechnology is happening in the future. And not all of it is "high-tech." For example, you can buy a disinfectant today that is made with nanotechnology. It is called EcoTru®. What it does is kill bacteria, but it does it the nano way. EcoTru® starts with nano-sized droplets of oil that contain a chemical that kills bacteria. The nano-sized particles -- called nanospheres -- are specially engineered to attack only bacteria and avoid other cells such as human cells. Because the droplets are so small, they can go right through the cell wall of the bacteria. This makes it one of the best, and least hazardous, disinfectants available today.

As you can see, when we start designing stuff at the nano level, things just keep getting better and better.