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Nanotech's medical payoff is coming

By IN-SUNG YOO / The News Journal
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The News Journal/JENNIFER CORBETT
Dawn Bonnell, a material scientist and director of the Nano-Bio Interface Center at the University of Pennsylvania, with an atomic force microscope.

Chances are, you've heard the term nanotechnology being thrown around as "the next big thing" in science and technology. Chances are also good that you still have no idea what it is.

So why is it such a big deal, and when will we see it?

Nanotechnology is all around you already. Your computer hard drive, the coated fabrics of stain-resistant shirts, fast-absorbing sunscreens, and the bulb-less, LED traffic signals on your streets; they are all examples of the technological breakthrough of the future at work in the present.

The truth is, nanotechnology has been around for years, and was a vital part of the semiconductor industry that enabled the computer age. Its potential for applications in medicine, however - which include treatments for cancer, heart disease, genetic diseases, and even wholescale organ production - are perhaps generating the most excitement.

The novelty of nanotechnology can be boiled down to this: size matters.

"The definition of nanotechnology has three components," said Dawn Bonnell of the Nano-Bio Interface Center at the University of Pennsylvania. "One is that you build materials or systems with molecular-level precision. In principle you can build them an atom at a time. Second, what you build takes advantage of properties that are specific to their small size. If you have a big chunk of metal, and you make it smaller, it's not just a smaller version of the same thing, it actually behaves differently when it passes a certain size. And third, it does something functional."

The constant miniaturization of technology has progressed to the point where we cannot only visualize at the molecular scale, we can manipulate and create materials at the very level at which the building blocks of life itself operate.

"All of biology is nano-scale," said Matt O'Donnell, biomedical engineering chair at the University of Michigan. "Nano means molecules; molecules are what we've studied in chemistry and molecular biology for generations. So this is nothing new, this idea of molecules controlling how a cell works, a cell controlling how a tissue works, and tissues controlling how organs work, and organs controlling how a body works."

Once we harness that ability to control molecules, the potential for medical applications are almost endless, say researchers.

One of the more straightforward applications of nanotechnology in medicine may allow us to drastically improve the effectiveness and efficiency of cancer treatment. Many chemotherapy drugs target cancer cells by attacking the cell division process. Cancer cells are killed, but the indiscriminate nature of the treatment also kills many other rapidly-dividing cells necessary to a healthy body, leading to a host of serious side effects. Where this approach is akin to carpet bombing, tiny nanoparticles studded with molecules programmed to link specifically to cancer cells could deliver that same drug with guided-missile precision.

"Once they're in those cells, it's just standard old conventional chemotherapy," said O'Donnell. "However, that accumulation of that drug in the cancer cells may be a thousand times more than it is in any other cell. That's what nanotechnology does. You can engineer it so that it targets particular little doorways that exist on the surface of cancer cells."

A similar approach could yield improved imaging systems that can detect the smallest of tumors. Eventually, scientists envision nanotechnology playing a big role in making gene therapy a reality.

HOW SMALL IS NANO-SCALE?

Researchers at the University of Delaware's Department of Material Science and Engineering are working on materials that may one day evolve into a variety of tissue implants, benefiting everyone from burn victims to patients in need of an organ transplant.

"The holy grail is to be able to make two-dimensional and eventually three-dimensional scaffolds that will hold and grow cells, or even be shaped like an organ and have the same function," said John Rabolt, a physicist, and chair of the department.

Bonnell predicts nanotechnology's permeation of the healthcare industry will be so complete that it will soon become all but invisible, much like previous technologies.

"Nuclear magnetic resonance is a tool [we use], but in the doctor's office we just call it an MRI," she said. "We don't put 'nuclear' in there. So maybe the same thing will happen with [nanotechnology]. Nobody's going to be out there saying, 'OK, this thing I'm injecting has nanotechnology in it,' but nanotechnology will be increasing the quality of healthcare in the country."

As of yet, researchers consider nanotechnology in a "precompetitive" phase; applications are largely rudimentary. But with the federal government putting an estimated $961 million of funding into research efforts in 2004, the support is present and the payoff is coming, say researchers.

"Everybody understands that there's going to be an economic outcome of this," said Bonnell. "This isn't a flash in the pan thing, this is a part of technology that isn't going away. When people ask me when is this starting, I say, 'It's started, it's here.' Some of it you didn't notice because nobody pointed it out to you. But it's going to continue to grow and it's going to impact all of technology."

"There's an old mantra about technical development," said O'Donnell. "The mantra was, 'you're always looking for opportunities where a quantitative difference leads to a qualitative difference.' People have been doing stuff at the borders of nanoscale for a long time. Now, because you're literally engineering stuff at the same dimension as the natural molecules that govern how life functions, there's potential for the qualitative change. The whole way we think about medicine is totally changed."

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A nanometer is one-billionth of a meter, or about the size of 4 atoms lined up in a row. DNA is approximately 2.5 nanometers. By comparison, the width of a human hair is about 80,000 nanometers.

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