A Matter of Taste: The Science Behind Better-Tasting Stuff

ISSUE 4 • 2008 www.nanooze.org

NANOOZE

THE FIVE SENSES PART 2

AN INTERVIEW WITH A SMELL SCIENTIST

BUILDING A BIONIC NOSE

WHAT MAKES A SMELL "SMELL"?

FEET: WHY THE STINK?

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****.*

THE FIVE SENSES PART 2

THE SECOND ISSUE IN OUR 3-PART SERIES DEDICATED TO THE FIVE SENSES: EXPLORING SMELL AND TASTE

Most of the time we almost forget about them but there are five of them—smell, sight, hearing, taste and touch. A stinky sock, pizza, Red Hot Chili Peppers (the sound or the taste?), a bee sting (ouch). We get a stuffed nose and then we can't taste much of anything. These are our five senses. How do they work? And what does this have to do with science? Lots.

WHAT IS ACTUALLY HAPPENING INSIDE OUR BODIES WHEN WE SENSE SOMETHING?

We have lots of different kinds of cells in our body. Some of these cells help with our different senses and each sense involves a special kind of cell. Cells inside our eyes detect photons of light, while tiny, delicate parts of our ears sense the different vibrations of sound waves. All those cells are hooked up to our central nervous system, which relays the signals triggered by those special cells to our brain where they're processed into a response. It may sound simple—touch an ice cube and your brain tells you "it's cold"—but it involves a lot of specialized cells and a complex transfer system to transmit signals to the brain. Then once the signal arrives, your brain needs to figure out what's going on and give you the right picture, sound, smell, taste or feeling. And it all happens at lightning speed!

SO, WHAT DO OUR FIVE SENSES HAVE TO DO WITH NANOTECHNOLOGY?

Scientists study our five senses to learn more about how they work and are finding out that they are pretty complicated. Nanotechnology is helping us figure out what's really happening in the tiniest parts of our bodies and can help us develop new tools that can sense like we do.

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!!

Q&A with Smell Scientist Christina Zelano

Christina Zelano is a graduate student in physics at University of California at Berkeley. She has a Bachelor of Science degree from the University of California at Santa Cruz. Christina is originally from Falls Church, Virginia.

Did you want to be a scientist when you were a kid? As a kid I was always designing and building gizmos and trying to make them work. Now that I am an adult the only difference is that people pay me to do it! I am gizmologist with a love of nature and an unquenchable curiosity about how nature works. I guess that makes me a scientist!

Do you remember when you first thought you might like to go into science? I always liked science. In elementary school science was my favorite subject, and the science fair was always my favorite part of the school year. One year I measured how much electricity could flow through different fruits and vegetables. I wanted to know which fruit would conduct the most electricity and why. Another year I did an experiment to see which kind of grape turns into a raisin the fastest, and then once all the grapes became raisins I conducted a taste test to see which grape made the best-tasting raisin!

Even though I still liked science, I remember in 7th and 8th grade I thought maybe I wouldn't go into science because I was afraid of math, and I knew math was very important for science. But in high school I realized that anyone can do math—it just seems scary at first.

First you went to college, now you are back in school studying for a PhD. Is it tough to do so much school? Some things have been tough. First, college was my first time living far away from my parents, so in the beginning I was a little bit homesick! Second, I studied physics in college and there weren't very many other girls in my classes. I found that very difficult in the beginning. Third, I had lots of tests and homework to do. But it was worth all of the hard work when I look back on it now! Studying for a PhD is tough in different ways than college. I still had to take some classes like in college, but classes aren't as important for a PhD as they are for college.

What is most important for a PhD is finding an interesting unanswered scientific question and figuring out how to go about solving it. This usually takes years to finish! This means you need to be very motivated to answer your scientific question, because it takes a very long time to solve. The hard work that goes into this kind of science is definitely worth it, because when you finally answer your question, you publish it in a scientific journal so that other people can also know the answer to your question. This means that you get to directly contribute to scientific knowledge!

