

## Nanotech Gamble

PART 1 of 4

# Amid Nanotech's Dazzling Promise, Health Fears Grow

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(March 22) -- For almost two years, molecular biologist Bénédicte Trouiller doused the drinking water of scores of lab mice with nano-titanium dioxide, the most common nanomaterial used in consumer products today.

She knew that earlier studies conducted in test tubes and petri dishes had shown the same particle could cause disease. But her tests at a lab at UCLA's School of Public Health were *in vivo* -- conducted in living organisms -- and thus regarded by some scientists as more relevant in assessing potential human harm.

Halfway through, Trouiller became alarmed: Consuming the nano-titanium dioxide was damaging or destroying the animals' DNA and chromosomes. The biological havoc continued as she repeated the studies again and again. It was a significant finding: [link TK] The degrees of DNA damage

and genetic instability that the 32-year-old investigator documented can be "linked to all the big killers of man, namely cancer, heart disease, neurological disease and aging," says Professor Robert Schiestl, a genetic toxicologist who ran the lab at UCLA's School of Public Health where Trouiller did her research.

Nano-titanium dioxide is so pervasive that the [Environmental Working Group](#) says it has calculated that close to 10,000 over-the-counter products use it in one form or another. Other public health specialists put the number even higher. It's "in everything from medicine capsules and nutritional supplements, to food icing and additives, to skin creams, oils and toothpaste," Schiestl says. He adds that at least 2 million pounds of nanosized titanium dioxide are produced and used in the U.S. each year.

What's more, the particles Trouiller gave the mice to drink are just one of an endless number of engineered, atom-size structures that have or can be made. And a number of those nanomaterials have also been shown in published, peer-reviewed studies (more than 170 from the National Institute for Occupational Safety and Health alone) to potentially cause harm as well. Researchers have found, for instance, that carbon nanotubes -- widely used in many industrial applications -- can penetrate the lungs more deeply than asbestos and appear to cause asbestos-like, often-fatal damage more rapidly. Other nanoparticles, especially those composed of metal-chemical combinations, can cause cancer and birth defects; lead to harmful buildups in the circulatory

system; and damage the heart, liver and other organs of lab animals.

Yet despite those findings, most federal agencies are doing little to nothing to ensure public safety. Consumers have virtually no way of knowing whether the products they purchase contain nanomaterials, as under current U.S. laws it is completely up to manufacturers what to put on their labels. And hundreds of interviews conducted by AOL News over the past 15 months make it clear that movement in the government's efforts to institute safety rules and regulations for use of nanomaterials is often as flat as the read-out on a snowman's heart monitor.

"How long should the public have to wait before the government takes protective action?" says Jaydee Hanson, senior policy analyst for the [Center for Food Safety](#). "Must the bodies stack up first?"

## **Big Promise Comes With Potential Perils**

"Nano" comes from the Greek word for dwarf, though that falls short of conveying the true scale of this new world: Draw a line 1-inch long, and 25 million nanoparticles can fit between its beginning and end.

Apart from the materials' size, everything about nanotechnology is huge. According to the federal government and investment analysts, more than 1,300 U.S.

businesses and universities are involved in related research and development. The National Science Foundation says that \$60 billion to \$70 billion of nano-containing products are sold in this country annually, with the majority going to the energy and electronics industries.

Despite the speed bump of the recession, a global market for nano-containing products that stood at \$254 billion in 2005 is projected to grow to \$2.5 trillion over the next four years, says Michael Holman, research director of Boston-based Lux Research. Another projection, this one from National Science Foundation senior nanotechnology adviser Mihail Roco, says that nanotech will create at least 1 million jobs worldwide by 2015.

By deconstructing and then reassembling atoms into previously undiscovered material -- the delicate process at the heart of nanotechnology -- scientists have achieved medical advancements that even staunch critics admit are miraculous. Think of a medical smart bomb: payloads of cancer-fighting drugs loaded into nanoscale delivery systems and targeted against a specific tumor.

Carbon nanotubes, rod-shaped and rigid with a strength that surpasses steel at a mere fraction of the weight, were touted by commentators at the Vancouver Olympics as helmets, skis and bobsleds made from nanocomposites flashed by. Those innovations follow ultralight bicycles used in the Tour de France, longer-lasting tennis balls, and golf balls touted to fly straighter and roll farther.

Food scientists, meanwhile, are almost gleeful over the ability to create nanostructures that can enhance food's flavor, shelf life and appearance -- and to one day potentially use the engineered particles to craft food without ever involving a farm or ranch.

Yet for all the technology's promise and relentless progress, major questions remain about nanomaterials' effects on human health. A bumper sticker spotted near the sprawling Food and Drug Administration complex in Rockville, Md., puts it well: "Nanotech -- wondrous, horrendous, and unknown."

