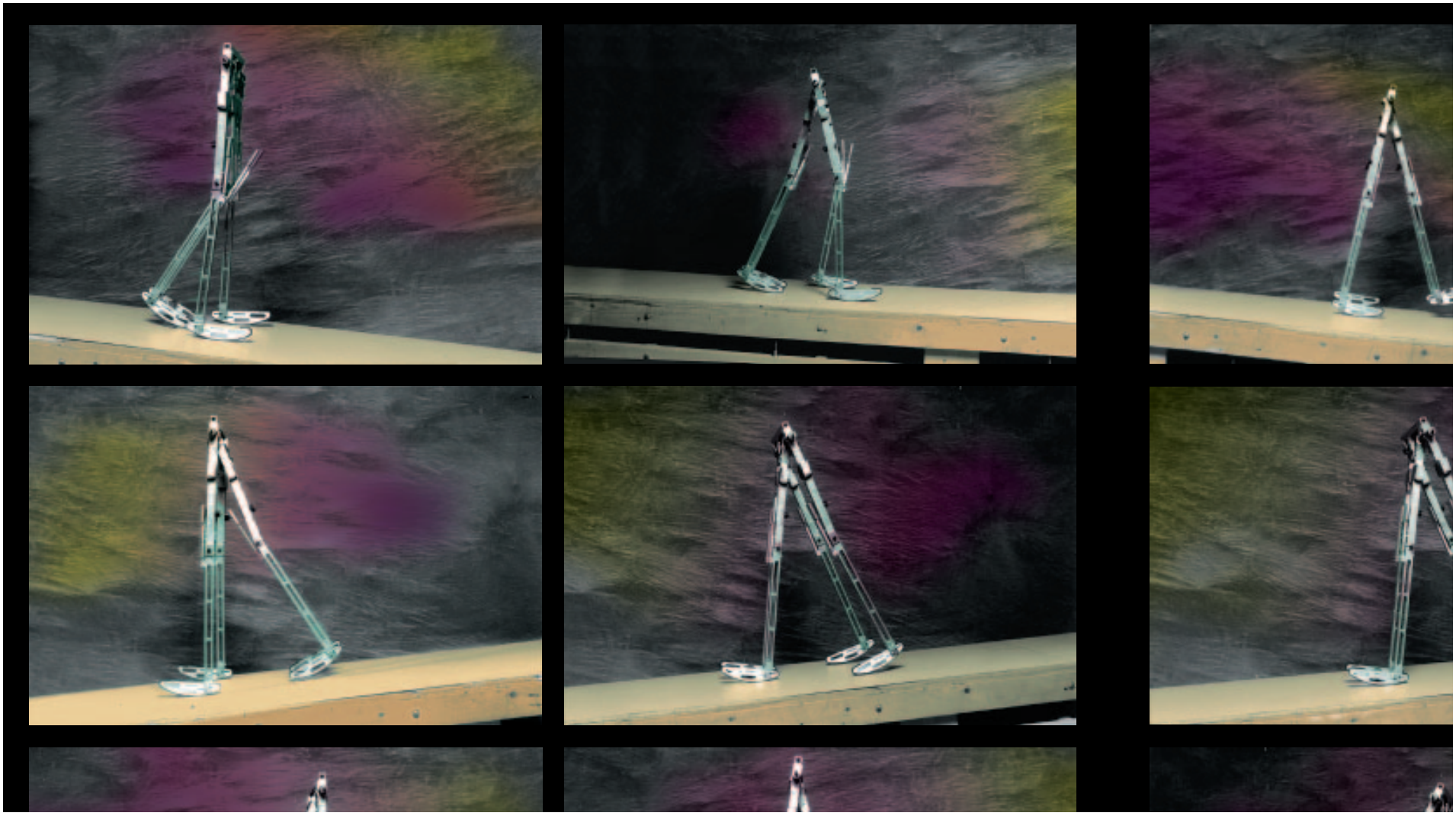
HumanLocon

Andy Ruina's students explore the mechanics of n



So this must be where bicycles go to die. On the third floor of Kimball, a nondescript door opens on a scene out of a Schwinn's worst nightmare. Bikes hang from the ceiling like sides of beef in an abattoir. Dismembered parts—wheels and pedals, chains and bits of frame—are strewn about, odd little gizmos that once went somewhere.

But though these bikes may have departed to that big velodrome in the sky, this research room is going places. For a decade, the Human Power Lab has been a place to study what makes Sammy run—and jump, and row, and pedal, and walk. It was founded as the Bicycle Lab in 1986, but research here has since taken a broader view of locomotion. Along with the skeletons of dissected bikes are rowing machines in various states of assembly and the lab's de facto mascot "Junior," a prototype of a walking robot.