So you study the way we smell. Can you tell us a bit about that? The nose is the first part of the sense of smell. I study the second part, which is the brain. After the receptors in the nose bind to smell particles in the nose, they send a signal to the brain. The brain does all kinds of things with these signals, like decipher the code made by the receptors. And it also creates memories of smells. The brain also determines whether an odor smells pleasant or unpleasant. I study the sense of smell by looking at people's brains while they smell things. To do this, I have a person agree to go inside a big machine that lets me see the inside of their brain. Once they are inside the machine, I give them odors to smell and I look at activity in their brain in response to the odors.

What is it like to work with things that you can't really see? Working with things you can't really see is very hard at first. You don't know how to picture it in your head, which makes it difficult to feel like you understand what's going on. But in time, you start to develop your own way of picturing it in your head. When I try to imagine what is happening when we smell things, I picture a molecule like you see in chemistry books going into a nose, all the way up to the end of the nose, and then hitting a receptor that looks like a lock that a key might fit into.

So now that you know a lot about the way we smell, do things smell different to you? Actually, yes, I think they do! I tend to think much more about what I'm smelling, and I think I've gotten better at identifying certain smells.

If you are not doing science, what do you do? When I'm not in the lab working, there are lots of other things I like to do. I love to hula-hoop, and I do that pretty much every day! I play fetch with my dog, I go for long hikes, and I do a lot of rock climbing. I also love cooking, which has become even more fun since I study smell because of all the different odors that appear when you cook things.

What a Nose Knows

APPLES TO ORANGES
What makes an apple smell different from an orange? Tiny molecules!

The sense of smell is one of the least understood of our five senses. For the other four senses—hearing, sight, touch and taste—scientists understand what is going on much better.

Many reasons about why things smell like they do remain a mystery to scientists.

When we see something, for example, light waves enter our eye and the wavelength of that light is what determines what color we will see.

In the sense of smell, tiny molecules enter our nose when we breathe in. When they get all the way up to the top of our nose, the smell molecules bind to cells called receptors. It is these receptors that begin to code what those molecules will smell like to us.

Molecules come in many different shapes and sizes, and when we sniff something, lots of different kinds of molecules enter our nose. So how do we figure out what is going on when there are lots of different smells entering our nose at the same time?

No one knows what it is about a molecule that makes it smell the way it smells. But when you peel an orange, for example, billions

The Bionic Nose: Smelling a Better Future?

Is it possible for scientists to build fake noses that can help us identify odor molecules just like our own noses do? Well, they are working hard on it!

In the future, fake noses could be used for things like "smelling" diseases to help detect diseases sooner, to sniff out dangerous stuff like bombs, or even to detect very small levels of pollutants. The greatest thing about these fake noses is that they never get tired or stuffy. So they are smelling all the time!

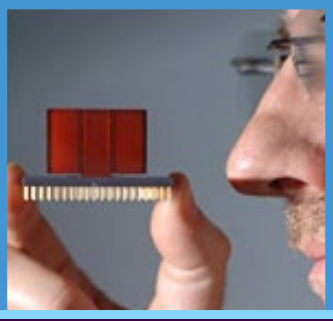
Bionic noses, just like our own noses, consist of three parts: a receptor that senses or identifies the odor molecules, a transfer system to respond to and wire the information, and a computer or "brain" to recognize and identify the information.

Scientists have already figured out the transfer system part. A special class of transistors called "field-effect transistors" are sensitive to their environment. They can "sense" changes in their environment. When something in their environment changes (like a new molecule is introduced) their ability to conduct electricity changes.

If scientists can measure how much electricity is going through one of these transistors, then they can measure what the transistor is sensing. That is the easy part. The harder part is making a transistor for a specific odor molecule. In your nose, the mucus layer helps protect your receptors but allows molecules to diffuse in.

In a fake nose, scientists use different kinds of films similar to plastic wrap that mimic the mucus layer. They are able to create plastic films that only let certain kinds of molecules pass through.

Most of these films will only help detect one type of molecule. So scientists have developed fake noses that can detect a few different types of molecules, but they are a long way off from making fake noses that function just like our own that can detect thousands of different smells.



