Q&A: FOUR QUESTIONS for SIX EXPERTS

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NANOOZE

THE FOOD ISSUE

THE NANOSCIENCE OF MAYO MAKING

LIPOSOMES IN YOUR FOOD, OH MY!

NATURE'S NANO MACHINES

NANOTECHNOLOGY: IS IT SAFE?

NANOSENSORS, LASERS, AND CROPS

Nanooze

ALL ABOUT THE THINGS TOO SMALL TO SEE

Welcome to Nanooze!

What is a Nanooze? (Sounds like nah-news.) Nanooze is not a thing, Nanooze is a place to hear about the latest exciting stuff in science and technology. What kind of stuff? Mostly discoveries about the part of our world that is too small to see and making tiny things using nanotechnology. Things like computer chips, the latest trends in fashion, and even important stuff like bicycles and tennis rackets. Nanooze was created for kids, so inside you'll find interesting articles about what nanotechnology is and what it might mean to your future. Nanooze is on the Web at ***www.nanooze.org****, or just Google "Nanooze"—you'll find interviews with real scientists, the latest in science news, games and more!*

HOW CAN I GET NANOOZE IN MY CLASSROOM?

Copies of Nanooze are free for classroom teachers. Please visit ***www.nanooze.org*** *for more information or email a request for copies to* ***info@nanooze.org****.*

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THE FOOD ISSUE

NANO MAYO?
The properties of molecules at the nanometer scale transform egg yolks, oil and lemon juice into the emulsion we call mayonnaise.

Nanotechnology is all around us—and not just in our computers and iPods. It's in our food, the air we breathe, and lots of the stuff we use every day. Nanotechnology is everywhere and you might be surprised to find out that it isn't new. Even before the first microscopes—and way before there were microscopes that can see things on the nanometer scale—we have been using nanotechnology. And sometimes we don't even know it.

Goofy foods like mayonnaise are made with nanotechnology. By whipping together the ingredients—eggs, oil and lemon juice—we produce emulsions from tiny drops of oil surrounded by water. This issue of Nanooze is all about nanotechnology in food and agriculture. Nanotechnology already plays an important role in the food we eat and will become even more important as we learn how to apply it to agriculture and food production in the future.

In this issue we'll also discuss concerns about nanotechnology and what we might want to be on the lookout for. Because the products of nanotechnology are too small to see, sometimes we can't avoid them or even know they are there. Six experts from around the world will share with us their different views of nanotechnology and how they think nanotechnology could change our lives.

NANO KNOW-HOW

Learning about nano stuff is fun but it can be complex, so it helps to keep these four important facts in mind:

1. All things are made of atoms.

It's true! Most stuff, like you, your dog, your toothbrush, your computer, is made entirely of atoms. Things like light, sound and electricity aren't made of atoms, but the sun, the earth and the moon are all made of atoms. That's a lot of atoms! And they're incredibly small. In fact, you could lay one million atoms across the head of a pin.

2. At the nanometer scale, atoms are in constant motion.

Even when water is frozen into ice, the water molecules are still moving. So how come we can't see them move? It's hard to imagine that each atom vibrates, but they are so tiny that it's impossible to see them move with our eyes.

3. Molecules have size and shape.

Atoms bond together to form molecules that have different sizes and shapes. For instance, water is a small molecule made up of two hydrogen atoms and one oxygen atom, so it is called H_2O. All water molecules have the same shape because the bonds between the hydrogen atoms and the oxygen atom are more or less the same angle.

Single molecules can be made up of thousands and thousands of atoms. Insulin is a molecule in our bodies that helps to control the amount of sugar in our blood. It is made up of more than one thousand atoms! Scientists can map out the shapes of different molecules and can even build most types of molecules in the lab.

4. Molecules in their nanometer-scale environment have unexpected properties.

The rules at the nanometer scale are different than what we usually encounter in our human-sized environment. For instance, gravity doesn't count because other forces are more powerful at the molecular level. Static and surface tension become really important. What is cool about nanotechnology is that we can make things that don't behave like we expect. **Things are really different down there!!**

Nano Foods:
What Will the Future Taste Like?

