

YOUR FOLD-UP AIRPLANE
Park it in the garage
p.32



OREO-POWERED ROCKET!
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POPULAR SCIENCE

**GADGET
OF THE MONTH**

p.26



Free
calls from
anywhere

**THE
FUTURE
NOW**

THE WHAT'S NEXT ISSUE

20 INCREDIBLE INVENTIONS FROM THE NEAR FUTURE

The Gun That Heals

Cars That Can't Crash

**A Photographic-
Memory Machine**



NEEDLE-FREE

Meds injected by
this gun will help
you grow new heart
muscle quickly.

**IS IT RAINING
ALIENS?**
A new clue to the
origins of life p.31

**NETWORK
YOUR YARD** And more
great how-to
projects p.72



WHAT'S YOUR MISSION?



FX4 shown; can tow 8,606 lbs.

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STILL FOGGY



"NETWORK-CENTRIC WARFARE." The phrase may not have quite the ring of a classic like "fog of war," but it does have a certain seductive appeal, particularly in our IT-obsessed age. The idea, which has driven much of Donald Rumsfeld's efforts over the decade to transform the U.S. military, is that America's armed forces must embrace the technologies and capabilities of the Information Age—that a fully networked fighting force, able to communicate seamlessly with up-to-the-second intel, can act with unprecedented speed and agility. To which the most natural response would seem to be "Hallelujah, and what took you so long?"

But there is a danger in believing too ardently in the transformative powers of technology. And although the lightning-fast march on Baghdad at the outset of the current Iraq war was touted as evidence for how awesomely effective network-centric warfare could be, the current reality tells a different

Many American soldiers aren't even equipped with radios.

story. As Noah Shachtman and David Axe report in "Winning—and Losing—the First Wired War" [page 52], even the soldiers in the Army's first "digital division" can find themselves stymied by their high-tech gear. "Networked" navigation systems are incompatible from tank to tank. Digital maps can be a year or more out of date. And at a time when insurgents stay connected using disposable cellphones, many American soldiers aren't even equipped with radios.

"Bringing frontline infantrymen into the network isn't as easy as wiring up a headquarters," Shachtman writes. "Battlefield gear has to be wireless, durable, secure, and completely effortless to use in the chaos of combat." The fact that it isn't—yet, anyway—is no discredit to Rumsfeld and his military planners. The discredit is in the fact that they're asking soldiers to rely on it as if it were.

The great military theorist Carl von Clausewitz is said to have been the first to use the word "fog" to describe the bloody confusion and information gaps that are among the most characteristic qualities of battle. Network-centric warfare was supposed to blow the fog away. Here's hoping that someday it does.

MARK JANNOT

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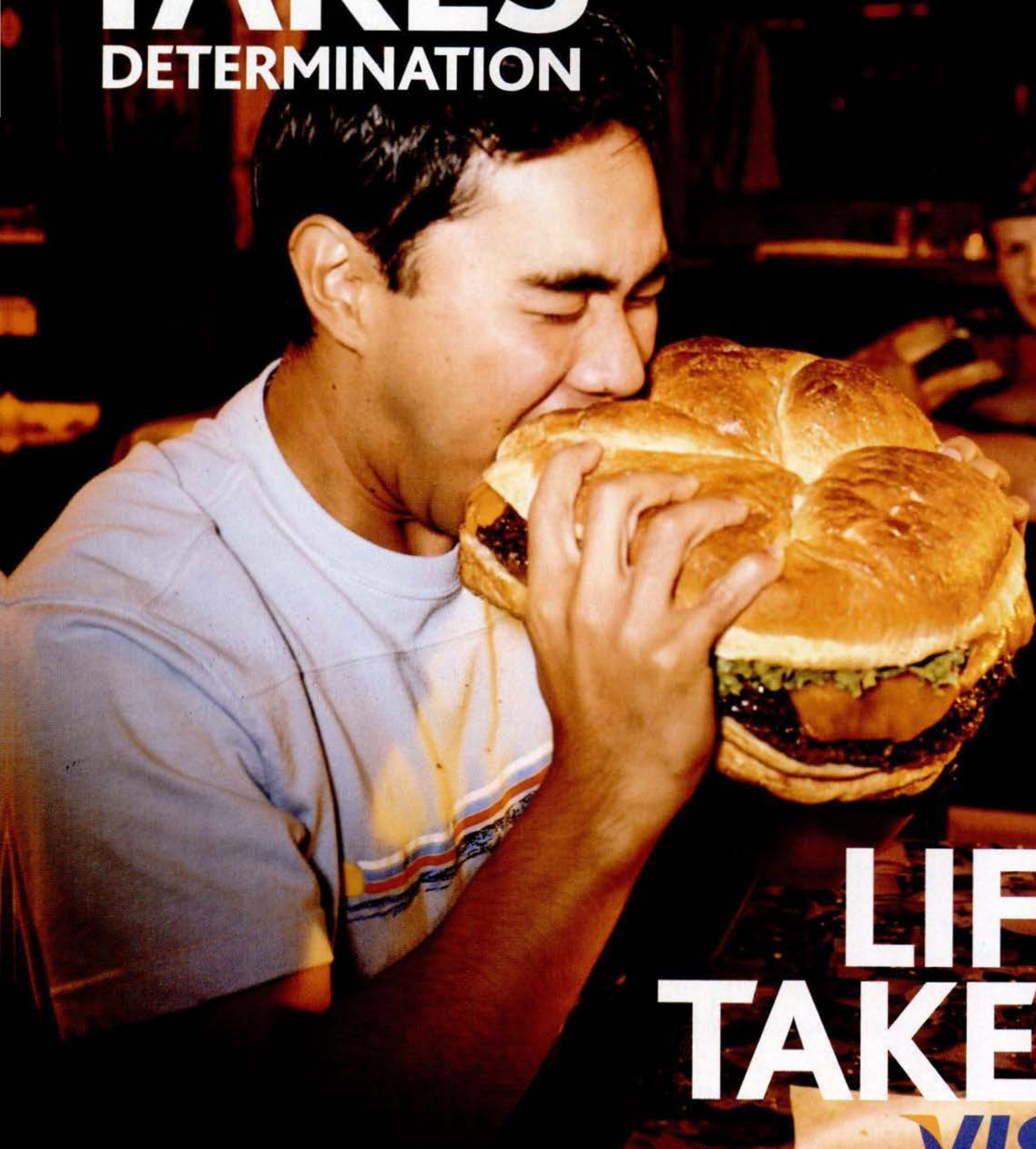
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LIFE TAKES

DETERMINATION



LIFE TAKES

VISA

FEATURES

BEST OF WHAT'S NEXT 2006

41 20 INCREDIBLE INVENTIONS THAT ARE SET TO CHANGE YOUR WORLD

Our third annual Best of What's Next delves into today's hottest research, then predicts the technology you'll be using 5, 10 and 25 years into the future. Photographic memory, anyone?

SPECIAL REPORT

52 WINNING—AND LOSING—THE FIRST WIRED WAR

Despite the brass' big dreams, most frontline troops in Iraq don't have an effective communications network. We go on the ground to see how the "networked battlefield" is really playing out. **By Noah Shachtman and David Axe**

INSTANT EXPERT

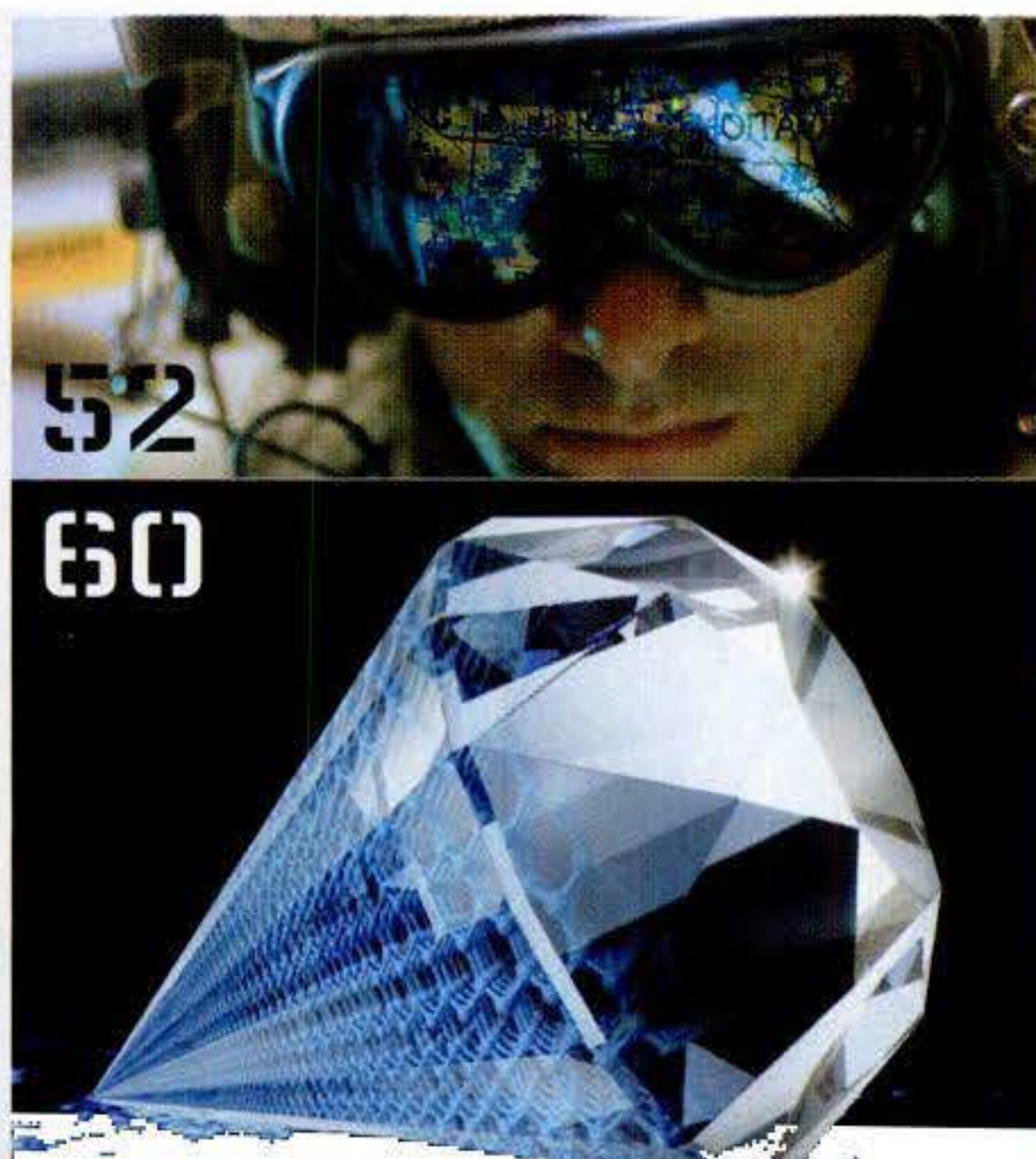
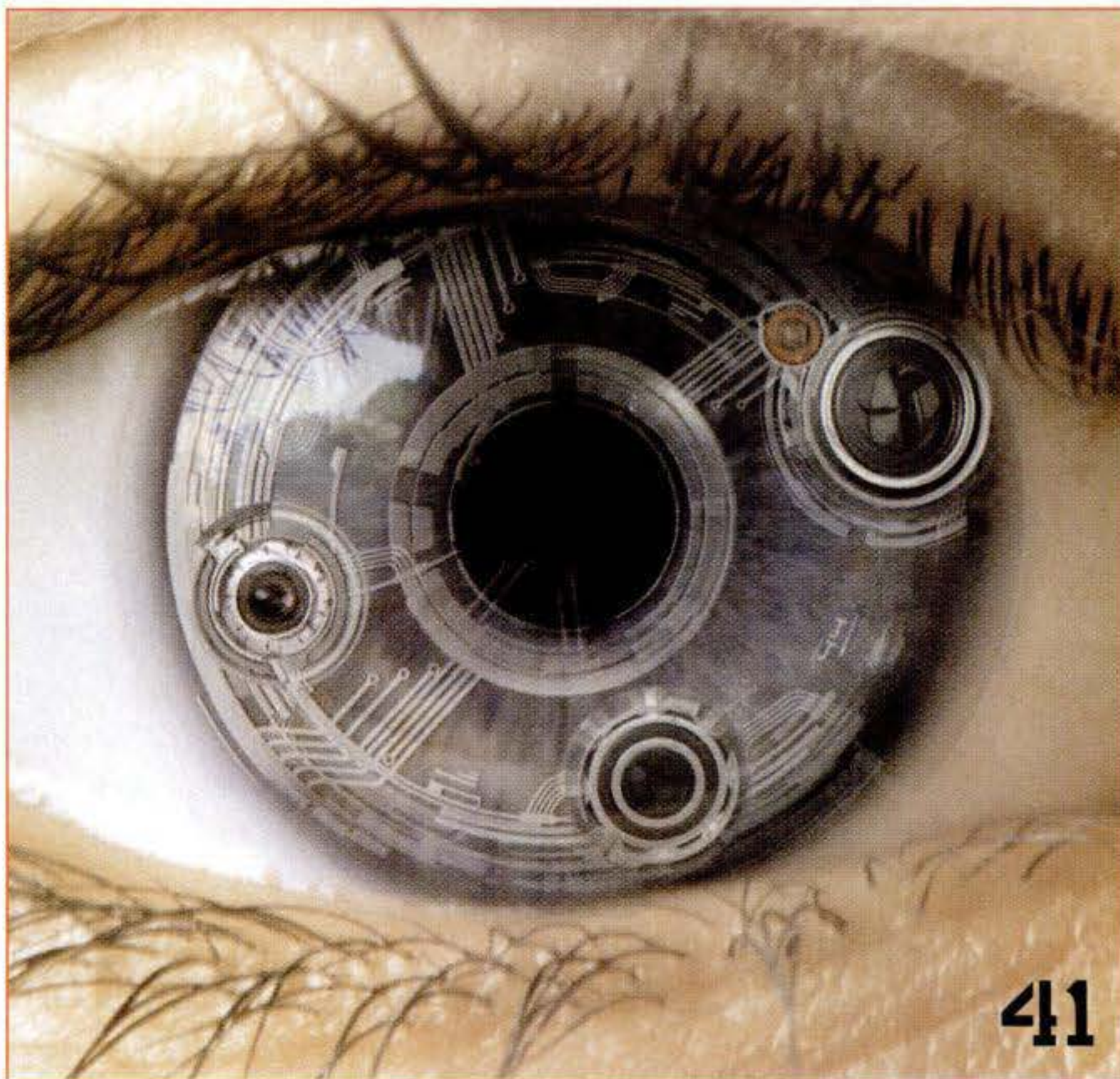
60 FLAWLESS MAN-MADE DIAMONDS

A diamond may be "forever," but labs are churning out top-quality bling at a rate of a carat every 12 hours. **By Elizabeth Svoboda**

THE FUTURE OF MOVIES

62 RETURN OF THE 3-D Scrap those headache-inducing blue-and-red glasses. New 3-D technologies will make the two-dimensional movie-viewing experience a thing of the past.

