The college's newest institute aims to tailor the next generation of smart clothing by joining designers and scientists with the fashion industry.

High Tech Meets **High Fashion**

BY KENNY BERKOWITZ

Anil Netravali holds a Comet skateboard made from his biodegradable, plant-based materials. Photo by Mark Vorreuter.

Standing by a workbench in his second floor lab, Huiju Park is building better boots for firefighters, which reduce the stress that comes from wearing more than 100 pounds of turnout gear on every call. Down the hallway, Anil Netravali is creating nanocomposites out of rice starch and cellulose, Juan Hinestroza is developing cotton transistors for the next generation of smart clothing, and Jintu Fan is using custom-built manikins to study the physiological effects of fabric on the human body.

Welcome to the newly launched Cornell Institute of Fashion and Fiber Innovation (CIFFI).

"When I first came here, I saw a department that was well-positioned at a major university and doing excellent fundamental research in fiber science," said Fan, Rebecca Q. and James C. Morgan Sesquicentennial Faculty Fellow and chair of the Fiber Science & Apparel Design (FSAD) department, who came to Cornell from Hong Kong Polytechnic University. "The time has come for the department to build stronger partnerships with industry, translate great ideas in the laboratories into commercial products, and make a real impact in the industry and in communities."

Fan's vision is for department researchers to foster collaborations between academia and industry and lead innovations in fashion, fiber science and technology, and textile testing. As members of CIFFI, companies can tap into Human Ecology's knowledge base and gain access to everything FSAD has to offer: state-of-the-art fashion and textile studios; the apparel performance lab's 3D body scanners, thermal infrared imaging, manikins, and motion capture system; a prototyping facility with a fiber extruder, laser cutter, and sample loom; and the nanotechnology lab's atomic force microscope and electrospinning machines.

CIFFI is beginning to work closely with retailers in New York City and manufacturers around the world to develop new materials, streamline product development, and promote smart, sustainable fashion.

"If we can bring the parties together, doing the research at Cornell, and scaling up the innovative ideas with the manufacturers and retailers at an earlier stage, we can eliminate an enormous amount of wasted resources," said Fan. "It makes perfect business sense because if you can work well with industry, industry will want to work with you. By founding this institute, we raise the potential for what we can do in design, research, and scholarship."

Thinking green

Before coming to Human Ecology, Netravali worked in Cornell's College of Engineering, first in materials science and then in >>>

Cornell student Sandy Mattei '14 models a prototype of an anti-malaria garment at a Cornell Fashion Collective runway show.

mechanical engineering. In the 25 years since, as a professor in the FSAD department, he's built an international reputation for his work on fiber-reinforced green composites. He has relied on banana, hemp, jute, kenaf, ramie, and sisal to create biodegradable materials that can be used as an alternative for most anything that can be made out of wood. Now, with his first sample spool of liquid crystalline cellulosic fibers, he's entering a new world of "advanced green composites."

"They're much stronger than any conventional natural cellulosic fibers, almost twice the strength," said Netravali, while sitting across from Park, an FSAD assistant professor who specializes in protective clothing. "There is no waste coming out of the manufacturing process, and the molecules are all very organized with the highest stiffness and the greatest strength possible. And because they stretch much more than Kevlar, and require more energy to break, if you made a bulletproof vest out of these fibers, it would actually perform better than Kevlar."

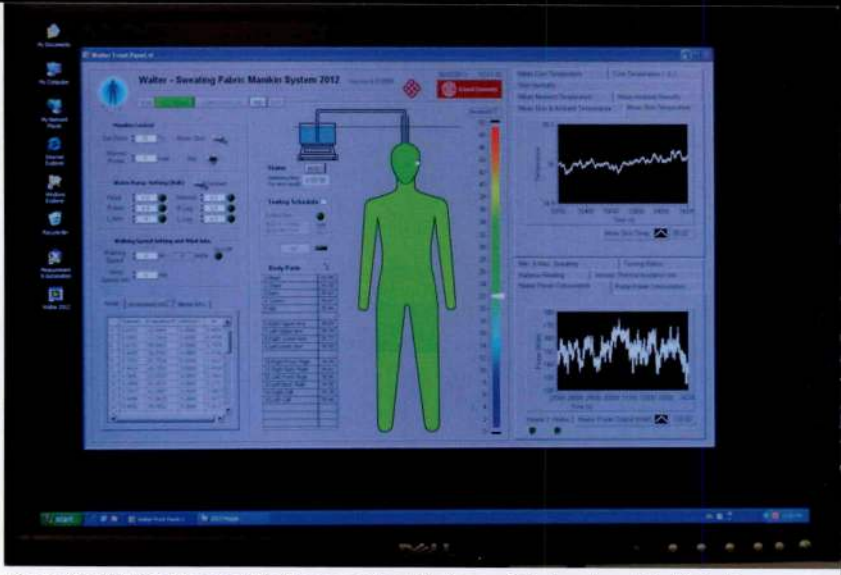
Park, who has bullet-tested composites in the past, leaned forward. "That's a huge potential to replace Kevlar . . . "