THAT'S A NOSE?
It doesn't look like much, but bionic noses hold a lot of promise for the future.

of tiny particles get shot into the air and when you sniff, you smell—orange!

When you have milk that has been sitting in the fridge for a long, long time and you open it to see if it has gone bad, billions of tiny particles enter the air around you and the milk carton, and when you sniff in, you perceive the horrible smell of rotten milk!

No one understands why you think that the particles in rotten milk smell horrible and the particles in orange peels smell wonderful.

The nose registers a pattern in those particles that scientists haven't been able to find yet. Most scientists think it has to do with the shape of the molecule, and the way it fits into the receptors inside your nose.

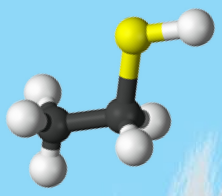
The receptors inside your nose are really small, measuring less than ten nanometers across.

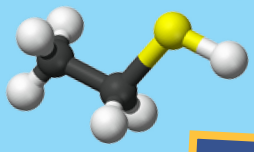
Some of the stinkiest odor molecules are really stinky. One of the stinkiest of them all is ethyl mercaptan. Skunks use ethyl mercaptan to keep other animals and people away and it is also added to natural gas to let us know when there is a leak.

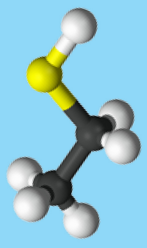
We can smell about 50 parts per billion of ethyl mercaptan in the air. How much is that? Think of it this way: In one cubic foot of air (think of a cube that is one foot on each side) there are about 10^{23} molecules of air. That is 100,000,000,000,000,000,000,000 molecules!

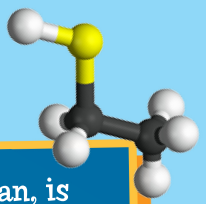
If we sniffed a small fraction of that, let's say one cubic inch, it would take about 10^{13} molecules of ethyl mercaptan for us to smell it. That seems like a lot but that is only ten nanograms! And there are a billion nanograms in a gram. Your average skunk weighs about two thousand grams so that is about one-trillionth of the weight of that skunk.

Figure it this way: That is like one hair out of all of the hairs on all of the heads of all of the people on Earth!



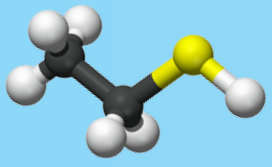






This molecule, ethyl mercaptan, is responsible for a skunk's stink. Our noses can detect ethyl mercaptan in extremely small quantities.

When a skunk lets loose with its spray most animals, including humans, run away. Owls don't because they have a poor sense of smell.



Thanks to Christina Zelano for the excellent smell description.

Tastes Like Chicken?

Some things taste great, like pizza, lemonade or a fresh strawberry, and others *don't* taste great, like medicine. Sometimes tasting great is a matter of "taste"—there are some things that taste good to some people and not to others. Other things taste bad to most people.

Take Limburger cheese for example. It has a powerful, pungent odor, and assertive, distinctive taste. Some people love it, but to a lot of people it tastes really bad. For things like Limburger, if you don't like it, you don't have to eat it. But for other things, like medicine, it would be nice to have them not taste as bad, right?

Tasting is a lot like smelling—there are receptors on your tongue and these receptors bind different molecules. When certain kinds of molecules are bound to them, the receptors send a signal to the brain and you think, "Wow, this tastes great!" or "Ugh, that's terrible!"

Scientists know a lot about how molecules taste. Since molecules have shape and size, scientists can analyze their shapes and then figure out how they taste.

By comparing lots of different molecules with slightly different shapes they can start to see patterns and maybe start to figure out how to build a molecule that tastes better.

Sometimes molecules that look very different taste the same. For example, there is common sugar (sucrose) and aspartame, which is a fake sugar. Their structures look entirely different but they taste very similar.

Scientists are always tweaking the structure of molecules to make them taste better using some pretty sophisticated experiments. At companies that make ingredients for food they use very sensitive equipment to figure out all of the molecules that contribute to a taste.