By Gregory Mone



ROAD DEBRIS CAN'T DAMAGE WHAT IT CAN'T TOUCH.

As your vehicle travels back and forth from destination to destination, it constantly collides with all kinds of tiny debris like bugs, tar and bird droppings. Once these objects hit your car, they can be hard to clean away. Bug residue, for example, contains proteins that act like glue, which is why it adheres so well. The residue is also slightly acidic, which can attack paint and metal surfaces and, worse still, it has growing bacteria inside that produces more acid. So, if you don't act fast enough, your vehicle is left with little scars and stains, even after you've cleaned away the mess.

Fortunately you can prevent this problem with Rain-X Bug & Tar Protective Shield. This car care advancement is based

on a very simple idea: Bugs and tar can't damage what they can't touch.

Safe on chrome, metal, paint, and plastic, Rain-X Bug & Tar Protective Shield is an aerosol spray that creates a thin barrier of acrylic polymer on your car. Once applied, the debris sticks to the coating instead of your car's surface.

Safe on chrome, metal, paint, and plastic, Rain-X Bug & Tar Protective Shield is an aerosol spray that creates a thin barrier of acrylic polymer on your car.

The film is water-soluble and easily washes off, carrying all the potentially damaging and unsightly specks away as well.

And for the areas that the shield doesn't hit, there's Rain-X Bug & Tar Pre-Wash Gel. The gel formula clings to surfaces to break down stuck-on debris, making it easier to remove. So drive on and don't worry. If you can avoid the big objects in the road, Rain-X Bug & Tar will help you avoid the little ones.

rain-x

www.rain-x.com



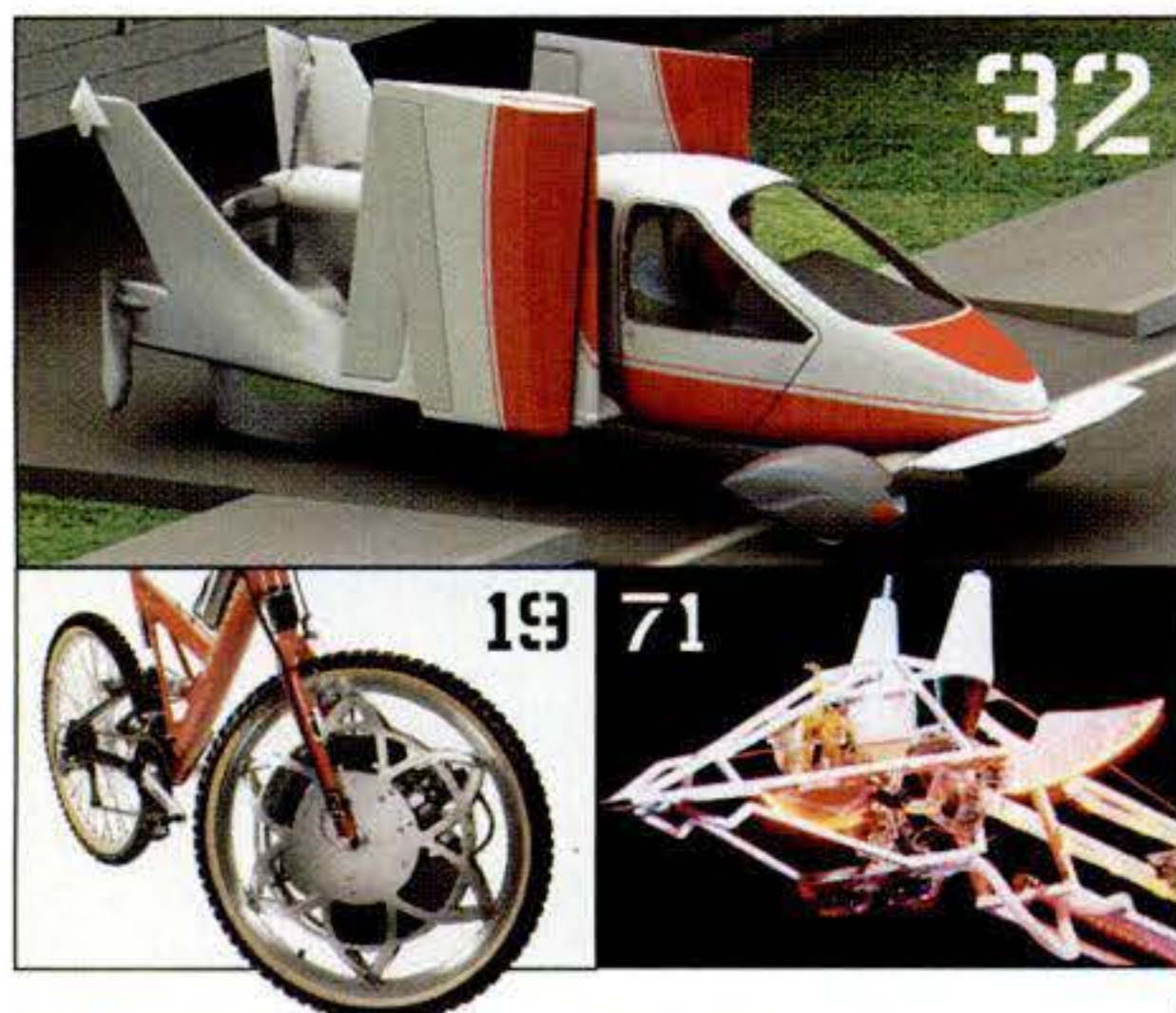


DEBRIS HAPPENS.

Be prepared for whatever lands on your car with Rain-X Bug and Tar Pre-Wash Gel. It adheres to bugs, tar, bird droppings and other hard-to-remove debris, breaking them down so they easily wash away.



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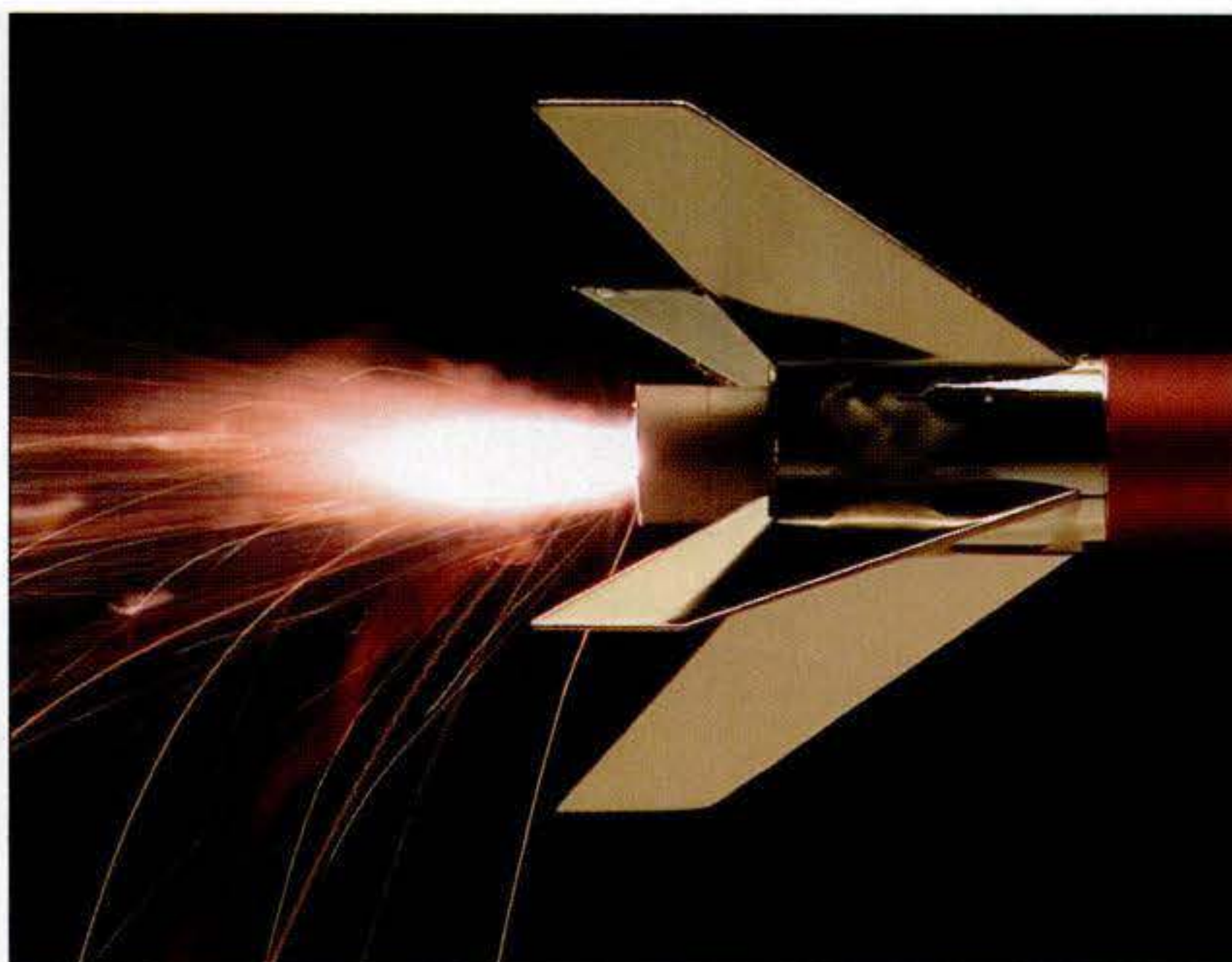
104 THE FUTURE THEN

NEW
AND
IMPROVED!

PopSci

ON THE WEB

W W W . P O P S C I . C O M



THE GOOD SHIP LOLLIPOP

A jolt of sugar might send kids bouncing around the playground, but did you know it can also fuel a rocket? Visit popsci.com/candy to watch one of these sweet ships blast off.



OUR CONTRIBUTING

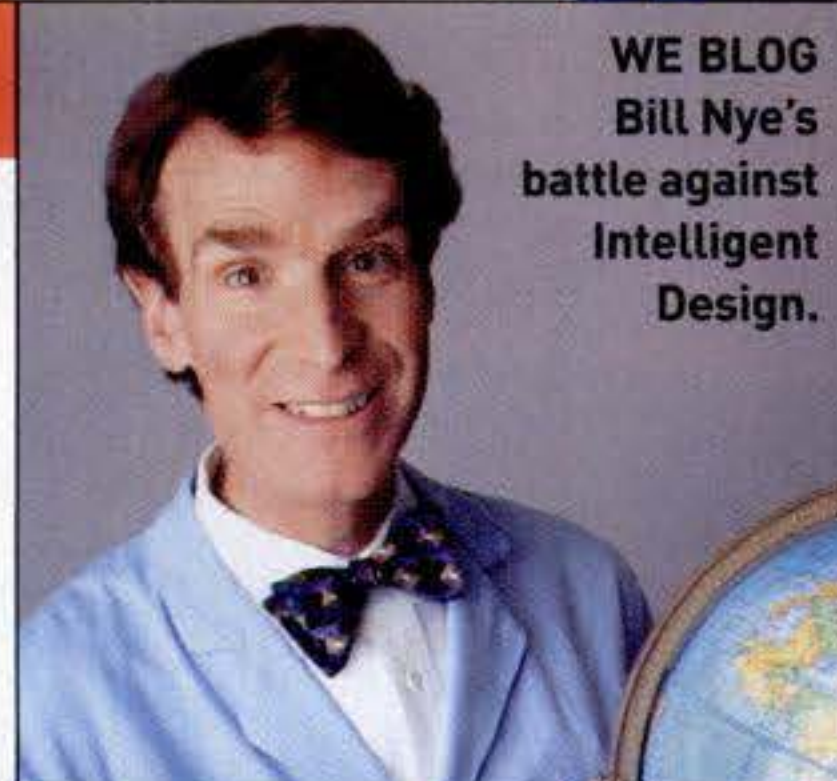
TROUBADOUR, Jonathan Coulton, talks with editors and experts (and might even sing) about new 3-D movies, India's "blood rains" and our predictions for the next decade or so of innovation at popsci.com/podcasts.