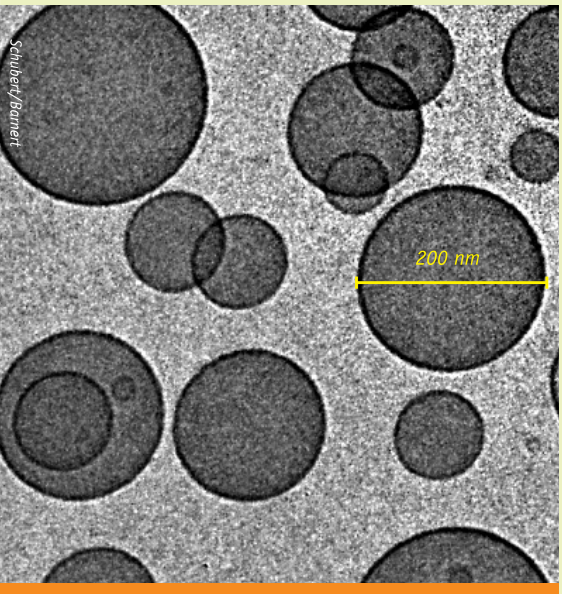
Liposomes and vitamins

Liposomes can be used to encapsulate certain vitamins that are very sensitive to air. This protects the vitamins and allows them to be added to other types of food.

Does your chewing gum lose its flavor on the bedpost overnight? Sure it does. A lot of ingredients in foods, especially those that give food a certain taste or a smell, can quickly disappear from the food.

Two things can happen: First, most flavors or smells can evaporate easily and go off into the air. That's actually how we can smell stuff, because the molecules travel from the food through the air to our nose. Second, some flavor molecules react to the oxygen in our air causing them to go from tasting or smelling good to tasting or smelling bad.

But there are lots of things you can do to protect the flavor of foods and nanotechnology is giving food producers some neat tricks.



Liposomes under the microscope

This image of liposomes in water was created using Transmission Electron Microscopy. Each liposome is only a few hundred nanometers across.

Flavors can actually be put into capsules so tiny that a few thousand can fit across the width of a hair. So scientists are making capsules for food ingredients that are incredibly small but also able to release the stuff inside when it is needed.

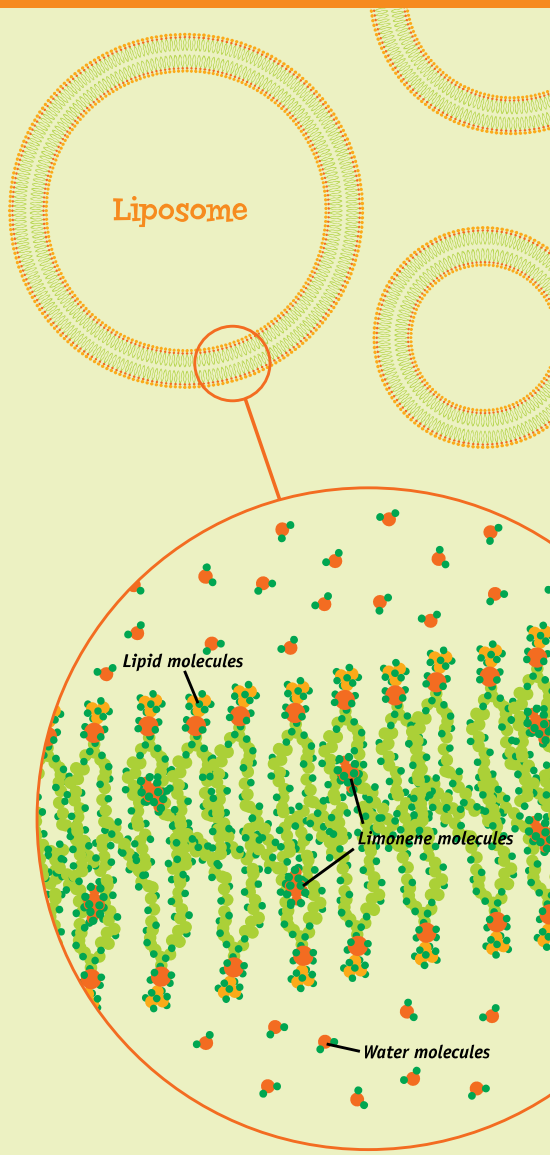
One kind of capsule is called a liposome, so called because it is made of lipids. Think soap bubbles, except these are filled with a flavor or a scent.

