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SPOTLIGHT ON NANOTECHNOLOGY

The rapidly advancing science is forecast to transform society

By Bruce Lieberman, STAFF WRITER

In a sleek UCSD laboratory, physicist Ivan Schuller is developing sensors for chemical and biological weapons — instruments so tiny that millions will fit on a chip the size of a postage stamp.

At the nearby Burnham Institute, also in La Jolla, Erkki Ruoslahti is testing microscopic spheres that act like guided missiles, carrying chemotherapy drugs to a cancer tumor.

Schuller and Ruoslahti are two of many scientists worldwide working on nanotechnology — the manipulation and control of carbon, silicon, gold and other elements in amounts as small as a handful of atoms measuring a few nanometers across. A nanometer is one billionth of a meter; a human hair measures about 80,000 nanometers wide.

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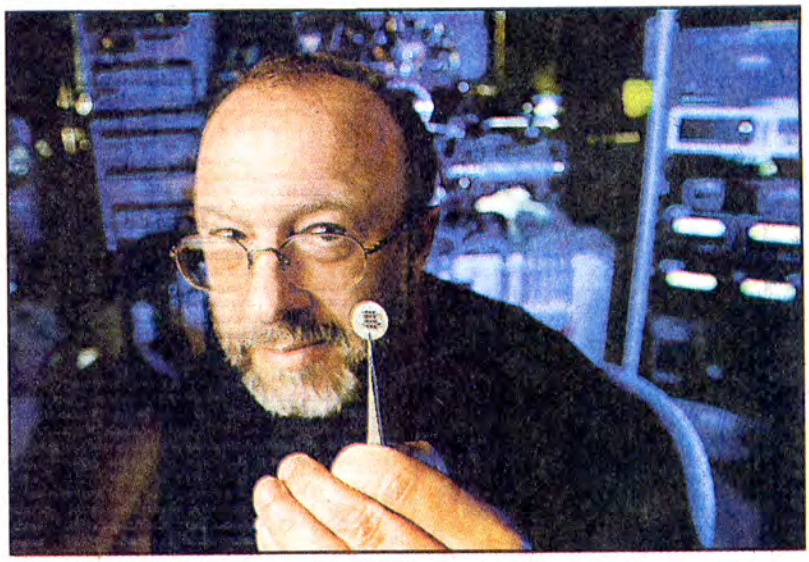

Ivan Schuller held a prototype of tiny sensors that could potentially detect biological and chemical weapons. *Nelvin Cepeda / Union-Tribune*

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Nanotechnology is expected to pervade society

The rapidly advancing science of things incredibly minute stands to change everything — the clothing people wear, the houses in which they live, the cars they drive, the medicines they take, the foods they eat, the computers they use and much more.

Nanotechnology will be a major theme at the annual meeting of the American Chemical Society, which begins tomorrow in San Diego. More than 60 reports on the topic will be presented to an expected audience of 14,000 scientists through Thursday.

Researchers have found that assembling things at such small scales can alter their magnetism, reflectivity, electrical resistance and other physical properties. They are studying how those properties can lead to faster hard drives, paint and fabrics that change color according to temperature, new fuels, more powerful solar cells and other applications.

"Nanotechnology truly will bring a revolution in technology and industry," said Mihail Roco, senior adviser for nanotechnology at the National Science Foundation.

It will transform society faster than the computer industry and pervade daily life in obvious and subtle ways, Roco said. By 2015, he predicts, more than half of all new products will come from nanotechnology. Many people regard nanotechnology as the driver of a second industrial revolution.

But with the benefits come fears about unintended dangers.

It's unclear, for example, whether some particles manufactured at such tiny scales — so small they can pass through the membranes of cells — may prove deadly if not handled properly.

Science fiction has seized on the uncertainty. Michael Crichton's 2002 novel "Prey" paints a picture of nanotechnology run amok as self-replicating "nanomachines" multiply uncontrollably and overwhelm humanity.

In reality, nanotechnology has resulted in many new products. These include water filters, a dental bonding agent, special car bumpers, protective coatings for eyeglasses, novel sunscreens and cosmetics, stain-resistant clothing and longer-lasting tennis balls.

In the future, some of the most dramatic advances might include wireless computers and video screens embedded in eyeglasses, as well as minuscule machines that can assemble themselves to achieve tasks.

The federal government is backing nanotechnology in a big way.

Its funding for research and development has increased from $116 million in 1997 to $961 million in 2004, according to the National Nanotechnology Initiative. President Bush's latest budget proposes a 2 percent increase to $982 million for 2006.