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WE BLOG
Bill Nye's
battle against
Intelligent
Design.

WHAT'S NEW See the gas-powered bike in action at [/revo](http://revo).

HEADLINES Watch RoboCup soccer matches at [/robocup](http://robocup).

HOW 2.0 Find out how to network your backyard at [/wifi](http://wifi).



DARRELL WALTRIP EDITION TUNDRA

This limited-edition Tundra is the same durable truck you'd expect from Toyota, with a little boost from "Jaws" himself.

Featuring 18" TRD wheels, the #11 badge, race-inspired decals and a front grille you won't find on any other Tundra.

It's the ultimate show of allegiance to one of racing's all-time greats.

Check out toyota.com/dw for more info.

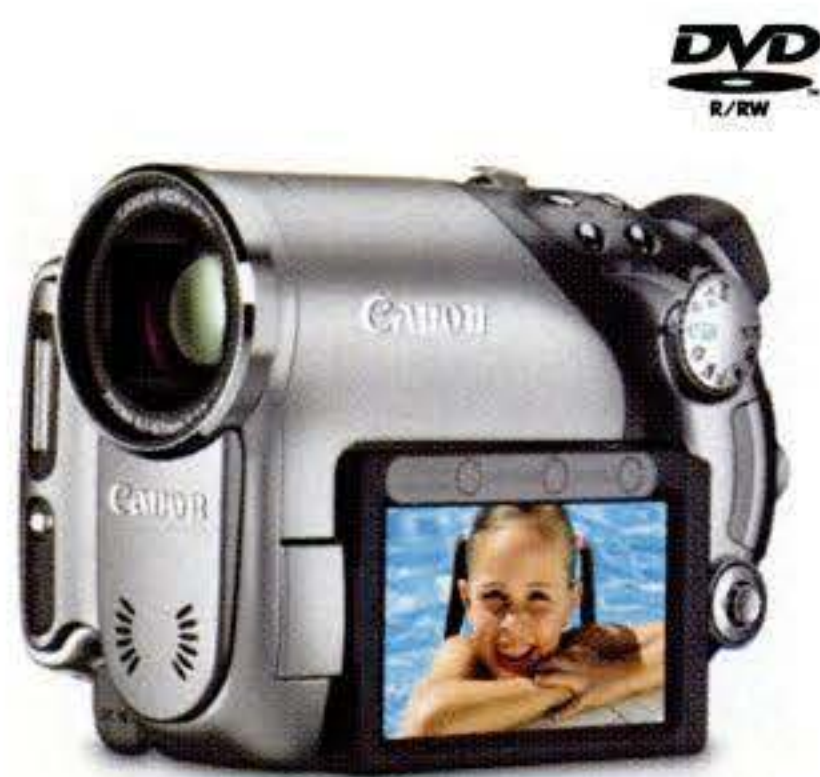


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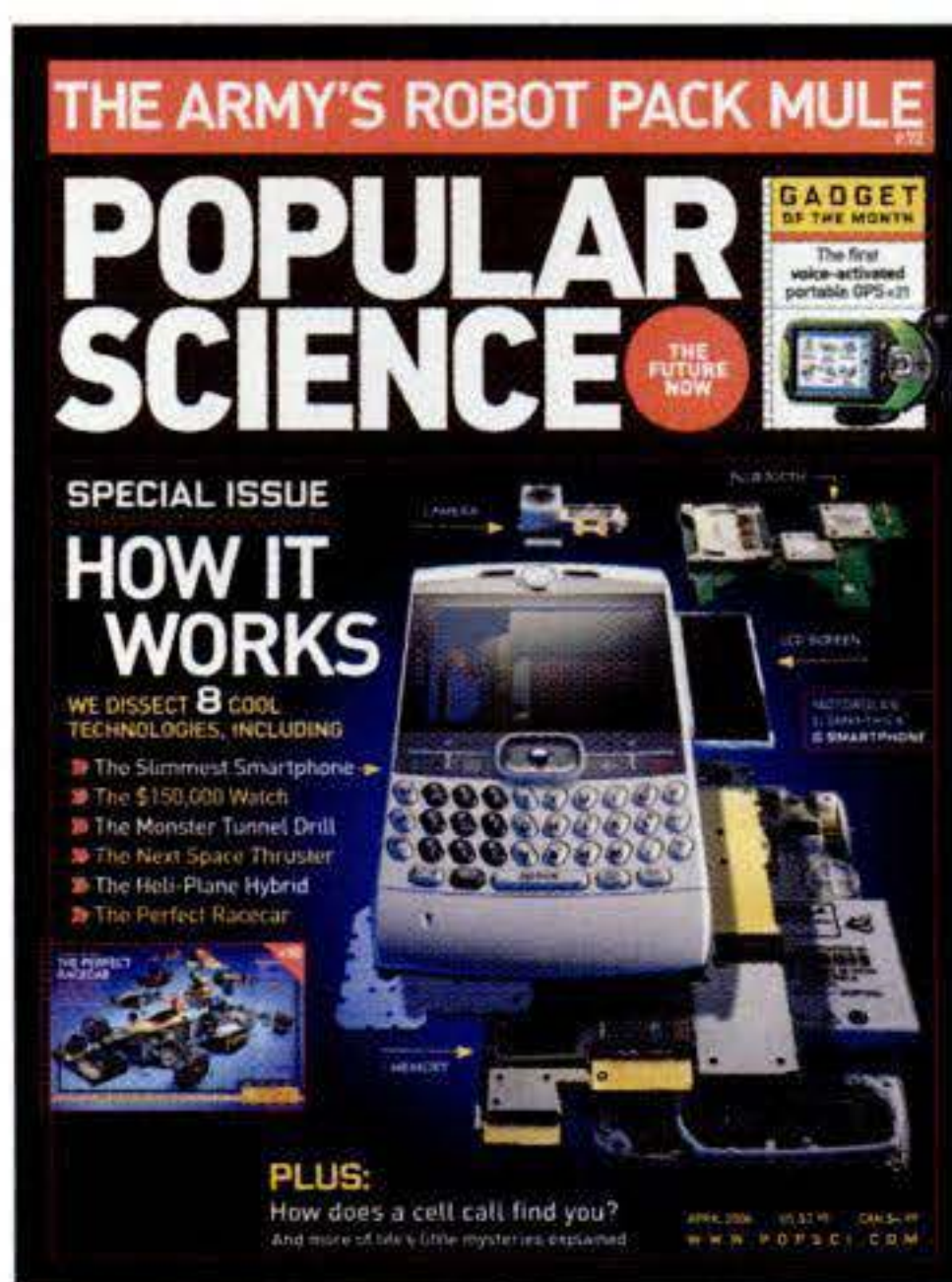
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LETTERS

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Watching the Watch



The Porsche chronograph, though an engineering marvel, is not "the first mechanical watch with a digital display" ["How It Works," April]. I inherited the "digital" pocket watch shown here from my late grandfather; it's at least 70 years old. There are no markings to indicate who made it or the date of manufacture, so I'd love to know if any readers recognize it.

Ron Philippsborn
Langley, Wash.

The Fast and the Furious

I couldn't believe that my longtime favorite and hitherto-respected source of science and technology news acted so irresponsibly in publishing an article that aids people in breaking the

law ["Radar-Aware at 140 mph," What's New, Apr.]. Speeders endanger other drivers, as well as emergency-services personnel who respond to the many crashes they cause. And you think it's a good idea to review radar and laser detectors that aid their reckless behavior?
Peter S. Andersen Willington, Conn.

No Altoids at Altitude

I built one of the Altoid-tin battery chargers you described in "Make a Gadget-Charging Mint Tin" [How 2.0, March]. It works wonderfully. Be careful, however, when traveling with it, especially by air. Apparently, the Transportation Security Administration folks get a little tense when they see a tin box with wires and a battery in their x-ray screen.

Mark Libich Grass Lake, Mich.

Corrections

In "The Tunnel Monster" ["How It Works," Apr.], we neglected to name the Robbins Company, the designer of the MB471-316 drill.

The illustration in "The Smartest Robotic Pet Yet" [What's New, May] was credited incorrectly. It was the work of Mack Fraga, UGOBE.

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Small is Inspiring.

Introducing Canon's newest DVD camcorders.

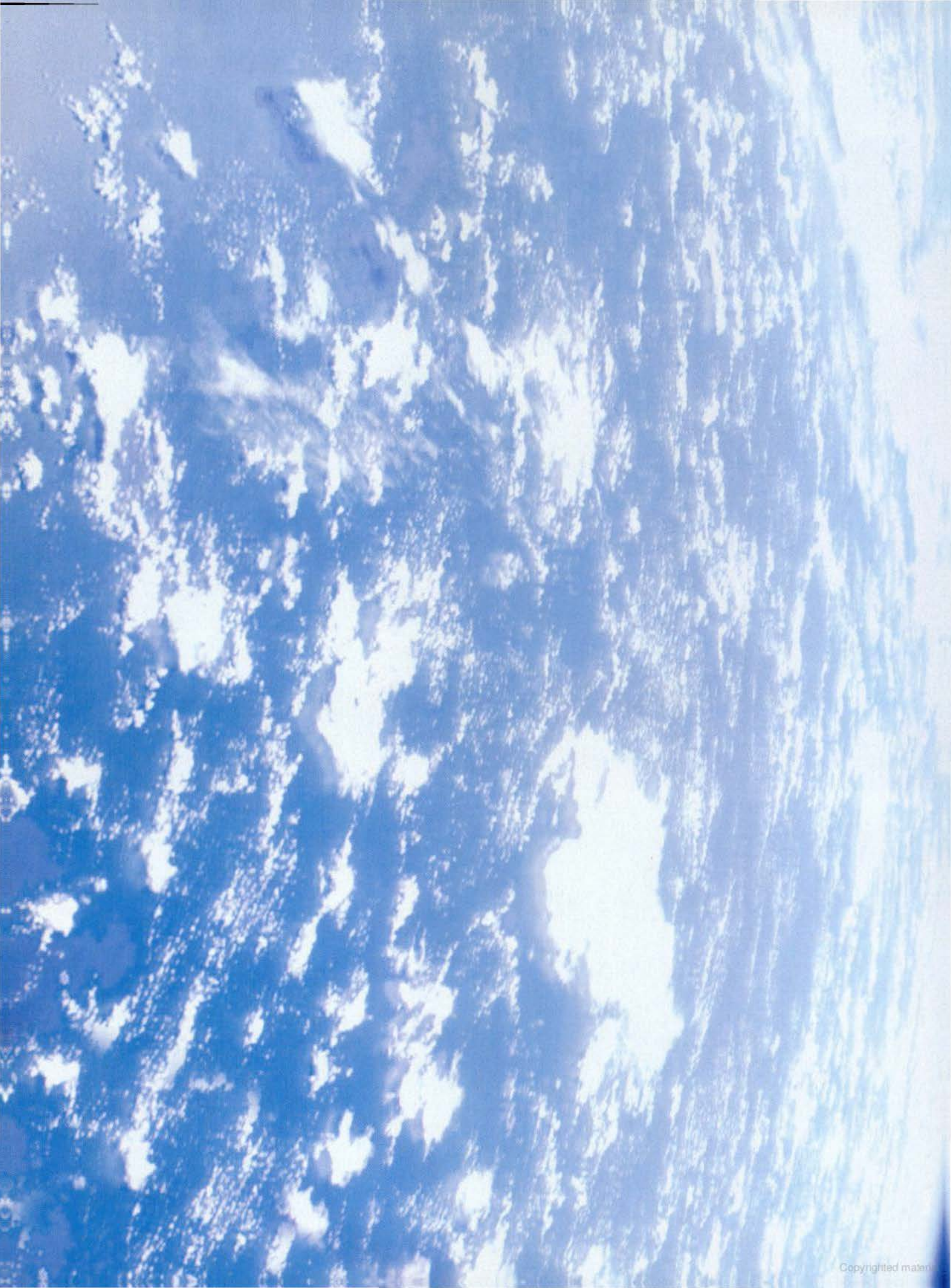


Being small is very big. And the Canon DC40 and DC100 DVD camcorders are two giants in the world of small. But while these camcorders are indeed slim, cool and wonderfully portable, they are more than just a pretty face. They are form meets function meets affordability. The DC40, awesome in its power, offers 4 megapixels for remarkable video and extraordinary photos. And the DC100, while unbelievably slim, shoots in high resolution 16:9 widescreen. Our point? It's good to be small. Visit www.canondv.com or call 1-800-OK-CANON.