Liposomes can form by self-assembly with the flavor in the middle surrounded by the lipid. That's because the lipid molecules have one end that is hydrophilic—meaning it likes water—and the other end is hydrophobic—meaning it hates water (okay, doesn't really *like* water).

Under the right conditions all this stuff forms small capsules that protect the flavor from the air and also keep it from evaporating. If you design them right they even release their contents when you want.

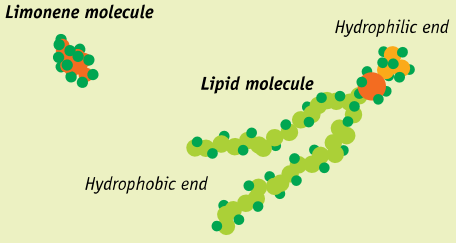
The same encapsulation technology is used for vitamins, some of which are very sensitive to air.

To fortify food with vitamins, scientists are encapsulating them in liposomes—so small that many thousand can fit across a hair. By using nanotechnology, food can be made to taste better and be better for you.



A lemon-scented liposome

In this liposome, limonene molecules nestle in between the tails of lipid molecules. Limonene has a very strong citrus scent.



4 Questions for 6 Experts

Thoughts on Nanotechnology and Life

Jennifer Kuzma
University of Minnesota

What first comes to your mind when you think of "nanotechnology"?
Applications at a small scale. The ability to accomplish more using less and more targeted materials.

If you weren't in science, what else might you be doing?
The fine arts. I always wanted to be a musician. I (try to) play piano and classical guitar, but I dream of playing cello in an orchestra. Another dream is being a painter.

What do you recall made you decide that you wanted to be in science?
I was fascinated by my general biology and chemistry classes, and the explanation of macro-scale world phenomena looking at molecules and cells.

In 25 years what do you imagine will be the most revolutionary change in our lives that involves nanotechnology?
I hope it occurs in the medical and environmental areas—using less material and promoting sustainability or more targeted treatment of diseases like cancer. I like to think of the social benefits (environment and health) as the potential revolution. But it will take targeted public funding to reap these benefits. Currently, nanotechnology in the market (for example, in better tennis rackets or cosmetics) does not reflect our greatest societal needs.

George Whitesides
Harvard University

What first comes to your mind when you think of "nanotechnology"?
Electronics, quantum, subcellular, strange and cool.

If you weren't in science, what else might you be doing?
Nothing fascinates me more than science, so I don't think about an alternative.

What do you recall made you decide that you wanted to be in science?
I liked washing dirty labware when I was a lab tech as a teenager. That was my moment when I decided that I wanted to be in science.

In 25 years what do you imagine will be the most revolutionary change in our lives that involves nanotechnology?
It's already in progress. The remodeling of the world by IT (Information Technology). Nanotechnology has contributed in many ways to the means through which we communicate. Think back before the Internet and that level of connection—we have already gone through a revolution.

Aaron Strickland
Cornell University

What first comes to your mind when you think of "nanotechnology"?
Science fiction coming to life. On several occasions I've witnessed success in an experiment or proof-of-concept study that at first seemed like a very far-fetched idea.

If you weren't in science, what else might you be doing?
Not sure, but I started college wanting to be an architectural engineer. Designing and building buildings sounds incredibly exciting and challenging. Kind of like building molecules in the lab (my current job), but on a slightly different scale.

What do you recall made you decide that you wanted to be in science?
I was surrounded by science and scientists most of my life; my father is an ecologist. However, I did not really decide on a career in science until my college life, and I can trace this back to a few great teachers I had. These people presented science to me in a way that was very compelling. Science is interesting, challenging, competitive and fun all at the same time.

In 25 years what do you imagine will be the most revolutionary change in our lives that involves nanotechnology?
Given the diversity of nanotechnology and the diversity of "nanotechnologists," I can imagine many revolutionary changes; however, I believe nanotechnology will play a major role in informing us about our planet and how to better manage our footprint on Earth. Whether it be sensors used to gather information on climate change and water pollution or new approaches to generating alternative energy, scientists will look to the tools of nanotechnology to solve many of these problems.

Michael Merjan

Rosalyn Berne

University of Virginia

What first comes to your mind when you think of "nanotechnology"?
The first thing I think of is, "That's nature's world way down there!" Because so much of what nature does starts at that nanoscale. But nanotechnology is about humans working in that world, that domain of the exceedingly small. So I think about how humans are working inside of nature's world in order to make our world a better place for us to live.