". . . In certain applications," Netravali interjected.

"If you can make a large sample, we can easily prove the concept," said Park, as the conversation bounced from engineer to designer and back again. But for Netravali, the material is still too new to be manufactured in large quantities.

So the discussion shifted to other ideas: Park suggested using a 3D printer to make the composites into lightweight, breathable orthopedic casts; Netravali went one step further, adding a nanofabric to keep the wound dry. Park talked about the Kevlar that lines the bottoms of his prototype boots; Netravali talked about creating high-efficiency filters from agricultural waste. The conversation seemed to be exactly what Fan envisioned for the new institute's focus on fostering fashion and fiber innovations.

Park went on to report the progress he's made using carbon nanofiber heating units for winter clothing, and Netravali responded with photos demonstrating the natural fire-resistance of advanced composites—ones that won't burn even when you point a torch at them. Before long, they turned to Park's class in Functionable Aspects of Clothing Design, where students are using a 3D body scanner and motion capture technology to work on lighter, less restrictive gear for first responders that can reduce on-site musculoskeletal injuries.



Specs for Walter, the world's first sweating fabric manikin developed by Jintu Fan. Photo by Mark Vorreuter.

"My passion is in incorporating the latest technology into garment design," said Park. "More and more, clothing will become the interface between our bodies and the outside world, but we need to design clothes that don't look like they came from a lab. We don't just want to make interesting prototypes; we want clothing that will be available to many people. That's where we can create synergy with manufacturers and retailers. We come up with the concepts, prove them with science and technology, and have manufacturers make the products that go to market. It's a win-win situation."

"Our goal," added Netravali, "is to get these innovations to the public. We have the science, and industry has the means to commercialize it. . . . That's the idea of CIFFI."

Weaving partnerships

Arriving as the department chair of FSAD in January 2012, Fan set to work on a series of priorities: attracting funds for research; expanding the graduate program; fostering increased cross-fertilization between design, technology, and business; and developing partnerships with faculty across the university, including the new Cornell NYC Tech campus. At CIFFI, while continuing his research in flexible piezoelectric fibers and fabrics for high-tech textiles, Fan has been establishing regular roundtables, conferences, and seminars.

In October, not far from Manhattan's Garment District, Fan and Tom Nastos, president of the fashion tradeshow organizer ENK International and chair of the CIFFI advisory board, hosted the institute's first roundtable meeting, where Cornell fashion and fiber experts got acquainted with apparel designers, textile scientists, and business leaders from as far away as Hong Kong, Italy, Brazil, and California. At the top of the agenda: how to best collaborate to bring the most promising technologies to market in products and clothing without sacrificing fashion.

"What's so interesting about CIFFI is there's a huge emphasis on user needs and serving customers," said Jin Seo '91, founder of womenswear label 51 Inc., at the roundtable. "The key is finding that balance of technology, innovation, beauty, and usability and wrapping it all up into one garment."

Human Ecology students and faculty contributed to a de-stressing vest that kneads away unhealthy levels of stress. Photo provided.

Nastos believes CIFFI will "bridge the gap" between industry and academia and provide a channel for Cornell experts to hear about the most pressing industry needs.

"The fashion industry needs an outlet to provide feedback on what technology it is looking for, to test new ideas and materials, and to determine what research it is willing to fund," Nastos said. "When you put the researchers together with people in industry, it's a great combination."