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MEGAPIXELS

THE MUST-SEE PHOTOS OF THE MONTH



TOSSED IN SPACE

What to do with an old space suit? Turn it into a satellite

Part laundry bag, part experimental satellite, this repurposed Russian space suit, now orbiting Earth at 17,500 miles an hour, may be among history's most creative recycling efforts. *SuitSat*, as the makeshift craft is called, is the brainchild of a Russian ham radio operator who saw an opportunity to do something useful with old space suits on the cramped International Space Station. To test the satellite idea, ISS crew members stuffed a suit with a radio transmitter, some digitized recordings of children's voices, three batteries and, oh what the heck, old laundry. Then they tossed the whole thing overboard. An antenna mounted on the helmet broadcast the voices for two weeks in February to amateur radio operators worldwide before the suit's batteries died, leaving it to orbit Earth in silence until this August, when it's expected to burn up in the atmosphere. *SuitSat-2* is scheduled to fly next year. **PHOTOGRAPH BY BILL McARTHUR**

THAT'S ONE FLY FLY

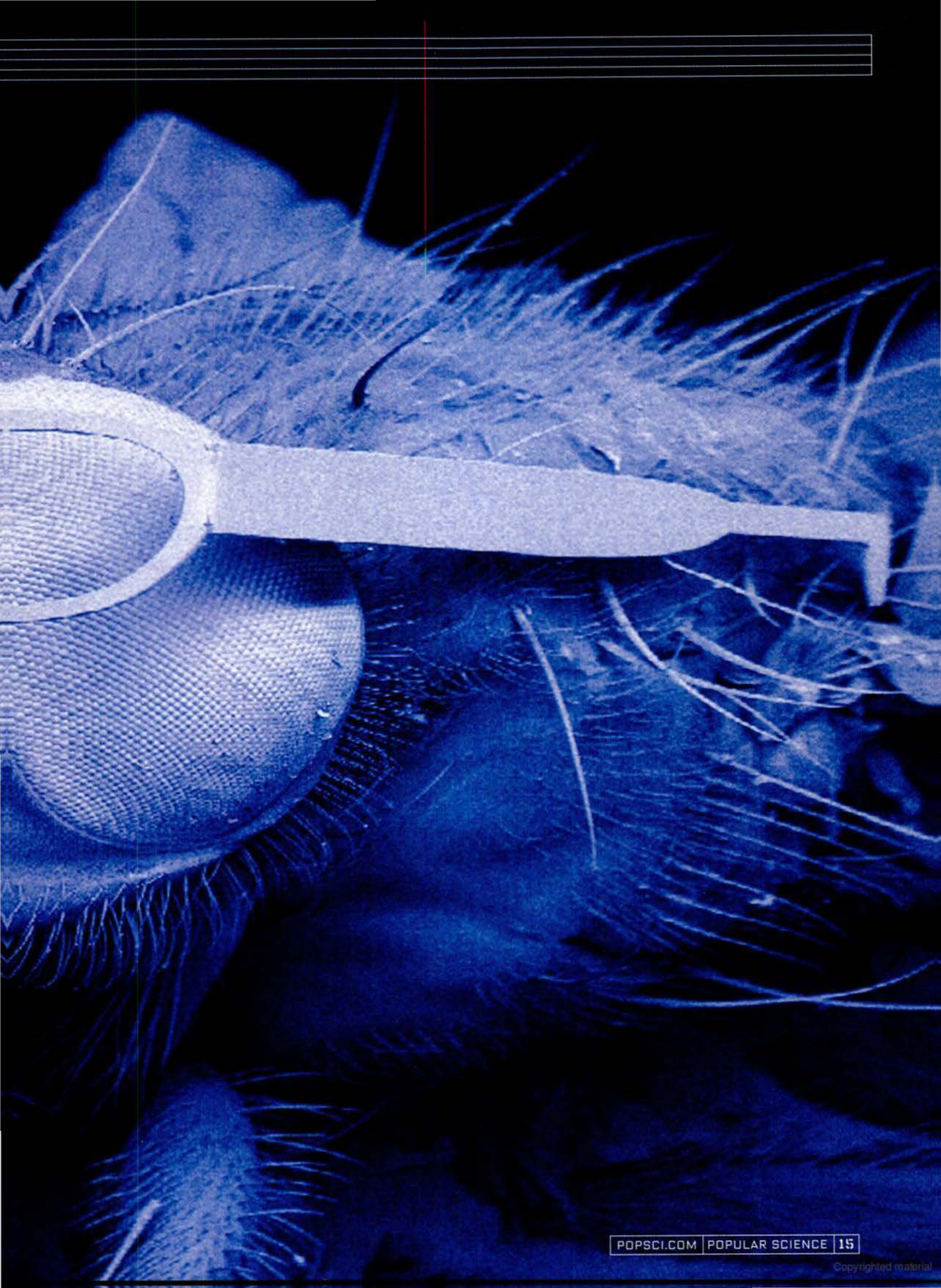
High-tech lasers sculpt microscopic bug glasses

It looks like a Photoshop job, but it's real. This preserved housefly is indeed sporting metal-rimmed eyeglass frames. The creation of micromachining firm Mireon GmbH in Hannover, Germany, these custom specs are a scant two millimeters wide and are decorated with the company's logo, a *mu* symbol, etched as thick as a human hair into the bridge. What's the point? To tout ultrafast-laser technology, which uses pulsed laser beams to carve delicate materials like glass, semiconductors and even biological tissue without damaging them. **PHOTOGRAPH BY FRANK KORTE AND GÜNTER KAMLAGE**



See more micro-machining images at popsci.com/micro.





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for those who like options



7200 series:
the big picture plus audio,
weather and traffic options



*c340 offers traffic service options in select cities; requires GTM 11 receiver and possible subscription.



WHAT'S NEW

TECH THAT PUTS THE FUTURE IN THE PALM OF YOUR HAND



20

Running shoes with steel laces



24

Infrared night vision for your car



26

Internet calls—no computer required



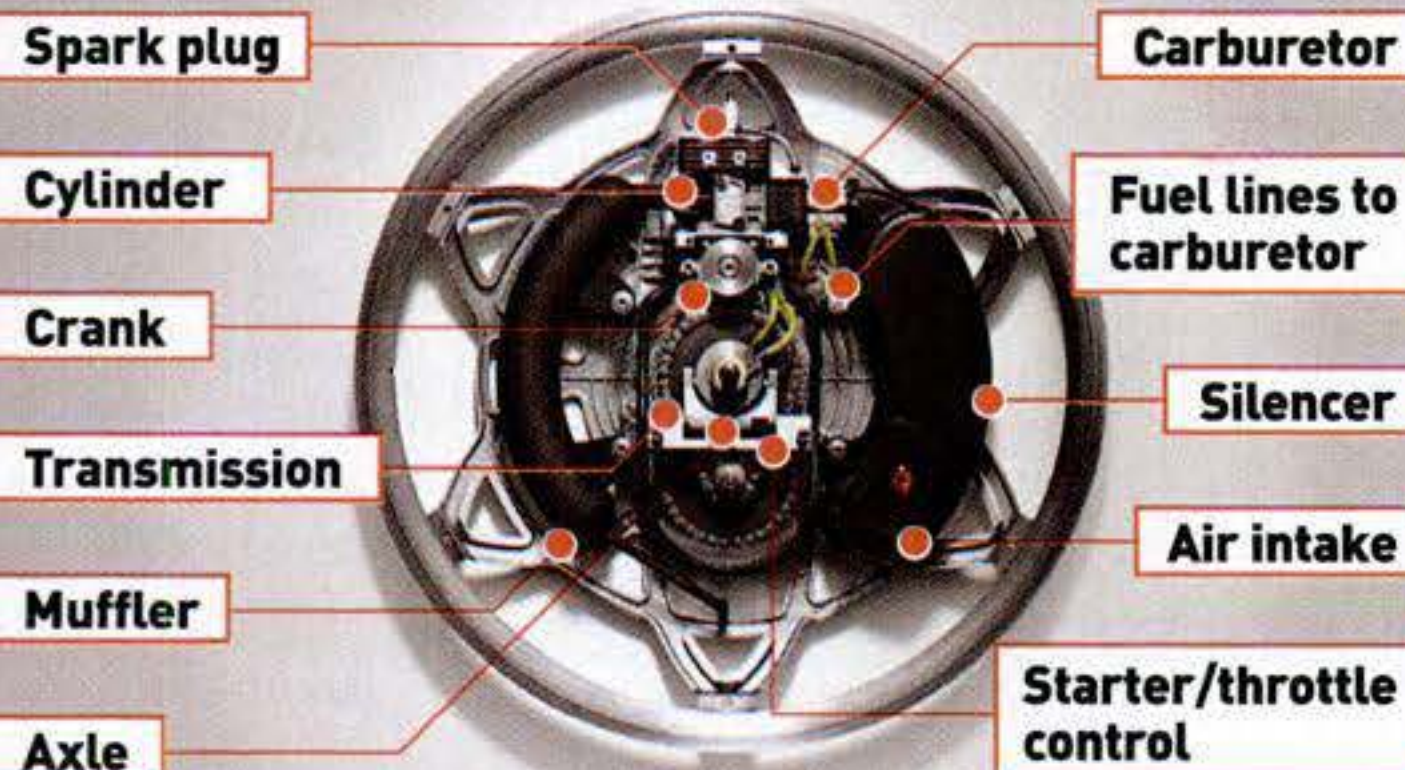
PEDALING IS SO 2005

An easy-to-install, gas-powered wheel turns any ordinary bicycle into a moped

CYCLE YOUR WAY OUT OF TRAFFIC JAMS and high fuel costs—without breaking a sweat.

Simply slide a canister of gasoline into your water-bottle holder, clip a throttle to your handlebars, and swap your front wheel for the Wheel, designed by Denver-based RevoPower (revopower.com). The Wheel's hub holds a 23cc, two-stroke internal combustion engine and a superthin gear train; less than three inches thick, it all fits between the prongs of your bike's front fork. Start pedaling and squeeze the throttle, and the engine kicks in, rotating the wheel around its fixed axle and boosting your power. Let the throttle go, and you can keep pedaling as usual. Just remember two things: Bring your driver's license (the engine may trigger regulations in some states), and don't drink from the water bottle.—LAUREN AARONSON

THE GUTS



REVOPOWER WHEEL

SIZE: 26 in.
WEIGHT: 15 lbs.
SPEED: 20 mph
POWER: 1.1 horsepower
EFFICIENCY: 200 mpg
PRICE: \$400; available in early 2007





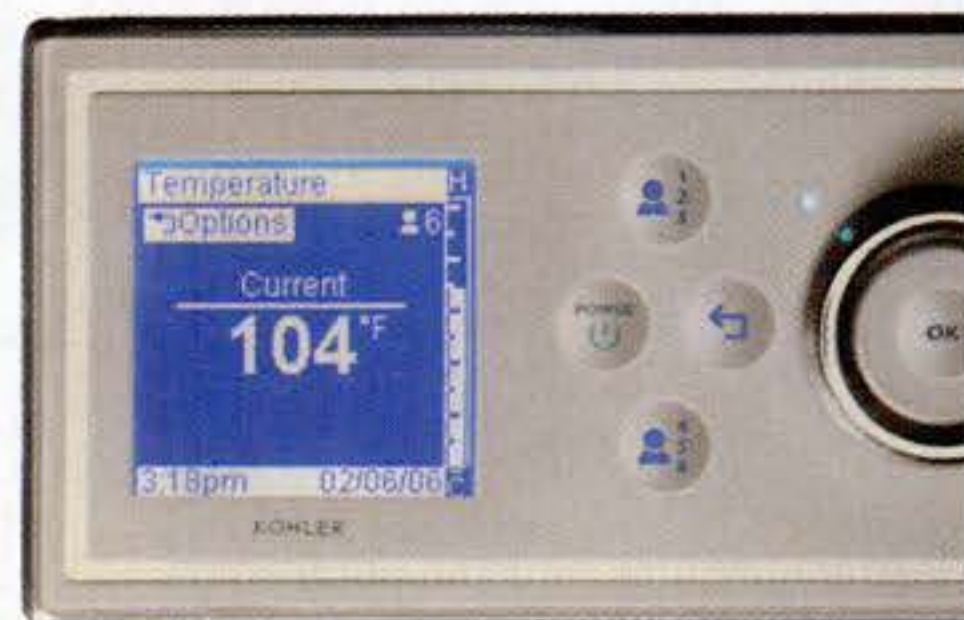
OFF-THE-WALL SOUND

Unlike other in-wall models, these speakers' woofers sit in a ported cabinet—similar to floor-standing speakers—enabling them to produce booming bass. **Axiom W22** \$650 per pair; axiomaudio.com

I, SHOWER

The first fully digital shower system. Punch in your desired temperature and water pressure, and the system regulates the water to make sure it sprays how you like it.