If you weren't in science, what else might you be doing?
I study scientists, and I think and write about what scientists do. Maybe if I weren't doing that I would *be* a scientist! I am really interested in cosmology, marine biology, and geology.

What do you recall made you decide that you wanted to be in science?
When I was in middle school I used to run experiments on mice and plants in my bedroom. I started working to understand scientists instead of doing the actual science when I became curious about why we humans interact with the physical and natural world in the ways we do.

In 25 years what do you imagine will be the most revolutionary change in our lives that involves nanotechnology?
Twenty-five years from now nanotechnology will have changed our computing systems, our food processing, our medical procedures, entertainment, our transportation systems, the way we fight wars, the way we socialize and communicate, how classrooms work, and, let's see, what else? Just about everything except maybe the way we worship. So, rather than one revolutionary change, I see fundamental change in what it feels like to be alive, only we will still struggle to simply be human.

Norm Scott

Cornell University

What first comes to your mind when you think of "nanotechnology"?
The world of "really small" with tremendous opportunities for the agriculture and food systems.

If you weren't in science, what else might you be doing?
I really have no idea because otherwise my dream was to be a major league baseball player, but talent and skills were not there! For sure I was going to be an engineer in some way!

What do you recall made you decide that you wanted to be in science?
A deep interest in mathematics and science through my high school years and success in these in school. In addition, growing up on a farm led to a very developed work ethic and an inquisitiveness about how things work.

In 25 years what do you imagine will be the most revolutionary change in our lives that involves nanotechnology?
I believe the advancements of nanotechnology in agriculture and food will be revolutionary in terms of how we produce, process, store and package food products. Nanoparticles will pervade our foods to produce healthier and more nutritious foods. Also, products will be tracked from origination to the table and ultimate point of consumption.

Jochen Weiss

University of Hohenheim, Germany

What first comes to your mind when you think of "nanotechnology"?
A tremendous step forward with an as yet not fully explored potential for innovations. An incredibly exciting area to work in. As in all new technologies, though, the risks need to be critically evaluated.

If you weren't in science, what else might you be doing?
I decided to become an engineer when I was 15. My father was an engineer and I always wanted to follow in his footsteps. While studying chemical engineering in Germany I had a great Ph.D. advisor that put me on the path to become a professor in food science instead.

What do you recall made you decide that you wanted to be in science?
I am a huge fan of science fiction and so I have always been interested in future technologies and the development of new machines and devices. Oddly enough, I started out studying the design of large-scale process equipment that can handle tons and tons of product. It's a bit ironic that I ended up working on the tiny nanometer scale!

In 25 years what do you imagine will be the most revolutionary change in our lives that involves nanotechnology?
That is difficult to say since the field is moving forward so quickly. But I see most of the advances being made in the development of new materials that are useful in a large number of applications that span all kinds of industries.

NOT SO FAST, NANOBOTS!

Nanobots like this one are only imaginary, they don't exist yet. So far, no one has figured out how to make teeny tiny robots.

DID YOU KNOW?

Myosin is a molecule in your muscles that helps them make them move. It is responsible for every single movement your body makes from jumping out of bed to blinking your eye. Every time your heart beats, you can thank myosin for getting the job done.

Nature's Nano Machines

Some of the exciting stuff in nanotechnology is all about making little machines that move around on their own.

These things called nanobots are mostly created from the imagination of some pretty clever people. It is too hard right now to make microscopic machines that can motor around all by themselves.

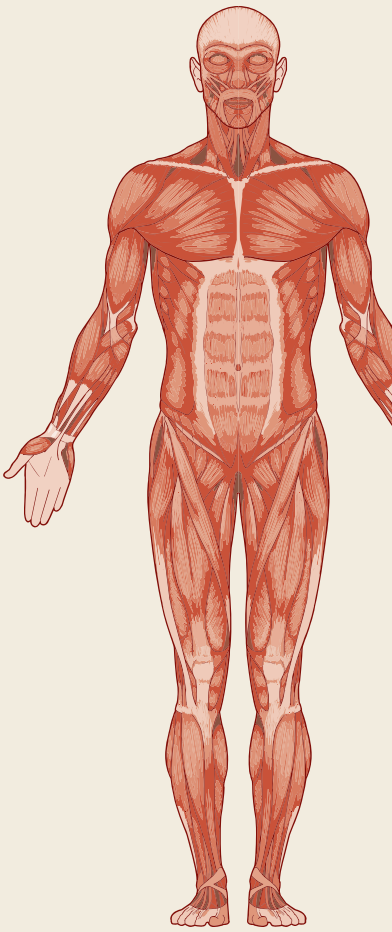
At the nanometer scale things are in constant motion and that motion would shake up nanodevices, making it just about impossible to move in a specific manner. And it is especially hard when they are floating around in a liquid or in the air.