Some cheese has more than 100 different kinds of molecules that make it taste just right. All that to make a better-tasting pizza!

Nanotechnology is also being used to make things that mask tastes. "Taste-masking" means one molecule blocks the taste of another molecule. The taste-masker doesn't have a taste itself, but it prevents you from tasting another molecule.

Yum!

Strawberries, pizza and lemonade all taste pretty different from each other. But most people think these foods taste great!

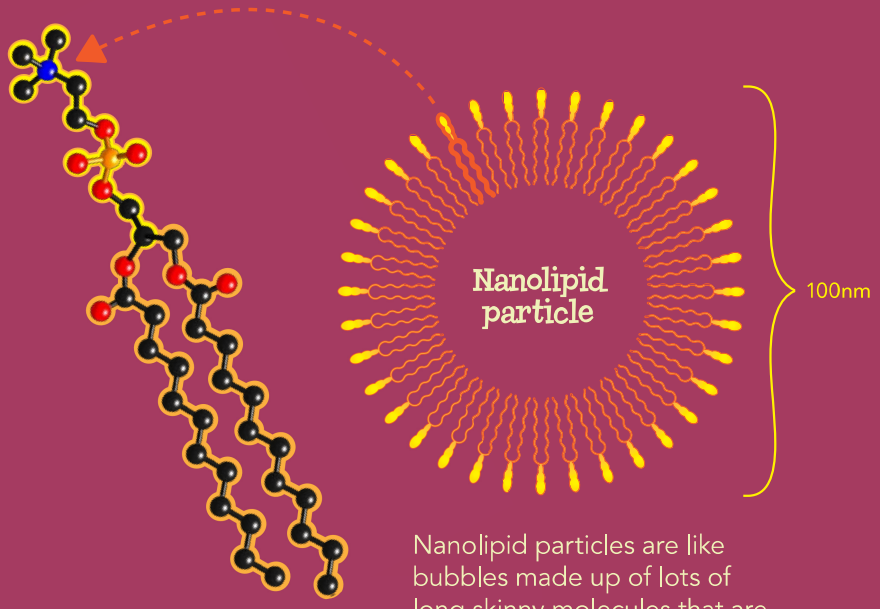
Scientists have developed nanometer-sized particles that are made of lipids (fats) that can mask tastes. These nanolipid particles bind to the receptors that would otherwise bind to something like salt and prevent you from tasting salt.

Nanolipid particles are teeny tiny, around 100 nanometers. About 1,000 of these particles would fit across the width of a hair.

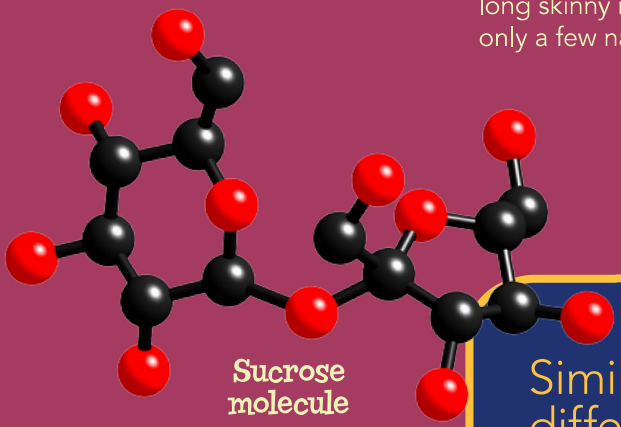
Nanolipid particles are an emulsion, much like mayonnaise—they have parts that don't like water—so some parts wind up on the inside of the particle, away from water, and some wind up on the outside of the particle where they are happy being surrounded by water.

Because they are so small, the particles can be mixed into a beverage and tests have shown that they can mask specific tastes.

Right now, companies are trying to use them in sports drinks so that you can load up on things called electrolytes, which are good to have especially after you sweat but also don't taste very good.