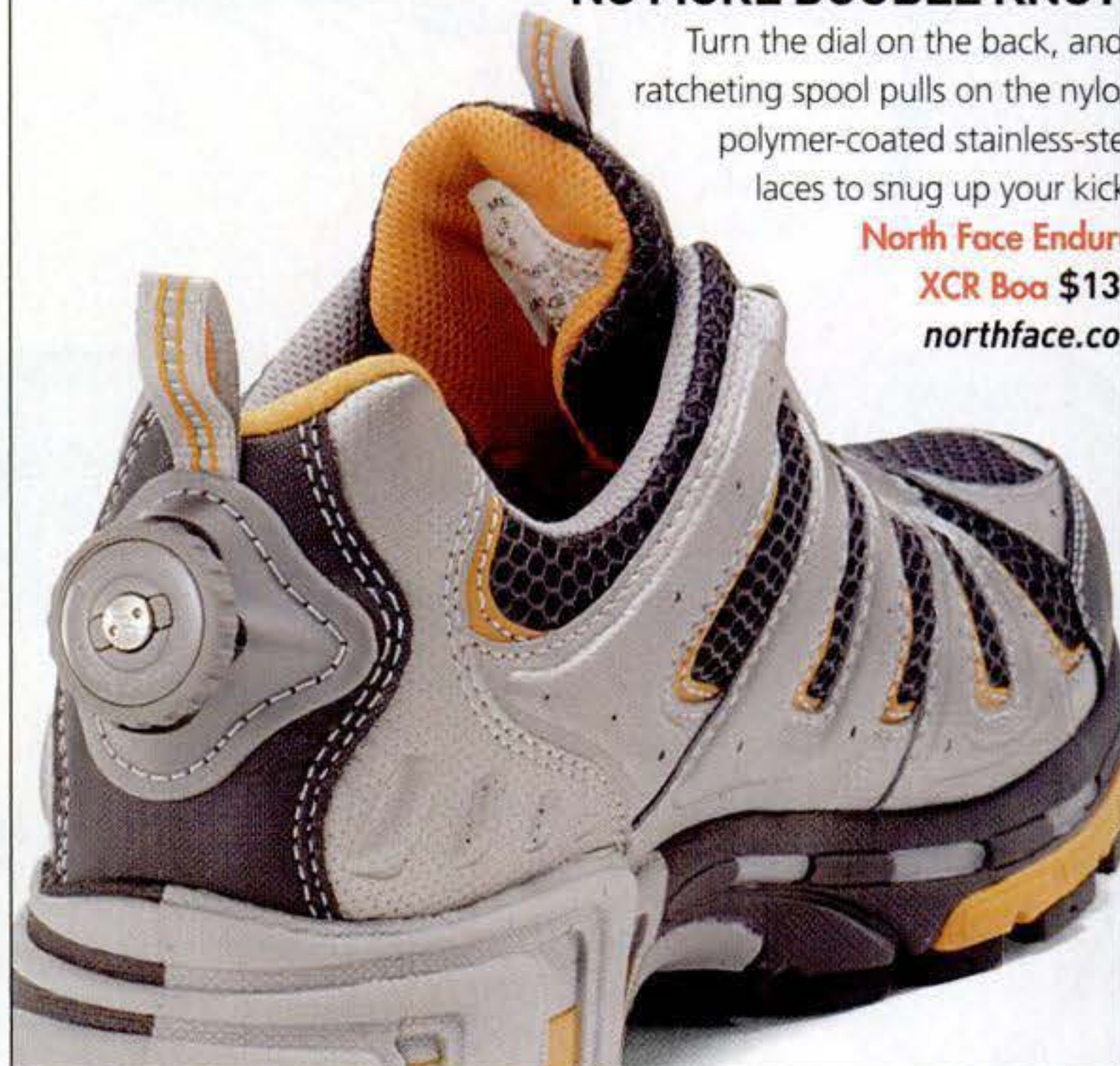
Kohler DTV \$2,000; kohler.com



NO MORE DOUBLE KNOT

Turn the dial on the back, and a ratcheting spool pulls on the nylon, polymer-coated stainless-steel laces to snug up your kick.

North Face Endur
XCR Boa \$130; northface.com



DINNER THEATER

The 10.4-inch LCD on this fridge's door sports a TV tuner and stereo speakers. It's removable, so you can pop it out and take your shows to the dining room. **Samsung PopCon** \$3,500; samsung.com



BASS-LOVING BUDS

Other earbuds use armature drivers—small, vibrating rods that produce sound. These use fully miniaturized loudspeakers, giving them uncharacteristically deep bass as well as clear high notes.

XtremeMac FS1 \$150; xtrememac.com



SWEET-SOUNDING MUSIC SERVER

Because the 400-gig drive inside floats on a special bearing, it's silent, so it won't muck up the sound of your music. Holds 1,100 CDs, ripped in high-quality lossless-compression format.

Olive Opus \$3,000; olive.us

THE GOODS

12 MUST-HAVE PRODUCTS



KLUTZ-PROOF

Not only is this 7.1-megapixel pocket shooter waterproof to 10 feet, but the circuit board is on a shock-absorbing bracket, so it can withstand a five-foot fall. **Olympus Stylus 720 SW \$400; olympusamerica.com**



MULTIMEDIA MULTITASKING

Surf the Web while watching the big game. This 20-inch LCD is the first monitor that can display TV shows and your PC's screen at the same time. 1,650 x 1,080 pixels. **Sony MFM-HT205 \$900; sonystyle.com**

GIVE YOUR BACK A BREAK

This laptop lugger looks weird, but it's worth the embarrassment. The shoulder pads direct the weight of the load across your entire back instead of on one shoulder. And it's easy to sling on. **Ogio Shling Laptop Bag \$200; ogio.com**

MICROCHIP SHOT

Slice your drive into the rainforest? A tiny radar chip in each ball communicates with the scanner so you can find it. **RadarGolf \$250; radargolf.com**



GUIDED BY THE LIGHT

Having trouble cutting a straight line? Try a pair of laser-guided scissors. Click a button on the handle, and it emits a laser beam across whatever you're slicing. **Ideaworks Laser Scissors \$15; jobar.com**



MAID OF THE MIST

Push a button, and this showerhead-mounted gizmo sprays cleaning solution in a 360-degree arc around the tub. **Automatic Shower Cleaner \$25; sbasc.com**





IT'S ABOUT
TIME

THE UN-ERASER

Kodak's new pocket shooter lets you resurrect deleted photos

WHEN WAS THE LAST TIME you—dang!—erased a once-in-a-lifetime picture? Until now, it was nearly impossible to correct those mishaps. Kodak's sleek, palm-size EasyShare V610 eliminates your cancellation calamities by storing the photo you've just killed in its memory even after you've moved onto the next frame. Just erased a keeper? Select "undo delete," and the picture comes back. The V610 also has Bluetooth and in-camera image correction that can help bad lighting and other common mistakes. So snap a pic, clean it up, and send it to your e-mail-capable

mobile phone to blast it off to family and friends—no PC necessary. And the dual-lens setup gives it a mammoth 10x optical zoom. —JACKSON LYNCH

KODAK EASYSHARE V610

RESOLUTION: 6.1 megapixels
ZOOM: 10x optical, 4x digital
LCD: 2.8-inch TFT
VIDEO: VGA, 30 fps
DIMENSIONS: 2.2 (h) x 4.4 (w) x 0.9 (d) inches
GET IT: \$450; kodak.com

TESTED

NEW LONGER-LIFE BATTERIES

Batteries aimed at the unique needs of digital cameras use new chemical concoctions to deliver faster flashes and double the exposures. We spent weeks snapping thousands of flash photos with a Fujifilm FinePix S9000 and found out that the new batteries (and this camera) are very efficient. Conventional alkalines lasted 533 shots. But that's nothin'...



DURACELL POWERPIX 920 SHOTS; \$5 for 4

Nickel Oxy Hydroxide (NiOOH), the new chemical cocktail inside Duracell's PowerPix, is better at high-drain bursts and gives more kick than alkaline cells—1.7 volts instead of 1.5, so your camera focuses faster and your flash is ready again sooner. duracell.com



PANASONIC OXYRIDE 990 SHOTS; \$5 for 4

Oxyrides, available in Japan for two years now, were the first batteries to use NiOOH technology. According to Panasonic, their slightly longer life is due to a manufacturing technique that crams extra material into the cell. panasonic.com

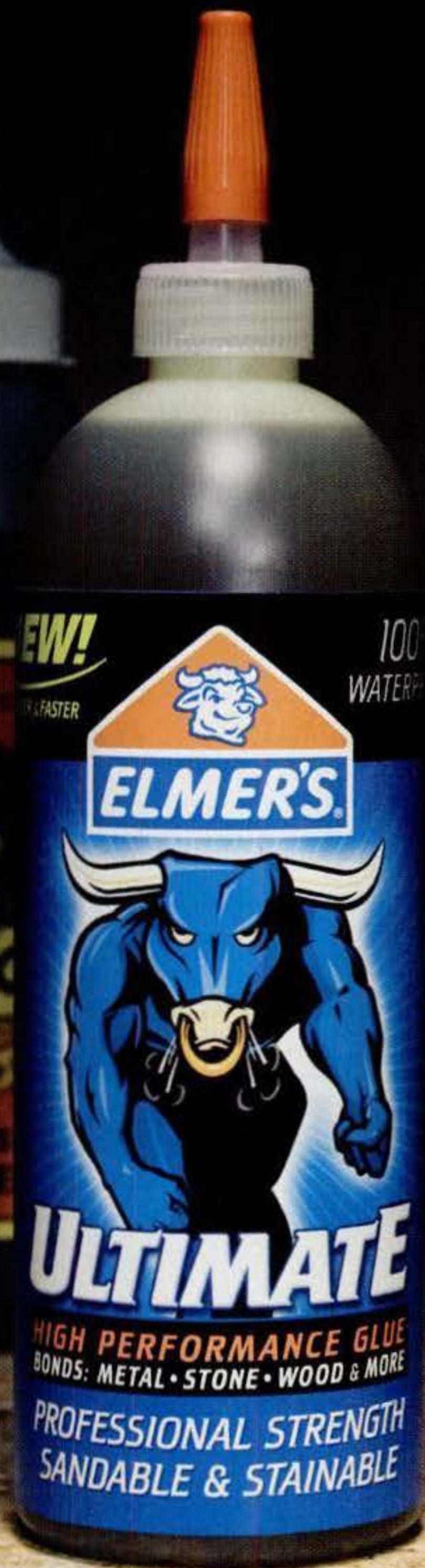


ENERGIZER e² LITHIUM 3,107 SHOTS; \$10 for 4

Energizer's e² batteries use energy-dense lithium to deliver steady voltage throughout discharge. Lithium stores more power than NiOOH or alkaline, which makes for the crazy-long life. They're pricey, but worth it. energizer.com

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TESTED

CARS THAT SEE IN

These luxury cars use infrared night vision to spot hazards in time for you to react

BICYCLISTS, ANIMALS, debris in the road—it's tough to avoid obstacles like these even in broad daylight. At night your opportunity to react is cut to mere milliseconds. Mercedes-Benz and BMW hope that new infrared night-vision systems—now available in their flagship sedans—will alert drivers to threats before they're visible to the naked eye.

The cars employ different types of infrared, but both use large in-dash LCD screens to provide drivers with high-resolution views of the road ahead. They're cool to look at, but do they really prevent accidents? It's not enough to detect an obstacle; its presence has to be effectively conveyed to the driver. We spent a cold, clear, dark night at a local racetrack to find out.

-ERIC ADAMS



2007 MERCEDES-BENZ S550

BASE PRICE: \$86,175
NIGHT-VISION COST: \$1,775
ENGINE: 5.5-liter V8
HORSEPOWER: 382
TORQUE: 391 lb.-ft.
TOP SPEED: 130 mph (limited)
0-60: 5.4 sec.
WEIGHT: 4,270 lbs.
AVAILABLE: Now

2007 BMW 750i

BASE PRICE: \$72,500
NIGHT-VISION COST: \$2,200
ENGINE: 4.8-liter V8
HORSEPOWER: 360
TORQUE: 360 lb.-ft.
TOP SPEED: 150 mph (limited)
0-60: 5.8 sec.
WEIGHT: 4,486 lbs.
AVAILABLE: September

HOW IT WORKS



MERCEDES-BENZ NIGHT VIEW ASSIST

Mercedes uses a pair of illuminators next to the headlamps that project near-infrared light nearly 500 feet down the road. The light is invisible to the human eye but reflects off objects and is detected by a camera at the top of the

windshield. The bright, crisp image is displayed on an eight-inch LCD screen in the driver's main instrument cluster. The illuminators switch on above eight miles an hour, so you won't see much unless you're rolling.



BMW NIGHT VISION

BMW uses passive far-infrared technology. Instead of blasting the night with infrared light, a thermal-imaging camera detects heat from objects nearly 1,000 feet away. The image on the 8.8-inch screen, which is in the center of the

dashboard (as opposed to directly in front of the driver), is not as crisp as the one in the Mercedes, but it reveals people and animals with startling clarity. The camera is mounted on the front bumper, which generates a very low perspective.

ILLUSTRATIONS: L. DOPA;
 PHOTOGRAPHS: JOHN B. CARNETT

THE DARK

NOT X-RAY VISION
Infrared can see into the dark, but it gets stymied by inclement weather.



THE TESTS

MERCEDES

BMW



STATIONARY OBJECTS

We placed a shopping cart, a stack of tires, a traffic cone and a muffler side by side at the end of the track's main straight and stopped when all four were visible on the screen at the same time.

B I was able to see all four items at 130 yards, thanks to the powerful illuminators. People, animals and inanimate objects, however, are all equally bright, so it was hard to tell them apart.

B- The 7 Series didn't pick up the muffler until I was 37 yards away because it was so low to the ground. I saw the other three items much sooner, though still far later than I did in the Mercedes.