But we can be inspired by things going on in nature, inside of cells. Nature has made some really clever "machines," different collections of molecules that work together to move along. With these processes, different parts of a cell, or even the whole cell, can move around.

Cells are not just a bag of water, full of DNA, proteins and other stuff. They have lots of different compartments and ways to move throughout their different parts, called organelles.

Inside of plant and animal cells are molecules that form a scaffold much like train tracks. These tracks give the cells shape and they also guide tiny locomotives that move things around the cell. The locomotives are other molecules that can climb along these tracks.

One of these tracks found in muscle cells is called actin, a long skinny protein. Myosin is sort of the locomotive and moves along the actin. Actin and myosin are how muscles contract, with the myosin locomotive moving along the actin tracks.



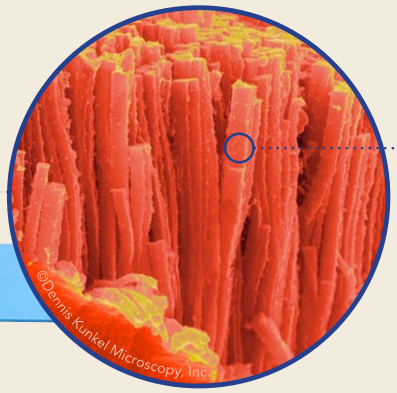
YOUR MUSCLES: THE REAL NANO MACHINES

We all know that muscles help us move around every day. But what is really going on inside them? Muscles, like everything else in this world, are made of atoms and molecules. Myosin and actin are two types of molecules inside your muscles that help them contract.

ACTIN MYOSIN FILAMENTS

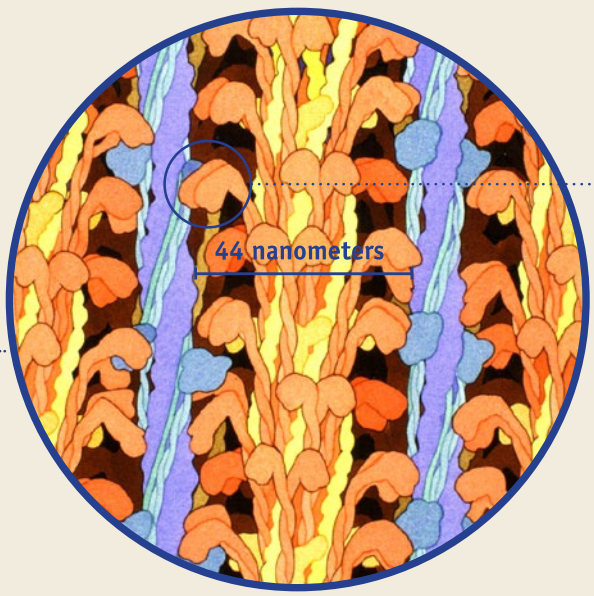
Actin makes up about 20% of the protein inside your muscle cells.

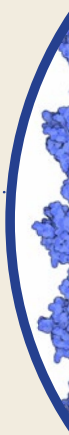
Magnification 2000x



ACTIN MYOSIN STRUCTURE

Strands of actin molecules twisted together provide the stucture for myosin to move along.





Thanks to David S. Goodsell for contributing illustrations and information for this article.

METAL IN YOUR BODY

Pins and screws are used to stabilize broken bones. They stay inside your body for a long, long time without doing any harm.

Nanotechnology: Is it Safe?

Nanotechnology and the products that you can make with it are all around us. The government and private companies have spent a lot of money to develop nanotechnology. But is it safe? **The answer is, we just don't know for sure.**

Some people think nanotechnology is safe because a lot of nanomaterials are not much different than things that we find in nature. For example, the first carbon nanotubes were not made in a high-tech laboratory but actually found in a furnace.