"It's interesting to learn how the body works," says Professor Andy Ruina, who has been having a love affair with pedal power ever since he was a kid. "I thought bikes were neat. Now kids think bikes are neat. After I got my driver's license I thought it was cool to ride," he says. "In the future, bicycling and walking will be more important than they are now. In the long run, the world can't support so many cars, for health reasons, if nothing else. We have got to use their bodies more around."

Over the years, 306 Kimball has become a showcase of curiosities and relics inherited from other projects, designs leftover from earlier projects, and miscellaneous gadgetry of interest to the lab's inhabitants.

The first is to better harness the body's power: to row faster, bike farther, exercise more efficiently. The second is to use the design of the human form as a basis for creating superior gadgetry. "Usually, the engineer designs the machine," says T&AM graduate student Mariano Garcia. "But when it comes to the human body, it's been designed already. The question is *how* it's been designed. It's sort of a backward approach. We're studying something that's been built already, by building something else."

There's no mantra posted in 306 Kimball, but if there were, it would be this: "Avoid negative work." That's the rule that governs the design of pedals. And bodybuilders know that you can bench press more pounds with a Nautilus machine than with free weights. Why? You don't have to waste energy trying to balance the weights and keep proper form; the machine does it for you. "All you have to worry about," says M.Eng. student Jason Cortell, "is putting as much power into it as possible."

Cortell is standing in front of his pet project, a prototype of a new kind of rowing machine he's been working on since last summer. Made of bright green metal, the monolithic gadget stands next to an earlier incarnation, crafted of wood. The original constrained rower looks like something out of the Marquis de Sade's rec room: two-by-fours and metal sheets cobbled together, all ready for the torturer and his hapless houseguest. But fear not: These aren't instruments of pain—at least not any more than your average Stairmaster. They're specially souped-up rowers that wrap around the user's body, shoulders to toes, to take advantage of every ripple of motion. "The idea," Ruina says, "is to design a machine that gets more power out of the human body than anybody has ever gotten before." Once it's finished, Cortell is looking forward to trying it out, maybe rowing his

> "In the end, if we want to have a Terminator-style walker, it would have to have actuators in each joint. Like a person walking across a stream with irregularly spaced stones—if you want to put your foot there, you have to tell it."

legs swing in just the right way so that it doesn't waste energy."

Junior's design exploits that principal: the concept that, surprisingly

justed, the rate at which the suction cups give way—Junior sometimes veers off the ramp, like a wayward toddler. But other times, the robot marches to the end of his runway with the confidence of an ROTC veteran. "It's sort of a subtle thing, where you put the weights so it works just right," Garcia says. "There was a lot of trial and error. And it turns out that most of the weights are around the hip area, just like the human body."

So the research comes full circle: the scientists use principals of human walking to design a robot—which helps them understand how people walk in the first place. "Is it a coincidence that this thing that mimics human movement can walk in this passive way? Probably not," says graduate student Mike Coleman, whose been known to build visual aids out of Tinkertoys and Legos.

When Junior's on a successful trot, the acute similarity to a person walking seems to endow him with all sorts of human—even childlike—qualities. It's impossible

the lab on metal limbs was born in the ones and zeros of the electronic netherworld. Work on Junior began with countless hours of computer simulations; until very recently, this research would have been extremely time consuming, if not impossible. "If you do it in the real world, you can do one configuration, or maybe two, before you get really tired," Cortell says. "On a computer, you can do dozens." But to do those simulations, the researchers first had to develop a procedure for measuring the parameters, using such variables as the center of mass and the moment of inertia. "The idea is to understand how the different parameters affect the motion," Garcia says. "What happens to the efficiency? What happens to the mobility? Can the thing walk at all, or does it fall over?"

With assisance from a couple of colleagues, Camp built Junior when he was an undergraduate in the Sibley School of Mechanical and Aerospace Engineering, immortalizing his work in a poster entitled "Knee Jointed Passive Dynamic Walking," complete with time-lapse strobe photographs of the robot strutting his stuff. For the project, he teamed up with Garcia, who did the computer work as part of his Ph.D. dissertation. Camp graduated last year and staved on for his

even questioned it," he says, '
it never seemed that far-fe
me."

He keeps the plans for
project in a raft of well-t
graph- paper notebooks with
ingly nonsensical title of "
Passive Dynamic Walking."
and passive? The theory,
on Junior's design, harken
Camp's description of human
If people essentially tumble f
step to the next in a controll
fall, Camp wonders, can t
cept be used to make a ro
walks on flat ground with v
power?

We can
the dy
use it
vanta
says.
ankles up, I'd like to fool th
into thinking it's walking
slope. As I see it, it's a th
solution to powering it, bec
still passive. I can visualize tl
slope. It seems really righ
One hint he's on the righ
When Camp turned in hi
work on the project, his
advisor thought he'd bun
power calculations. "He
I made a mistake," he says.