BLIND DRIVING

We drove each car at low speed around the entire half-mile course using, as much as possible, the night-vision systems alone. This, by the way, is dangerous. In other words: Don't try this, like, ever.

B+ It took me 20 seconds longer than normal to navigate the course, but I only had to look out the windshield twice. The system actually revealed turns far earlier than the headlights did.

C+ The BMW's low perspective and grainy display made this test tough. The edges of the road weren't clearly defined, nor were the turns. I had to look up more often, and even went off-road once.



MOVING OBJECTS

We positioned a (fully insured) staff member at the end of a straightaway. He chased a soccer ball across the track with no warning, and I stopped when his image in the LCD caught my eye.

B I distinctly saw both the soccer ball and the running human on the screen. But because everything on the screen is equally bright, I couldn't really tell it was a person until he started moving.

A+ Whether the mark was stationary or moving, I instantly noticed his bright heat signature in my peripheral vision. If animals—or people—are the main hazards in your area, this system is for you.



WEB CALLING CUTS THE CORD

Cheap—even free—wireless VoIP, without a computer

FORGET AT&T AND THE LIKE. The only phone company you need is Skype, which routes your calls over the Internet and costs around two cents a minute. And now you can almost forget your cellphone provider too—with this new Voice over Internet Protocol (VoIP) gear, you can make calls using Skype (or Vonage, another VoIP provider) from just about anywhere. No computer or dorky headset required. —MICHAEL MYSER

THE TREND

Internet phone service goes mobile, freeing consumers to make lower-cost calls from nearly anywhere.

WHY NOW

With Wi-Fi networks in coffee shops, airports and public parks, a Wi-Fi-enabled VoIP phone is nearly as useful as a cellphone.

HOW YOU'LL BENEFIT

You get cheap phone service without being tethered to your computer.

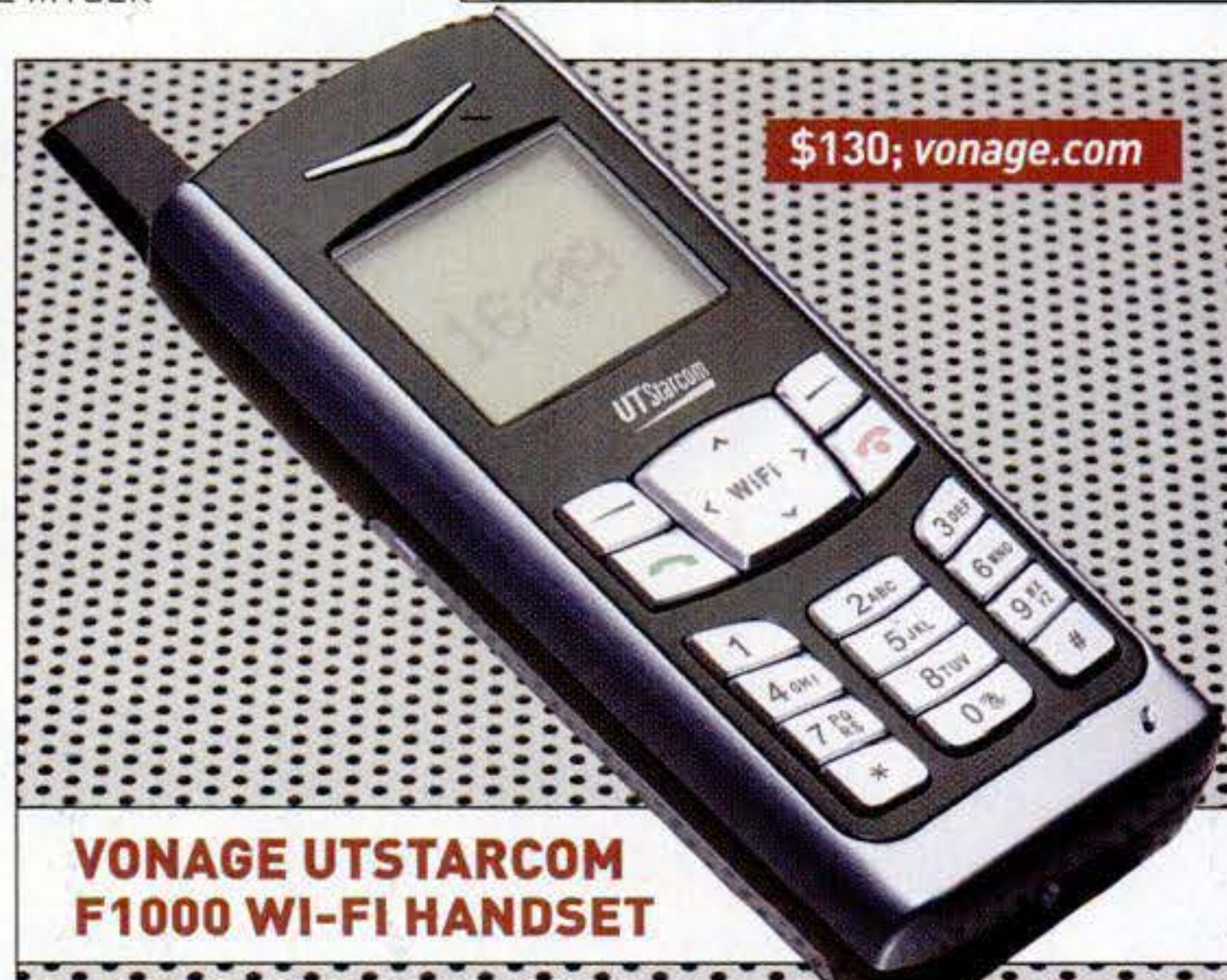


\$250; netgear.com

NETGEAR SKYPE WI-FI PHONE

Power up the phone on any wireless network, enter your Skype username and password, and your Skype contacts will populate the handset's color LCD screen. Call them free, or phone outside numbers for about two cents a minute.

SIZE: 4.3 x 1.8 x 0.8 in.
WEIGHT: 3.8 oz.
BATTERY LIFE: 3 hours talk; 50 hours standby
SERVICE: Skype

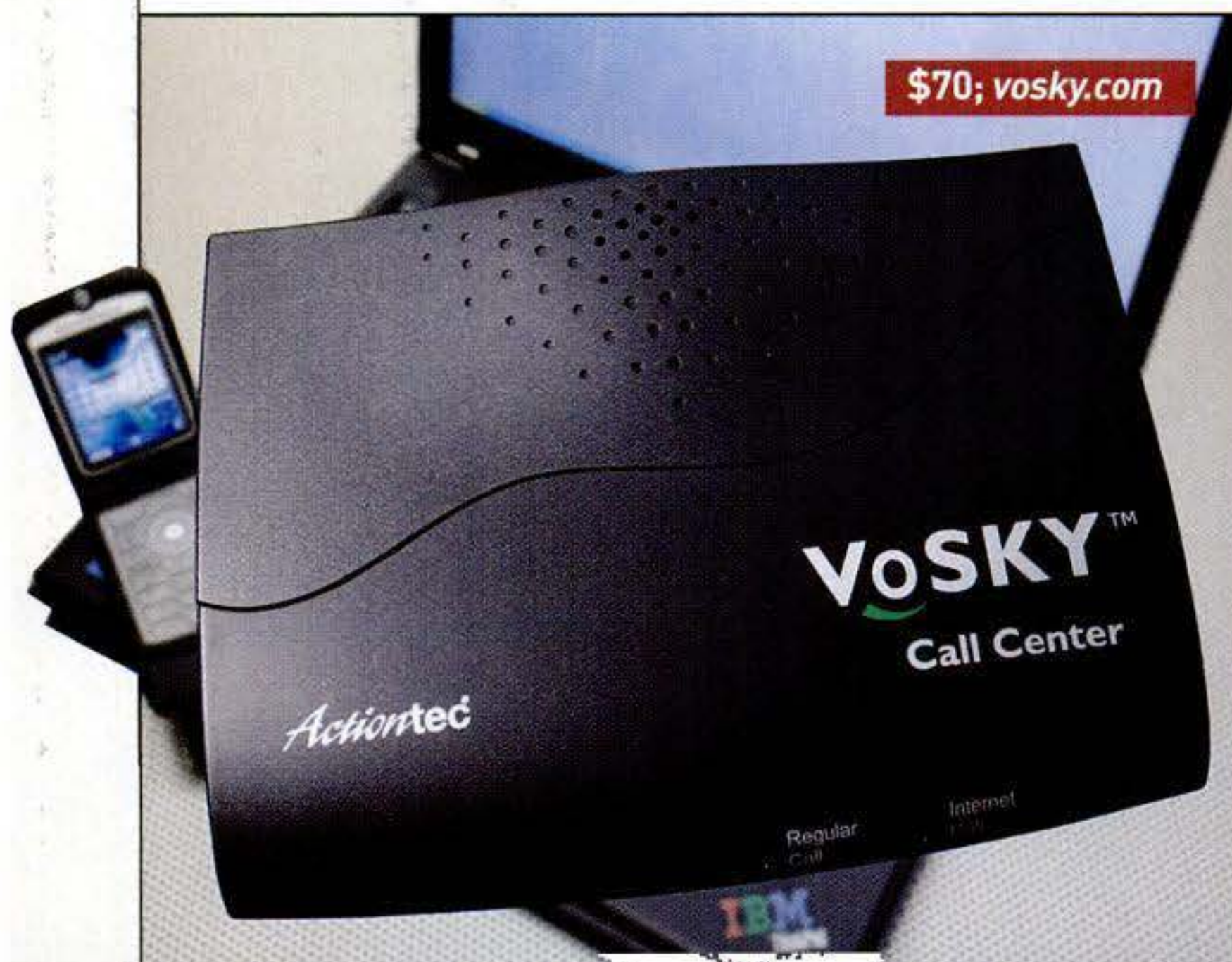


\$130; vonage.com

VONAGE UTSTARCOM F1000 WI-FI HANDSET

Find a hotspot and turn on the F1000, and you can make unlimited calls to the U.S. or Canada for \$25 a month. The Vonage handset acts a lot like a good cellphone; it's got three-way calling, call waiting—even ring tones.

SIZE: 4.2 x 1.7 x 0.9 in.
WEIGHT: 3.5 oz.
BATTERY LIFE: 5 hours talk; 50 hours standby
SERVICE: Vonage



\$70; vosky.com

ACTIONTEC VOSKY CALL CENTER

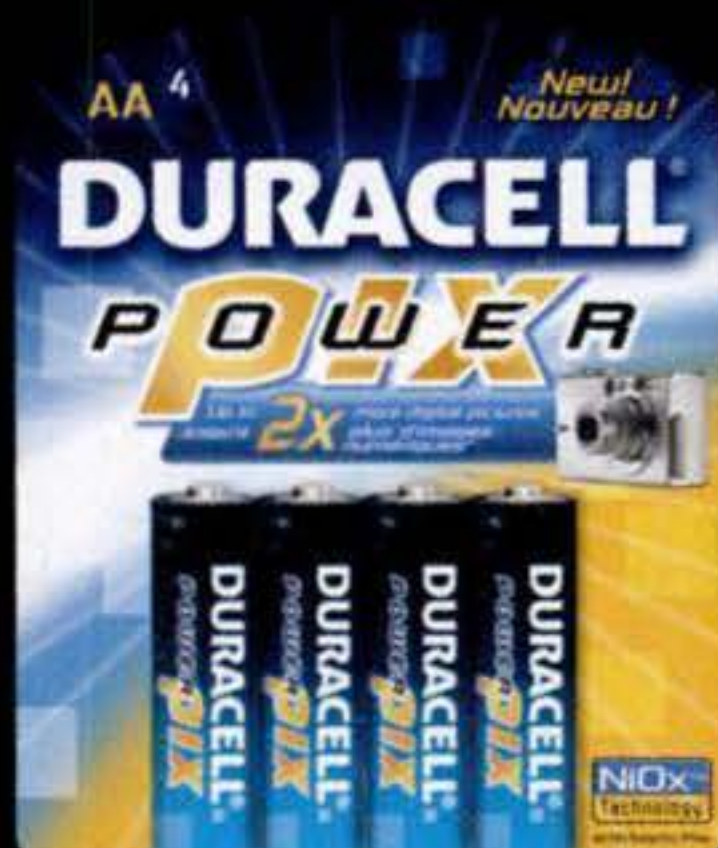
This router lets you access your Skype account remotely from any phone in the world, so you can make cheap calls away from home. Just hook up the box to your landline and your Internet-enabled PC, and anytime you call your home number, you'll be connected to the Call Center. Follow voice prompts to log into your Skype account, and dial away.

SIZE: 4.5 x 3.4 x 1 in.
WEIGHT: 5.1 oz.
SERVICE: Skype
SYSTEM REQUIREMENTS: PC running Windows 2000 or XP; analog telephone and number; Internet connection



Introducing Duracell PowerPix

A whole new kind of Duracell® for your digital camera.



It's probably not news to you that a digital camera can quickly drain the power from even the best alkaline battery. And if the expense of lithium batteries, or dealing with rechargeables isn't for you, consider this:

New Duracell Power Pix. With dedicated NiOx technology that gives you more power and up to twice as many pictures*.

*vs. ordinary alkaline batteries. Results vary by camera.