On the other hand, some people think that nanotechnology is dangerous because some materials look just like asbestos, for instance, which we know can cause cancer. So what is the truth? Probably a little bit of both, and scientists around the world are studying all different kinds of nanotechnology products looking for answers about what is safe and what is not.

But it's a pretty complicated process, because what makes things harmful? It depends on what they're made of, their size and shape, and also how they might enter your body. You could, for example, take a piece of steel and make it into a nice piece of jewelry for someone to enjoy, or you could shape it into a bullet and shoot it at a high speed that can cause some damage. Take that very same piece of steel and implant it into certain parts of your body and it could stay there not doing any harm for a long, long time.

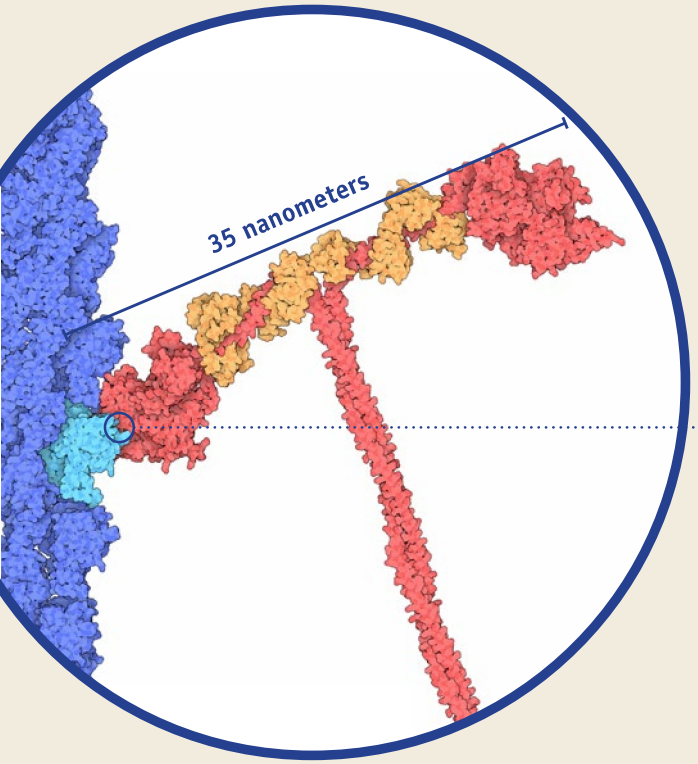
Because of their very tiny size, sometimes nanotechnology products can cause problems if they are inhaled.

Asbestos was at one time found to be a great insulator and was used to coat pipes that got very hot, as insulation in the walls of buildings, and even around electrical wires. Asbestos is made out of silicates, kind of the same stuff that is found in sand. But it wasn't until about 100 years after it was first used very effectively as insulation and for fire protection that we found out asbestos can also cause lung cancer when its molecules are inhaled.

The government is currently spending a lot of money to test the safety of nanotechnology products, but testing these products is not easy and we don't have a lot of good ways to do it yet. The best way is probably to use animals, although nobody really knows how much to test and what kind of animals to use. And using animals also poses an ethical problem. Developing better ways of testing will bring us closer to understanding how we can use nanotechnology and might also help us predict what kinds of nanotechnology materials are safe and which ones we need to be careful with.

