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How University of Texas Dallas Nabbed the Nation's #1 Nanotech Guy

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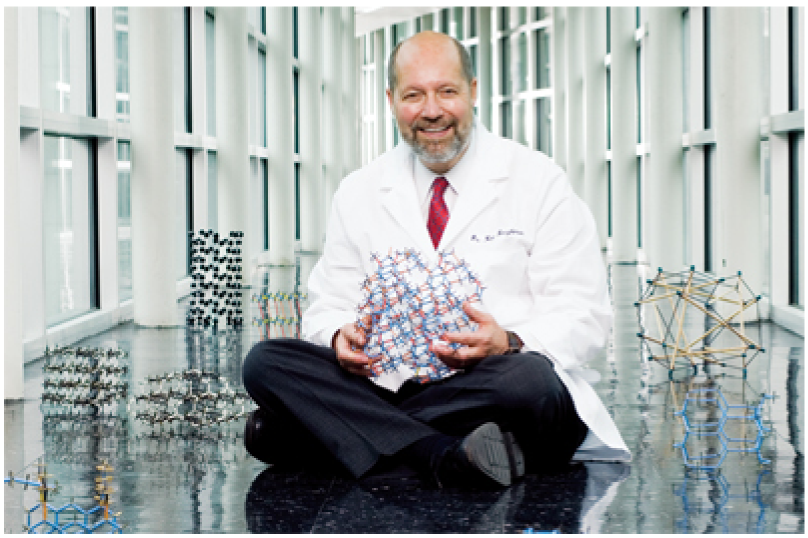
Ray Baughman, internationally acclaimed for his work in artificial muscles and carbon nanotubes, is also known for his toy collection. In his office at the University of Texas at Dallas, where he serves as director of the university's NanoTech Institute, amid Defense Department proposals and 400-page patents, sits a toy kangaroo he bought in Australia. It is red and wears a yellow t-shirt. Where its pouch would be is instead a spring that uncoils when you pull it.



MODEL STUDENT: A colleague says Baughman makes "surprising discoveries" every three or four months.
photography by Elizabeth Lavin

"I noticed if you stretch the spring, the head rotates," Baughman says. "So there's a stretch rotational coupling." It intrigued Baughman because his work, put simply, concerns the multi-functionality of things. Things like his team's carbon nanotube yarns, the toughest material known to man. The nanotubes are one ten-thousandth the diameter of a human hair and yet, pound for pound, 56 times stronger than steel wire. Someday nanotube yarns could be woven into a vest that is extremely lightweight but also anti-ballistic. The yarns conduct electrical current, too. So the vest could be used to power a soldier's telecommunication devices as he's fighting.

So how can a man who deals in such cutting-edge research be excited by a rotating kangaroo? Because the spring suggests how carbon nanotubes could also be used in artificial muscles. Baughman found that carbon nanotubes, if charged with a current, will change length and some will even rotate, simulating a muscle's range of motion. This would allow for minimally invasive microsurgery, with hundreds of the fibers working as artificial muscles and strung along, say, a catheter, repairing the injury.

Baughman gets up from his seat at a conference table and walks the few paces back to the bookshelf where the kangaroo sits. At 64 years old, he is a large man with the build of a basketball player gone academic, slim but for his belly, which bears evidence of Baughman's weakness for peanuts. His face is open and expressive despite his full beard, and he always seems to be smiling. He wears brown sandals and black socks.

He brings other toys back to the conference table because there are other advancements to be made. Here is a snake whose slithering motion reminds him that an expansion over here causes a bend over there and that these contractions and expansions are similar to a conducting polymer's. A fruit basket from Mexico cut from one piece of wood has the same cantilever effect as one of Baughman's fuel-powered artificial muscles. All these toys help with his ideas and 57 U.S. patents. The university happily reimburses him for these rather odd business expenses.

That's because Baughman has brought the NanoTech Institute to science's international stage and shined a spotlight right on UTD. In 2005, *Discover* magazine ranked Baughman's carbon nanotube yarns and carbon nanotube sheets as the eighth-most important scientific discovery of the year. Last year, the sheets and yarns were noted on the *Scientific American* 50, a prestigious list that has included Nobel laureates and the co-founders of Google.

Nano might turn out to be bigger than the computer revolution. In a not-too-distant future, nanotechnology will be in clothes that are stain resistant, in devices that fight cancer without chemo, in grids that power our houses more efficiently. Think of nano as the new plastic. That's why everyone wants a piece of it. There are roughly 130 nanotech centers in universities and institutions across the country—15 years ago there were none.

"Sixty papers are published a week on carbon nanotubes alone," Wade Adams says, exaggerating only slightly. He's the director of Rice University's nanotech center, the first in the world. "What makes Ray [Baughman] great is that he makes these sort of really surprising discoveries," Adams says. "And Ray just seems to come out with these things every three or four months. He's very clever."

A nanometer is a billionth of a meter. Imagine a marble compared to the size of the Earth. And all things in the "nano" realm are less than 100 nanometers. At that scale, scientists build things one atom at a time, and some materials begin to act strangely, develop new properties. That's where the multi-functionality of nano comes into play. Because new properties on the nano scale mean new products on the macro scale—like a vest that is lightweight, anti-ballistic, and electrically conductive.

Nano has been around for a couple decades, but you're hearing about it now because the applications for the first advancements are coming to market. By 2015, the National Science Foundation estimates, nanotechnology will be a $1 trillion industry.