DURACELL®
TRUSTED EVERYWHERE

TRICK OUT YOUR TOOLBOX

FULLY
LOADED

A new generation of tools puts pro-quality work within reach of the layman. It's time to upgrade the old workbench BY MARK CLEMENT

1 THE PRYING HAMMER

This tool's head pivots to let you customize its prying angle. Swivel it down for nail-hooking leverage, or flatten the head to get under overhead molding and rip it off the wall.

Norwolf Swivel Hammer \$85; norwolf.com

2 SMALL DRILL, BIG POWER

The first cordless drill with a brushless motor, the C12 is the smallest, lightest 12-volt model around. But don't call it dinky: It's also the most powerful drill of its size.

Festool C12 \$345; festoolusa.com

3 MR. FIX-IT'S LIGHT SHOW

Construction projects depend on plumb and level lines. This self-adjusting laser box shoots both, and it's the first such device that fits in the palm of your hand.

Pacific Laser Systems PLS2E \$330; plslaser.com

4 ONE-HANDED BOLT BITER

A micro-motor and battery enable the new Auto Wrench to adjust its jaw opening automatically. Push a button, and the jaws get the best grip on the bolt—no fiddling required.

Black & Decker Auto Wrench \$30; blackanddecker.com

5 THE ANGLE FINDER

This tool reads unknown angles—like between the panels on your bay window—and then tells you how to set your miter saw to copy the angle.

L.S. Starrett Prosite Protractor 505A-7 \$79; lsstarrett.com

6 TWIST ALMOST ANYTHING

The tool's steel jaws are shaped to turn bolts, but unlike a socket, they can grip pretty much anything. Adjust the jaws from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch using the thumbwheel.

Crescent R2 RapidRench \$29; cooperhandtools.com

THE COST OF GOING PRO

NORWOLF SWIVEL HAMMER	\$85
FESTOOL C12 DRILL DRIVER	\$345
PACIFIC LASER SYSTEMS PLS2E	\$330
BLACK & DECKER AUTO WRENCH	\$30
L.S. STARRETT PROSITE PROTRACTOR 505A-7	\$79
CRESCENT R2 RAPIDRENCH	\$29
TOTAL	\$898



SONY
HANDYCAM



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HEAR HD



ENJOY HD

Whoever said memories had to be fuzzy? Catch everything in Sony® HD. The Sony® HDR-HC3 Handycam® camcorder is the world's smallest and lightest 1080i high-definition camcorder*. HDMI™ connectivity, 4 megapixel still capture, and ClearVid™ CMOS Sensor all work in unison to deliver the crispest, clearest, most brilliant picture. Sony's total HD solution, from camcorder to television and everything in between, lets you capture emotion in every detail. Create, Edit, Hear and Enjoy HD. sony.com/hdworld

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**Designed to protect you from anything the road
throws at you, including boredom.**



“★★★★★”— NHTSA Crash Test Rating

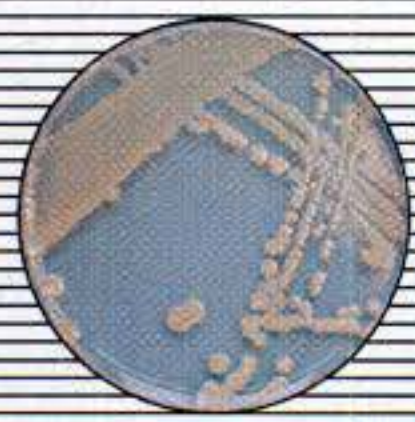
With the Hyundai Tucson, safety isn't optional. We believe a great driving experience begins with peace of mind. That's why the Tucson comes with Electronic Stability Control with Traction Control System, Anti-lock Braking System (ABS), and six airbags, standard. Nicely equipped with, of course, America's Best Warranty,^{™*} starting at \$17,845.^{**} **HyundaiUSA.com**

A Hyundai like you've never seen before.

T U C S O N

Government star ratings are part of the National Highway Traffic Safety Administration's (NHTSA's) New Car Assessment Program (www.safercar.gov). Safety belts should always be worn. *Hyundai Advantage.™ See dealer for LIMITED WARRANTY details. **Limited model shown, \$22,245. MSRP excl. freight, taxes, title, license, and options. Dealer price may vary. Hyundai and Hyundai model names are registered trademarks of Hyundai Motor America. All rights reserved. ©2006 Hyundai Motor America.

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HEADLINES

DISCOVERIES, ADVANCES & DEBATES IN SCIENCE

THIS MONTH



32

An airplane you park in the garage



37

New tech sniffs for nukes in Iran



38

Soccer-playing robots kick it in Germany

BIOLOGY



E.T. UNDER THE MICROSCOPE Scientists have yet to identify the unusual particles [above, magnified 500 times] isolated from India's mysterious red rainwater.

conditions of space and that the microbes hitched a ride on a comet or meteorite that later broke apart in the upper atmosphere and mixed with rain clouds above India. If his theory proves correct, the cells would be the first confirmed evidence of alien life and, as such, could yield tantalizing new clues to the origins of life on Earth.

Last winter, Louis sent some of his samples to astronomer Chandra Wickramasinghe and his colleagues at Cardiff University in Wales, who are now attempting to replicate his experiments; Wickramasinghe expects to publish his initial findings later this year.

Meanwhile, more down-to-earth theories abound. One Indian government investigation conducted in 2001 lays blame for what some have called the "blood rains" on algae. Other theories have implicated fungal spores, red dust swept up from the Arabian peninsula, even a fine mist of blood cells produced by a meteor

IS IT RAINING ALIENS?

Nearly 50 tons of mysterious red particles showered India in 2001. Now the race is on to figure out what the heck they are

AS BIZARRE AS IT MAY SEEM, the sample jars brimming with cloudy, reddish rainwater in Godfrey Louis's laboratory in southern India may hold, well, aliens. In April, Louis, a solid-state physicist at Mahatma Gandhi University, published a paper in the prestigious peer-reviewed journal *Astrophysics and Space Science* in which he hypothesizes that the samples—water taken from the mysterious blood-colored showers that fell sporadically across Louis's home state of Kerala in the summer of 2001—contain microbes from outer space.

Specifically, Louis has isolated strange, thick-walled, red-tinted cell-like structures about 10 microns in size. Stranger still, dozens of his experiments suggest that the particles may lack DNA yet still reproduce plentifully, even in water superheated to nearly 600°F. (The known upper limit for life in water is about 250°F.) So how to explain them? Louis speculates that the particles could be extraterrestrial bacteria adapted to the harsh

CONTINUED ON PAGE 33

CLOCKWISE FROM TOP RIGHT: COURTESY DR. GODFREY LOUIS; GETTY IMAGES; COURTESY DR. GODFREY LOUIS; DAVIES + STARR/GETTY IMAGES; STEVE WEINREBE/GETTY IMAGES



Want more? Download our exclusive podcast at popsci.com/bloodrains.

TALK ABOUT AUTOPILOT!

An aeronautical engineer presents a new twist on the ol' flying car: the road-ready airplane

EVEN THOUGH YOU'LL PARK IT IN YOUR GARAGE, drive it to your nearest airstrip, and pilot it to your destination, don't think of the Transition as a flying car. Carl Dietrich, the MIT aeronautical-engineering graduate student who is designing the vehicle, prefers the term "roadable aircraft"—meaning a plane that drives, not a car that flies. "We try to steer away from *The Jetsons*," Dietrich says. "It's a step in that direction, but a baby step."

Still, in an age of hub-centric commercial flights, Dietrich thinks the ability to cruise between two of the 4,800 small airports nationwide and then drive to a final destination, whether your office or vacation home, will be irresistible to amateur pilots. He and his team are finishing a one-fiftieth scale model for wind-tunnel tests. They hope to build a prototype within two years and to have the first Transitions rolling down runways by 2010. The projected price tag? About \$150,000, roughly the price of a fully loaded Ford GT sports car.—GREGORY MONE

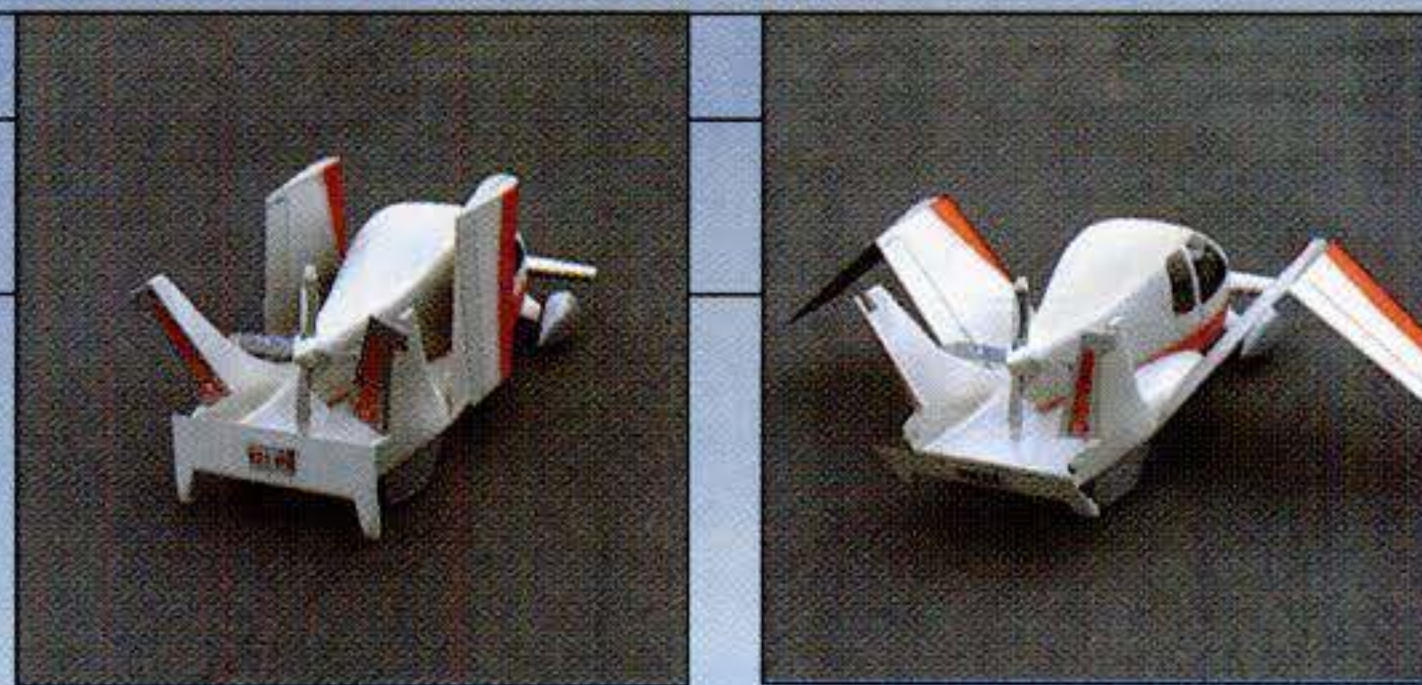
1 LEAVING HOME A fender bender could ruin the aerodynamics of the plane, so the big challenge is to make the Transition both flight- and road-ready. In car mode, the tail folds up, revealing a bumper. The control surfaces of the twin vertical stabilizers fold inward, shielding the propeller from debris.

2 DRIVING With only two seats and no trunk space, the Transition won't be ideal for trips to Costco. But the 6.5-foot-high car will be able to reach highway speeds, Dietrich says, and could be refueled at any gas station that sells super-unleaded gas. Expected mileage on the road: a not-too-shabby 40 miles per gallon.



3 TRANSFORMATION On the runway, a flip of a switch starts the metamorphosis. The tail folds down, the wings flatten and lock into place, and the control surfaces of the vertical stabilizers line up. A security system, such as a thumbprint scanner, will keep Junior from "taking off" with the car.

4 FLIGHT With an air-cruising speed of 120 miles an hour, the Transition will be able to fly 500 miles on a single tank of gas. Inside the cockpit, "it's all conventional general-aviation controls," Dietrich says, "so it should be familiar to pilots." In bad weather, you could simply divert to the nearest airport and drive the rest of the way.



Two hinges lock into place when the wings extend, securing the plane for takeoff.

CONTINUED FROM PAGE 31

striking a high-flying flock of bats.

Louis and his colleagues dismiss all these theories, pointing to the fact that both algae and fungus possess DNA and that blood cells have thin walls and die quickly when exposed to water and air. More important, they argue, blood cells don't replicate. "We've already got some stunning pictures—transmission electron micrographs—of these cells sliced in the middle," Wickramasinghe says. "We see them budding, with little daughter cells inside the big cells."

Louis's theory holds special appeal for Wickramasinghe. A quarter of a

Could the strange microbes found in India's red rains hail from space?

century ago, he co-authored the modern theory of panspermia, which posits that bacteria-riddled space rocks seeded life on Earth. "If it's true that life was introduced by comets four billion years ago," the astronomer says, "one would expect that microorganisms are still injected into our environment from time to time. This could be one of those events."

The next significant step, explains University of Sheffield microbiologist Milton Wainwright, who is part of another British team now studying Louis's samples, is to confirm whether the cells truly lack DNA. So far, one preliminary DNA test has come back positive. "Life as we know it must contain DNA, or it's not life," he says. "But even if this organism proves to be an anomaly, the absence of DNA wouldn't necessarily mean it's extraterrestrial."