Worldwide, governments are investing more than $3 billion per year. Like the United States, Japan, Korea, China and several European countries also have made it a priority.

Companies are getting on board, too. In 2000, Roco said, he could find only one business — IBM — with a nanotechnology initiative. Today, all Fortune 500 companies are involved in some form of nanotechnology research and development. Private investment in the United States has reached $1.7 billion this year, Roco said.

Back in La Jolla, Schuller said he likes to quiz his colleagues about nanotechnology by asking them the following question: If all the atoms that make up a short strand of hair were the size of peanut shells, how many sports stadiums would those shells fill?

Sensors like this prototype might someday detect biochemical weapons in the environment. *Nelvin Cepeda / Union-Tribune*

Getting to nano scale

Measuring objects in nanometers, or one-billionth of a meter

Ant: 5 million nanometers

Dust mite: 200,000 nanometers

OTHER OBJECTS	Nanometers
Head of a pin	1 million
Human hair	80,000
Red blood cell	2,000
DNA	2.5
Carbon nanotube *Can be used as an electrode*	1.3

SOURCE: National Nanotechnology Initiative — UNION-TRIBUNE

The answer: enough to fill Petco Park 500 million times over.

"Nobody guesses that," Schuller said. "Even scientists have no feeling for these numbers."

Modern industry has made tremendous advances in miniaturization. For example, there are millions of transistors packed into a Pentium computer chip.

But comparing the size of those transistors with a molecule is akin to placing an elephant next to an ant, said Mike Sailor, a UCSD chemist.

"Nanotechnology focuses on all the animals in between, and there are a lot of animals in the zoo," Sailor said.

He has developed sensors made from particles of silicon he calls "smart dust." Like flecks of living room dust that float in a beam of sunlight, Sailor's smart dust can flood an area. But here's the key difference: Smart dust has been engineered to reflect different colors of light when exposed to particular chemicals, such as sarin gas.

Some nanotechnology ideas have come from unlikely places.

Schuller's concept for sensors that can detect biological and chemical weapons began more than 20 years ago as he watched his infant son lying in a crib and reaching for a slowly rotating toy.

Once the baby touched it, he became startled and quickly withdrew his hand. The boy then examined his hand, appeared to think over the situation and then reached out again.

As Schuller watched his son, he thought of a tiny sensor that would reach out into the environment, react to what it touches, evaluate what it finds and then communicate that information to some nerve center — like a brain.

His experimental sensor, supported by the Defense Department, would combine a series of magnetic, infrared, chemical and biological detectors. These nano-instruments would send their findings to another part of the sensor that then transmits the information by wireless communication to a central command center.

All these functions would be packaged together, and millions of the sensors could be arrayed on a chip no larger than a square inch. The chips could be dropped from the air or planted in or outside a building, in water, up in trees and on the ground.

Many scientists working with nanotechnology said they are most excited by how the field will transform the medical world.

They look to the body's cells as an example of nature's ability to build and operate small things.

"Nanotechnology is something that nature's been doing for millennia," Sailor said.

In this sense, an increased understanding of nanotechnology will expand what scientists know about nature, Roco added.

"We will learn more what 'life' means because life is organized at nano-scales," he said.

When applied to treatment of diseases, such knowledge might allow researchers to target cancer cells with unprecedented precision, said Ruoslahti, the cancer researcher at the Burnham Institute.

Unlike conventional chemotherapy, the nano-particles that Ruoslahti is developing are projected to carry a small molecule that will attach itself — and its drug cargo — only to blood vessels that feed cancer tumors.

"As opposed to a drug, which is basically not smart, a nano-device can be designed so it is smart," Ruoslahti said. "By performing many functions, it can really focus the treatment and improve its quality."

The anticipated pervasiveness of nanotechnology in coming years has worried some people. Some scientists believe that newly made materials could become dangerous to human health and the environment.

These potential hazards will be a substantial topic at the American Chemical Society conference.

For instance, it's unclear how toxic some nano-particles might be to human health. The large surface area of nano-particles, relative to their overall size, increases their toxicity when inhaled. They can penetrate deep into the lungs and may move to the brain, liver and other parts of the body.

Some worry that nano-particles in the wrong hands could be used as terrorist weapons.

The National Institute for Occupational Safety and Health, part of the federal Centers for Disease Control and Prevention, is participating in an international effort to better understand how nano-materials might influence human health. It aims to pinpoint and control potential risks.

"We have to develop ways to deal with unexpected consequences," Roco said.

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