Fan is especially proud of the FSAD department's track record in developing new materials, and he's excited about the potential impact of CIFFI-related businesses on the local economy. Netravali's Ithaca-based company, e2e Materials, uses regionally grown flax and bamboo to produce a safe, green alternative to particleboard that reduces carcinogens in the home and in the workplace. Another business venture, Hinestroza's iFyber, is under contract to produce antibacterial wound dressings for the U.S. Navy and fabric for chemical warfare suits for the U.S. Air Force.

Both of the iFyber projects use the same basic principle—electrospinning fibers to imbue them with special properties at the nanolevel—that Hinestroza is using to explore the possibilities of filtering out infectious diseases, delivering time-release medications, detecting counterfeit passports, fingerprinting garments to prevent knock-offs, creating fabric that changes color, and designing clothes with their own computing power. In one recent breakthrough, Hinestroza unveiled a cotton transistor with nanoparticles so small that its threads feel like any other cotton threads.

"More and more, clothing will become the interface between our bodies and the outside world, but we need to design clothes that don't look like they came from a lab."
—Huiju Park

It's an invention with unimaginable potential. To Hinestroza, FSAD associate professor, it's an example of the kind of project that's tailor-made for CIFFI, with engineers and apparel designers working hand in hand.

"Scientists are used to taking one big problem and dividing it into lots of smaller questions, so that each individual answer can be used to build one solution," said Hinestroza. "Designers start the opposite way, envisioning the final product from the very beginning. They don't know how it's going to be built, but they can see it in their mind. . . . When you put these two approaches together, we can provide solutions that aren't possible if we're each working by ourselves."

Fan and Hinestroza know it will take years of breakthroughs before this technology can reach the marketplace, and that's exactly where CIFFI comes in: it generates partnerships to continue this research and works closely with manufacturing and retail to create products that can be mass-produced and mass-marketed.

"Industry is prepared to invest," said Fan. "By creating CIFFI, we can expand the graduate program, recruit more faculty members, and grow stronger together. We can use these new resources to continually strengthen our department's fundamental research, strengthen our academics, and become leaders in the field. It also creates special opportunities for our undergraduate and graduate students to work on real-world projects that make a difference."

"In today's economy, if you want to be a global player, you have to play with the rest of the world," added Hinestroza. "In this department, we go to New York City, China, India, Korea, Latin America, Singapore—anywhere there's growth in the industry. The world is changing, and even if you are only a small lab in Ithaca, you can be a significant part of that change." • • •

Nanoscience: More Than Meets the Eye

As director of the Textiles Nanotechnology Laboratory, Juan Hinestroza believes in the power of thinking small to create "a seamless interface between electronics and textiles."

"My rule is that if I can see it, it's too big for me," said Hinestroza. "That's the power of technology at the nanoscale. If you can understand how something works at the molecular level, you can transfer information to a much larger scale."

Two years ago, working with an international team of scientists, Hinestroza created the world's first cotton transistor by coating strands of cotton cellulose with gold nanoparticles before adding a thin layer of conductive polymer called PEDOT. The conductive thread is so pliable and durable that it can be machine-sewn into any fabric, and with a battery on one end and an LED on the other, these cotton fibers proved to be about a thousand times more conductive than plain cotton, which sets the stage for cotton-based sensors, circuits, and computers.

The results, published in *Organic Electronics,* went a significant step beyond the current technology, and around the world, the media noticed. Calling Hinestroza's breakthrough "seemingly out of science fiction," *National Geographic* predicted a coming day when clothes would charge cellphones, detect toxins, eliminate mosquitoes, capture smog, control body temperature, and monitor brainwaves. *Forbes* called the research "fascinating" and "pretty cool," and *WIRED* called Human Ecology's lab "a hotbed for this sort of convergence" between chemical engineers, fiber scientists, and designers.

"Our department is uniquely positioned with this visionary combination of fiber science and apparel design," said Hinestroza. "It may sound a little schizophrenic, but it's actually an incredible asset because we have the capability of directly transferring developments from the lab into the design studio. Very few places in the world can do that, and that's what gives us such an unusual perspective. If I worked in a chemical engineering department, I'd probably be doing some similar research. But here, as the work progresses, I can see the connections between what I do and what designers do. That makes me a better scientist, and makes my science better."

For more information:

CIFFI
www.human.cornell.edu/fsad/ciffi.cfm

Jintu Fan
jf456@cornell.edu

Juan Hinestroza
jh433@cornell.edu

Anil Netravali
ann2@cornell.edu

Huiju Park
hp347@cornell.edu