Adds Jim Alwood, nanotechnology coordinator in the Environmental Protection Agency's Office of Pollution Prevention and Toxics: "There is so much uncertainty about the questions of safety. We can't tell you how safe or unsafe nanomaterials are. There is just too much that we don't yet know."

What is known is by turns fascinating and sobering.

Nanoparticles can heal, but they can also kill. Thanks to their size, researchers have found, they can enter the body by almost every pathway. They can be inhaled, ingested, absorbed through skin and eyes. They can invade the brain through the olfactory nerves in the nose.

After penetrating the body, nanoparticles can enter cells,

move from organ to organ and even cross the protective blood-brain barrier. They can also get into the bloodstream, bone marrow, nerves, ovaries, muscles and lymph nodes.

The toxicity of a specific nanoparticle depends, in part, on its shape and chemical composition. Many are shaped roughly like a soccer ball, with multiple panels that can increase reactivity, thus exacerbating their potential hazards.

Some nanoparticles can cause a condition called oxidative stress, which can inflame and eventually kill cells. A potential blessing in controlled clinical applications, this ability also carries potentially disastrous consequences.

"Scientists have engineered nanoparticles to target some types of cancer cells, and this is truly wonderful," says Dr. Michael Harbut, director of the Environmental Cancer Initiative at Michigan's Karmanos Cancer Institute. "But until we have sufficient knowledge of, and experience with, this 21st-century version of the surgical scalpel, we run a very real risk of simultaneously destroying healthy cells."

When incorporated into food products, nanomaterials raise other troubling vagaries. In a report issued in January, the science committee of the British House of Lords, following a lengthy review, concluded that there was too little research looking at the toxicological impact of eating nanomaterials. The committee recommended that such "products will simply be denied regulatory approval until further information is available," and also raised the concern that

while the amount of nanomaterial in food may be small, the particles can accumulate from repeated consumption.

"It is chronic exposure to nanomaterials that is arguably more relevant to food science applications," says Bernadene Magnuson, a food scientist and toxicologist with [Cantox Health Sciences International](#). "Prolonged exposure studies must be conducted."

Given the potential hazards, public health advocates are calling for greater restraint on the part of those rushing nanoproducts to market. "The danger is there today in the hundreds of nano-containing consumer products being sold," says Jennifer Sass, senior scientist and nano expert for the nonpartisan [Natural Resources Defense Council](#). "Things that are in the nanoscale that are intentionally designed to be put into consumer products should be instantly required to be tested, and until proper risk assessments are done, they shouldn't be allowed to be sold."

David Hobson, chief scientific officer for international risk assessment firm [nanoTox](#), adds that the questions raised by the growing body of research "are significant enough that we should begin to be concerned. We should not wait until we see visible health effects in humans before we take steps to protect ourselves or to redesign these particles so that they're safer."

Hobson says that when he talks to university and industry nano scientists, he sometimes feels as if he's talking with

Marie Curie when she first was playing around with radium.

"It's an exciting advancement they're working with," he says.  
"But no one even thinks that it could be harmful."

### **More on Why Size Matters**

At a weeklong Knight Foundation Science Workshop on nanotechnology at the Massachusetts Institute of Technology in June, five professors -- four from the Cambridge school and one from Cornell University -- dazzled their fellow participants with extensive show-and-tells on the amazing innovations coming out of their labs.

At one point, one played a video of a mouse with a severed spine dragging his lifeless rear legs around his cage. A scaffolding made of nanomaterial was later implanted across the mouse's injury. Further footage showed the same rodent, 100 days later, racing around his enclosure, all four legs churning like mad.

When the five nanotech pioneers were asked about hazards from the particles they were creating, only one said she was watching new health studies closely. The others said size had no impact on risk: No problems were expected, since the same chemicals they had nano-ized had been used safely for years.

It's an argument echoed by researchers and nano-



manufacturers around the globe. But those assumptions are challenged by the many research efforts presenting strong evidence to the contrary, among them Trouiller's study, which was published in November.

"The difference in size is vital to understanding the risk from the same chemical," says Schiestl, who was a co-author on the UCLA study. "Titanium dioxide is chemically inert and has been safely used in the body for decades for joint replacements and other surgical applications. But when the very same chemical is nanosized, it can cause illness and lead to death."

### **Regulators Take a 'Wait-and-See' Approach**

Many public health groups and environmental activists fear the government's lethargy on nanotechnology will be a repeat of earlier regulatory snafus where deadly errors were made in assessing the risk of new substances. "The unsettling track record of other technological breakthroughs -- like asbestos, DDT, PCBs and radiation -- should give regulators pause as they consider the growing commercial presence of nanotech products," says Patty Lovera, assistant director of [Food & Water Watch](#). "This wait-and-see approach puts consumers and the environment at risk."