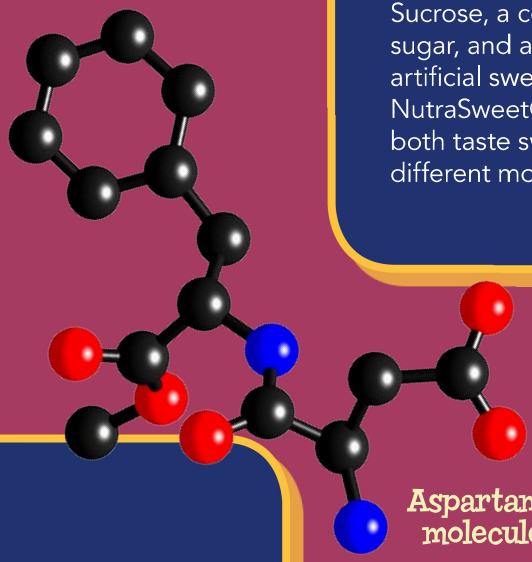


Nanolipid particles are like bubbles made up of lots of long skinny molecules that are only a few nanometers wide.



Similar taste, different shapes

Sucrose, a common form of sugar, and aspartame, an artificial sweetener found in NutraSweet® and Equal®, both taste sweet but have very different molecular structures.



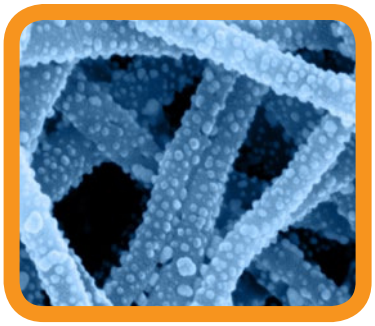
Yuck!

Medicine. Does anyone think medicine tastes good? Can scientists make medicine taste better? The science of taste-masking may make it possible!

Icky Stinky Feet

Ever wonder what makes your feet stink?

Well, mostly it's microbes—tiny bugs, bacteria, fungi. All of these creatures are growing happily on your feet, especially after a hot day outside when things are warm and moist. These microbes generally won't hurt you but while they eat and grow they give off bad odors. Kill the bugs and you prevent the stink.



Small, round **silver nanoparticles** can be applied to cotton fibers to help inhibit bacteria growth.

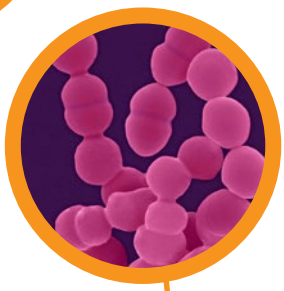
Some scientists came up with the idea of using tiny particles of silver

to kill microbes. Is the idea of using silver to help kill bugs something new? The result of a big research discovery at some top secret nanotech center? Not really. The ancient Greeks and Romans put silver coins in their water carriers to keep it safe for drinking. The problem was you couldn't just use silver because a coating of silver was too expensive and weighed too much.

Epidermophyton floccosum
A fungus that causes athlete's foot

A number of companies are selling socks with silver nanoparticles

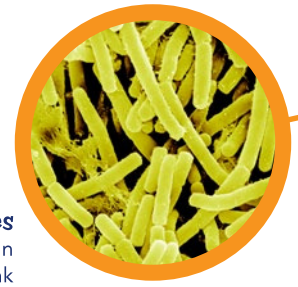
that are supposed to keep those stinky bacteria under control. How do these little silver particles work? These tiny silver nanoparticles are only a few nanometers in size, which is way, way smaller than any microbe. The silver nanoparticles are mixed into a polymer that makes it easy to apply to fabric.



Staphylococcus epidermidis
Bacteria found on your skin that can cause odors

Because they are so small, these silver nanoparticles can get into

the membrane, the outermost coat, of many microbes. Once the nanoparticles attach to the membrane they short-circuit the microbe cells so they can't make energy. When cells can't make energy they can't grow and eventually wind up dying. Current estimates are that almost one ton of silver is being used in fabrics to help kill microbes.



Propionibacterium acnes
Bacteria that lives on your skin and can make your feet stink