UTD wanted in on the action in 2000. The university charged Da Hsuan Feng, its newly appointed vice president of research, with building and staffing the nanotech center. One problem: he knew no one in the field. "I regretted it almost immediately after I said I'd do it," Feng says. He turned to Alan MacDiarmid, a friend and professor at the University of Pennsylvania who had just won the Nobel Prize in Chemistry for discovering plastics that conduct electricity like metals. MacDiarmid said he knew of someone who might be interested, one of the three people MacDiarmid would invite to Sweden for his Nobel acceptance speech, a guy named Ray Baughman.

Baughman had worked on the industry side, at Honeywell in New Jersey, for 31 years. Feng didn't know much about him, so he Googled the phrase "International Nanotechnology Conference." Baughman's name came up again and again as the keynote speaker in locales throughout the world. Something else Feng learned: General Electric was considering a buyout of Honeywell. The proposition had many Honeywell people nervous. Feng mentioned Baughman's name to John Ferraris, the department chair of chemistry at UTD. Ferraris didn't need to Google anything. The message from the top came back to Feng: "Do whatever it takes."

This unfortunately was the same message recruiters at other universities got, universities far more renowned than UTD. Worse, when Baughman asked his wife, Karan, what she thought of Dallas, she said, "I don't." So during his first trip to New Jersey, Feng decided against an expensive dinner at a restaurant with Baughman and instead had biscuits at the Baughman home. And for five hours, Feng tried to woo Karan.

"He was so sweet," Karan says. "But I was still highly reluctant." She didn't want to move from the East Coast. So Feng made more visits, and then John Ferraris came out, and when the Baughmans visited UTD in early 2001, while Baughman was hugging everyone he saw, as is his wont, Hobson Wildenthal, the university's provost, drove Karan around to look for houses and recommend school districts for the Baughmans' son, Alex. UTD wanted Baughman more than anyone else. "The message was so loud and clear," Karan says.

But Baughman wouldn't come without Anvar Zakhidov, a close associate of his at Honeywell, who was, in Baughman's words, "just an extraordinarily powerful physicist." This meant more wooing by the university, more time in the car with Wildenthal, driving around the Zakhidov family and showing them homes. But it paid off. UTD's NanoTech Institute opened its doors in the fall semester of 2001, with Baughman as the director and Zakhidov as associate director. They initially worked out of someone else's lab. Nevertheless, in 2002, Alan MacDiarmid himself joined the faculty at UTD. He wanted to work alongside his old friend.

One major breakthrough came in 2004 with a discovery that carbon nanotubes, the cylindrical sheets of carbon atoms, can be spun into yarns. Until then, carbon nanotubes held great promise—they were strong, electrically and thermally conductive, and pliant—but they didn't have much applicability. No one knew how to convert the nanotubes to the macro level without ruining them. Baughman and his group had an idea. The NanoTech Institute has a team of roughly 60, and one of its researchers, Mei Zhang, made a big discovery in 1999 in Japan when she found you could make a "forest" of these nanotubes. The forest to the naked eye looks like nothing more than a strip of a black substance on a piece of glass. At the nano scale, however, the forest is trillions of vertically aligned carbon nanotubes. If you could pull the fibers from these nanotubes together, and then spin them, much as a loom spins wool, what would happen? After collaborating with a team of Australian scientists who specialize in wool spinning, the result was nanotube yarns. Where before nanotubes grew to only about 300 micrometers, now nanotube yarns could be spun to any length. The yarn was stronger by weight than steel, yet far lighter and electrically conductive.

Baughman wasn't done. Next up were carbon nanotube sheets. Because if you could spin the nanotube fibers into yarn, what would happen if you simply pulled the fibers? Baughman and his team showed that teasing the fibers from the forest and attaching them to an adhesive tape created a sheet that was only 50 percent heavier than air but could hold more than a million times its weight.

Working with a Cleveland technology company called Tursiop, the NanoTech Institute has found that the sheets can be used to obtain high-resolution imagery of a mouse brain, about three millimeters in diameter. This resolution is much clearer than what is presently available. These sheets are only four microns thick, equivalent to one-twentieth the thickness of a human hair. "It's almost like doing something with thin air," says Tursiop CEO Brad Goldstein, leery of disclosing too much before Tursiop's own public announcement, which should occur within a few months. Goldstein commends NanoTech Institute's advancements for their commercial viability, unlike at other universities where the discoveries are "too futuristic" and not really applicable. This is due to Baughman's past in the private sector. But even so, he's working on some futuristic stuff, too.

The Defense Advanced Projects Agency (DARPA) approached Baughman in 2005, looking for him to improve upon his earlier advance in artificial muscles, the ones that incorporated carbon nanotube yarns and could potentially benefit people with prosthetic limbs. DARPA sees a future in which soldiers fight alongside humanoid robots powered by artificial muscles. The problem was the energy that fueled these muscles. It came from electricity, which meant they had to be recharged frequently. This was a hard problem to solve, even at an agency known for solving "DARPA-hard problems."

In March 2006, Baughman published his findings in *Science*. Using an elastic metal called "shape-memory wire," Baughman and his team created muscles that are powered by something other than electricity: alcohol. His new artificial muscles are more than 100 times stronger than natural muscles. "Just a couple shots of vodka" is all it takes for them to work, Baughman says.

A vodka-powered, super-strong robot. That's quite some toy indeed.