While the agency has many critics, the EPA, for its part, is pursuing an aggressive strategy on nanotechnology. Among nano-titanium dioxide's other uses, the particle is deployed

as an agent for removing arsenic from drinking water, and last year, the EPA handed out 500-page books of health studies on the particles to a panel of scientists asked to advise the agency on the possible risk of that practice. (Another EPA science advisory board held hearings into the hazards from nanosilver used in hundreds of products, from pants, socks and underwear to teething rings.)

The Food and Drug Administration's handling of nano-titanium dioxide provides a more emblematic example of the government's overall approach. Public health advocates and some of the FDA's own risk assessors are frustrated by what they perceive as the agency's "don't look, don't tell" philosophy. The FDA doesn't even make a pretense of evaluating nanoparticles in the thousands of cosmetics, facial products or food supplements that have already flooded the market, even those that boast the presence of engineered particles. Nano-Bliss Anti-Aging Cream (which sells for \$550 for a 1.7-ounce jar) or [Nano Gold Energizing Cream](#) (\$420) are among the many similar products unevaluated by the agency.

Dr. Jesse Goodman, the FDA's chief scientist and deputy commissioner for science and public health, says the exclusion of cosmetics and nutritional supplements from its regulations is what Congress wants. Goodman adds that "there is a most definite requirement that manufacturers ensure that the products be safe" but says that compliance is essentially voluntary, with the FDA taking action only after an unsafe product is reported.

AOL News repeatedly asked what steps the FDA was taking regarding nano-titanium dioxide, whose risks are acknowledged by other regulatory bodies, including the EPA and the NIOSH. The slow-to-arrive answer from spokeswoman Rita Chappelle: "If information were to indicate that additional safety evaluation or other regulatory action is warranted, we would work with all parties to take the steps appropriate to ensure the safety of marketed products."

Chappelle says FDA scientists are conducting research that focuses on nano-titanium dioxide but declined to offer any specifics. Several of her agency's own safety experts say they specifically have urged that the engineered structures not be used in any products they do regulate without appropriate safety testing.

### **Why Nano-Optimists Hold the Upper Hand**

Many government investigators join civilian public health specialists in denouncing the scant money that goes to exploring nanomaterials' possibly wicked side effects. The 2011 federal budget proposes spending \$1.8 billion on nanotechnology, but just \$117 million, or 6.6 percent, of that total was earmarked for the study of safety issues.

The Obama administration says it is being appropriately vigilant about nanotech. "This administration takes

nanotechnology-related environment, health and safety very seriously. It is a significant priority," says Travis Earles, assistant director for nanotechnology in the White House Office of Science and Technology Policy. After taking office, he adds, "We were able to immediately increase the spending in those areas."

But Earles, in what has become standard federal practice, is more fixated on nanotech's upsides. "We are talking about new jobs, new markets, economic and societal benefits so broad they stretch the imagination," he says. Yes, "absolutely," there are reasons for caution, he says. "But you can't refer to nanotechnology as a monolithic entity. Risk assessment depends fundamentally on context -- it depends on the specific application and the specific material."

There's some scientific basis for this emphasize-the-positive position. "Every time you find a hazardous response in a test tube, that should not necessarily be construed as a guarantee of a real-life adverse outcome," notes Dr. Andre Nel, Chief, Division of NanoMedicine at the California NanoSystems Institute and the University of California.

But there are two ways to proceed in the face of such uncertainty. One is to forge ahead, assuming the best -- that this will be one of those times where the lab results don't correlate to real-world experiences. Another is to hit pause and do the additional testing necessary to be sure that sickened lab animals do not portend human harm.

For advocates of more precautions for nanotech, the latter is the only responsible course.

"From cosmetics to cookware to food, nanoparticles are making their way into every facet of consumer life with little to no oversight from government regulators," says Lovera from Food & Water Watch. "There are too many unanswered questions and common-sense demands that these products be kept off the market until their safety is assured."

With a moratorium not a realistic option, the U.S. government, along with its counterparts abroad, is left to tread gingerly in responding to the emerging evidence of nanotechnology's potential hazards.

"They don't want to cause either a collapse in the industry or generate any kind of public backlash of any sort," says Pat Mooney, executive director of [ETC Group](#), an international safety and environmental watchdog. "So they're in the background talking about how they're going to tweak regulations -- where in fact a lot more than tweaking is required."

"They've got literally thousands of [nano] products in the marketplace, and they don't have any safety regulations in place," Mooney continues. "These are things that we're rubbing in our skin, spraying in our fields, eating and wearing. And that's a mistake, and they're trying to figure out what to do about it all."

*Filed under: [Nation](#), [Science](#), [Health](#), [Tech](#), Nano, Public Safety*