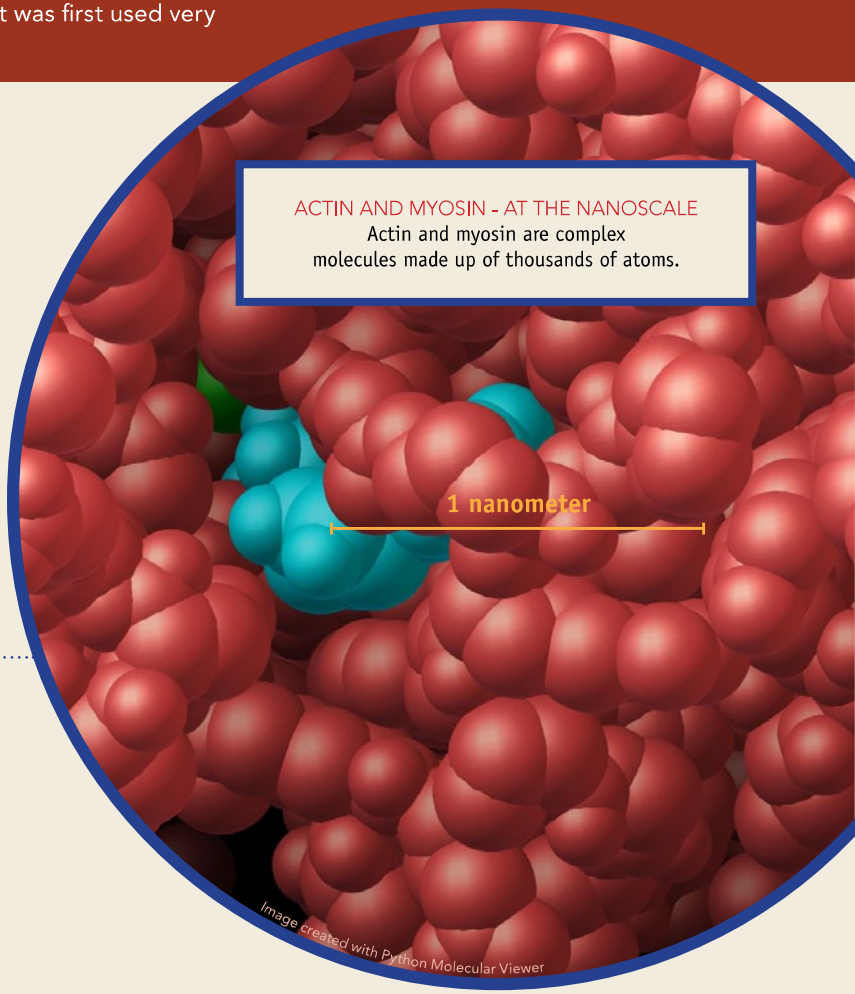
ACTIN MYOSIN POWER STROKE

The end of a single myosin molecule interlocks with an actin strand.



ACTIN AND MYOSIN - AT THE NANOSCALE

Actin and myosin are complex molecules made up of thousands of atoms.



Nanosensors

The year is Star Date 2XXXXX and you have pulled out your tricorder to detect...

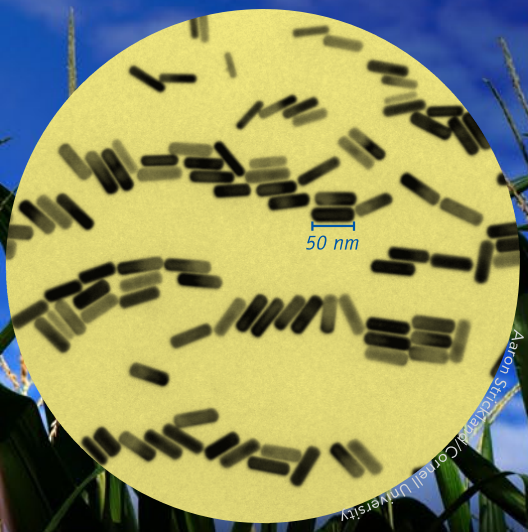
This is pretty good science fiction, but we don't have sensors that can tell you at a distance if you are sick or if there is some kind of toxic chemical in the environment. But we do have ways of detecting some things at a distance.

For example, scientists can look at the infrared spectrum of Mars and tell that there is methane in the planet's atmosphere. That is because methane has a particular chemical signature and there aren't a lot of things on Mars that have a chemical signature that is similar to methane. The chemical signature is made up of the atoms and the bonds in the molecule. But for a lot of things, there isn't an easy way to detect them because they don't have a really unique chemical signature.

So one idea is to use tiny sensors that can bind to whatever it is you want to detect and send back a signal. The problem is to make them small and also have them require little or no power, because batteries or solar cells will make the sensors bigger and heavier.

Scientists are making tiny particles out of gold and coated with molecules that can bind to things like pesticides. Farmers could spray these particles on their fields to detect a chemical like a pesticide. The idea is to shine a very powerful laser on these particles and get an image that would tell the farmer where the pesticide was and where it wasn't. Kind of like on those crime shows where they spray a chemical and then look for traces of blood with an ultraviolet light.

These crop nanosensors would help farmers know where they have treated the crops, which would help to reduce the amount of chemicals that we use on our land.



Gold nanoparticle sensors

These tiny rod-shaped gold nanoparticle sensors less than 50 nanometers in length could someday be used to help farmers manage their crops and make wise use of chemical fertilizers.