Louis and Wickramasinghe are planning further experiments to test the cells for specific carbon isotopes. If the results fall outside the norms for life on Earth, it would be powerful new evidence for Louis's idea, of which even Louis himself remains skeptical. "I would be most happy to accept a simpler explanation," he says, "but I cannot find any."

—JEBEDIAH REED

ARCHITECTURE

A CLIFF-HANGER

Want a more thrilling view of the Grand Canyon? Take a stroll over the all-glass Skywalk, and you can hover above it

STEP OUT ONTO the new Skywalk, and only a few sheets of glass will stand between you and a 15-second free-fall to the bottom of the Grand Canyon. Set to open late this year, this horseshoe-shaped footbridge (commissioned by the Hualapai Indian tribe, which owns the land) will jut 65 feet from the cliff edge and suspend 3,800 feet above the canyon floor, a height more than twice that of the world's tallest skyscraper.

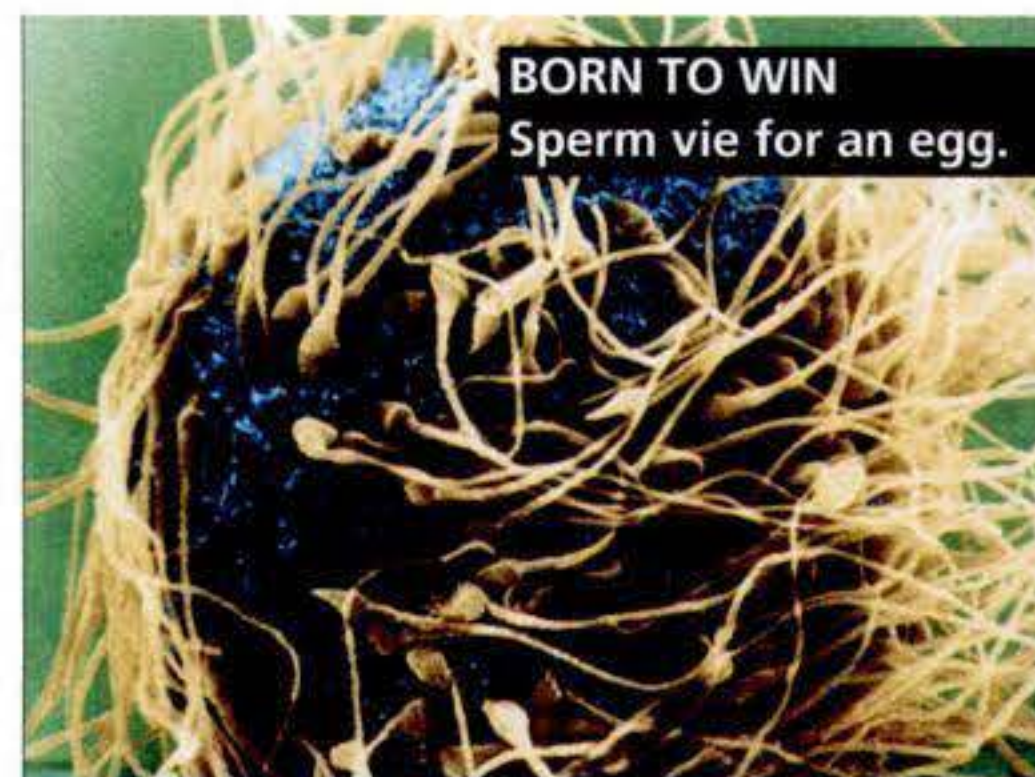
If you're a bridge, the Grand Canyon is probably the last place you'd want to be: 90mph vertical winds whip upward with tornado-like force, a condition endured by no other bridge in the world. To secure the Skywalk, Lochsa Engineering in Las Vegas has cantilevered it atop the cliff with 94 steel rods that bore 46

feet into the limestone rock. As a result, it can support 70 tons of weight, equivalent to roughly 700 hefty men, although the maximum occupancy is set at 120 people. Three oscillating dampers—steel plates, each 3,200 pounds—inside the hollow bridge beams act as shock absorbers, moving up and down to neutralize the vibrations from foot traffic and wind gusts. For further support, the walkway itself will be constructed of three-inch-thick, heat-strengthened glass and enclosed by five-foot-tall glass walls.

Too tame for you? Lochsa hints at future plans to ratchet up the thrill factor by turning a maintenance car designed to run on a track along the bottom of the Skywalk into a trolley ride for visitors. —ADAM M. BRIGHT



THE LOOKING GLASS
An artist's rendering of the Skywalk, perched 3,800 feet above the Colorado River.



BORN TO WIN
Sperm vie for an egg.

NEWS BRIEFS

MANLY SCIENCE

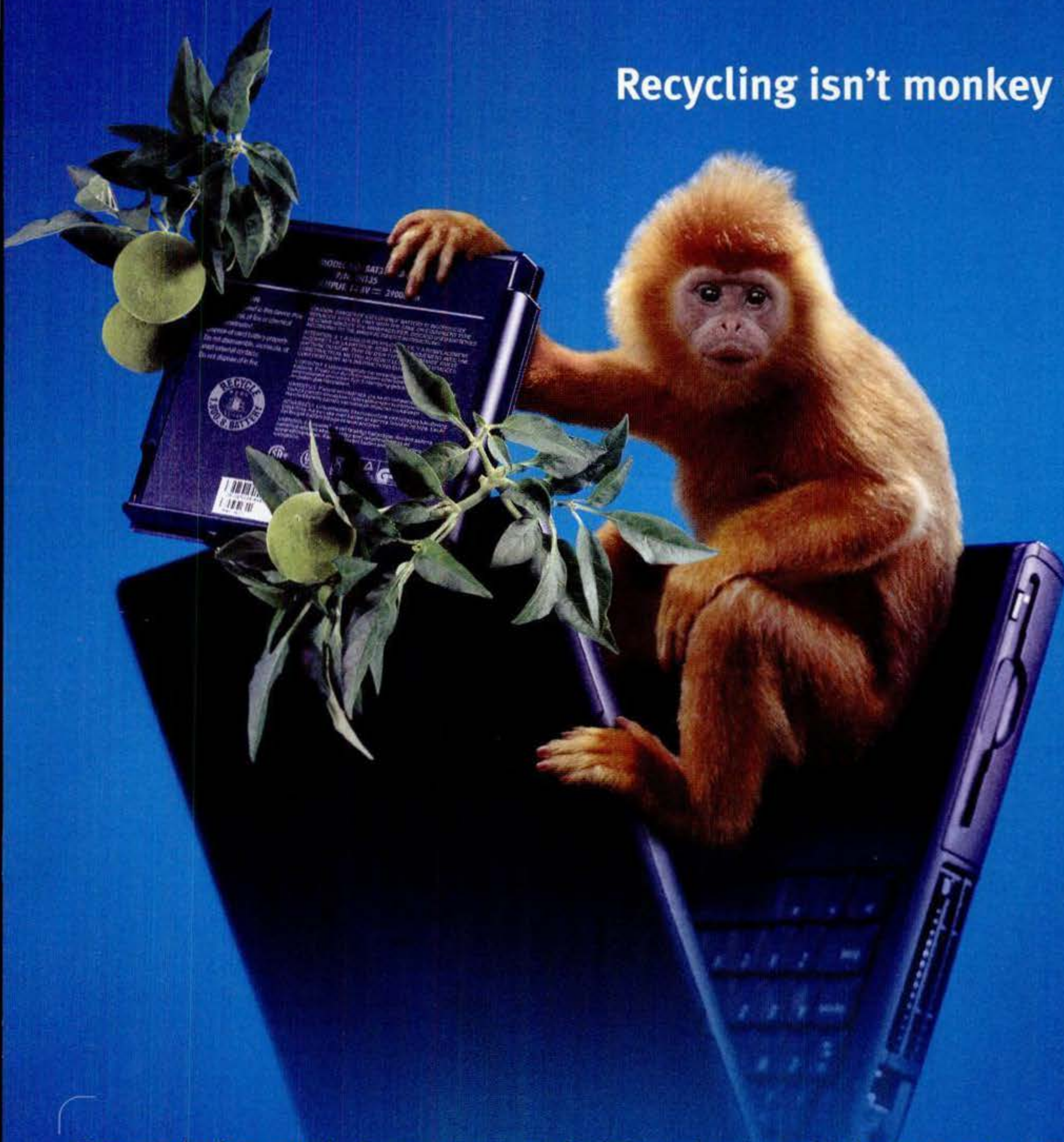
The latest findings on the curious Y chromosome

1 SWEET REVENGE Men are more likely than women to be pleased when bad guys get their comeuppance, according to a University College London study. Scientists took MRI scans of subjects participating in a simple Prisoner's Dilemma game, in which players can either cooperate with or double-cross each other. The scans revealed that when known traitors were punished with an electric shock, primitive reward areas of men's brains lit up.

2 ALL MY CHILDREN Move over, Wilt Chamberlain. Trinity College Dublin geneticists say that more than three million men living today are descendants of an even more prolific patriarch, fifth-century Irish king Niall of the Nine Hostages. Like mitochondrial DNA in females, the Y chromosome remains intact as it is passed down, and 20 percent of the male population in some parts of Ireland carry Niall's Y genes.

3 SURVIVAL OF THE FITTEST While confirming earlier studies that showed that stressed moms are more likely to miscarry male fetuses than female ones, scientists at the University of California at Berkeley also found that boys who survive stress in the womb live longer on average than those born during steadier times. —ELIZABETH SVOBODA

Recycling isn't monkey business.



Stop monkeying around. Everyone can recycle their used rechargeable batteries once they've worn out. It's easy. Check the batteries in your laptop computers, camcorders, cordless power tools, cordless and cellular phones, digital cameras, and two-way radios. If they no longer hold a charge, recycle them by visiting one of many collection sites nationwide, including those retailers listed below. For a complete list of rechargeable battery drop-off locations, visit www.call2recycle.org or call toll free **877-2-RECYCLE**.

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STAPLES

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BIOTECHNOLOGY



STYROFOAM



SOIL BACTERIA



PLASTIC FORKS

TRASH EATERS

Munching microbes may join the quest to recycle Styrofoam

THROW AWAY your typical Styrofoam coffee cup, and it could take millions of years to disintegrate. Now microbiologist Kevin O'Connor of University College Dublin and his colleagues have proposed a new technique that could help recycle the 2.3 million tons of Styrofoam (a.k.a. polystyrene) dumped in U.S. landfills every year. The key, O'Connor says, is a plastic-eating soil bacterium called *Pseudomonas putida*. Polystyrene is made of bonded

styrene molecules culled from petroleum. *P. putida* can't eat the stuff outright, but it can metabolize its styrene, which is found naturally in soil. To render the Styrofoam edible, the team heats it to 968°F, melts it into black styrene oil, and feeds the oil to millions of bacteria. Forty-eight hours later, the microbes yield teensy granules of translucent plastic that can then be turned into utensils, credit cards, even heart stents.—LAURA ALLEN

TAGS, THEY'RE IT
The thinnest radio tags
yet, next to salt grains



SHRINKAGE

THE QUEST TO MAKE REALLY TINY THINGS

FOLLOW THE MONEY

New ultrathin radio ID tags embedded in money can thwart counterfeiters

FOR YEARS, radio-frequency identification, or RFID, tags have been used to track everything from highway tolls to pets, but only Hitachi's newest tag is skinny enough to fit inside a dollar bill. Just 0.15 millimeter square and 7.5 microns thick, it's a mere 1/5 the size of the next smallest RFID chip. And it can do everything its predecessors can. Hitachi's tags store up to 128 bits of data—including prices, serial numbers and places of origin—that radio scanners can read from more than 10 feet away.

RFID chips typically use thick metal guard rings to insulate their circuitry. The insulation limits electrical interference but makes the tags too bulky for thin products such as paper. Hitachi's weight-loss solution is to remove the rings and separate the circuits into individual wells coated with a thin insulating layer of silicon dioxide.

So far, the new insulation trick has worked perfectly. An earlier version of the chip successfully debuted in tickets for the 2005 World Exposition in Aichi, Japan, as a way to stop counterfeiters, and a new, even slimmer version could appear in European and Japanese currency within the next few years. When that happens, banks and businesses can simply scan the tagged bills to confirm their authenticity or trace their origins.—ELIZABETH SVOBODA

STATISTICALLY SPEAKING

FAILURE TO LAUNCH

The low-cost SpaceX rocket burst into flames on its maiden flight in March. Here, a comparative look at the disaster

UH-OH
A fuel leak
dooms
Falcon 1.



6.7

Cost, in millions of dollars, of the 70-foot-long, two-stage *Falcon 1* rocket built by the California-based company SpaceX, minus the \$700,000 payload

25

Cost, in millions of dollars, of the comparably-sized Pegasus rocket, made by industry leader Orbital Sciences

55

Number of rocket launches worldwide in 2005

41

Percentage of rockets that fail on maiden launch

50

Total cost, in millions of dollars, of all 2005 rocket failures

1.5

Amount, in billions of dollars, for which SpaceX founder Elon Musk sold his previous company, PayPal, in 2002

Sources: SpaceX, Futron Corporation, Federal Aviation Administration

PHYSICS

IS THIS A POWER PLANT OR A BOMB FACTORY?

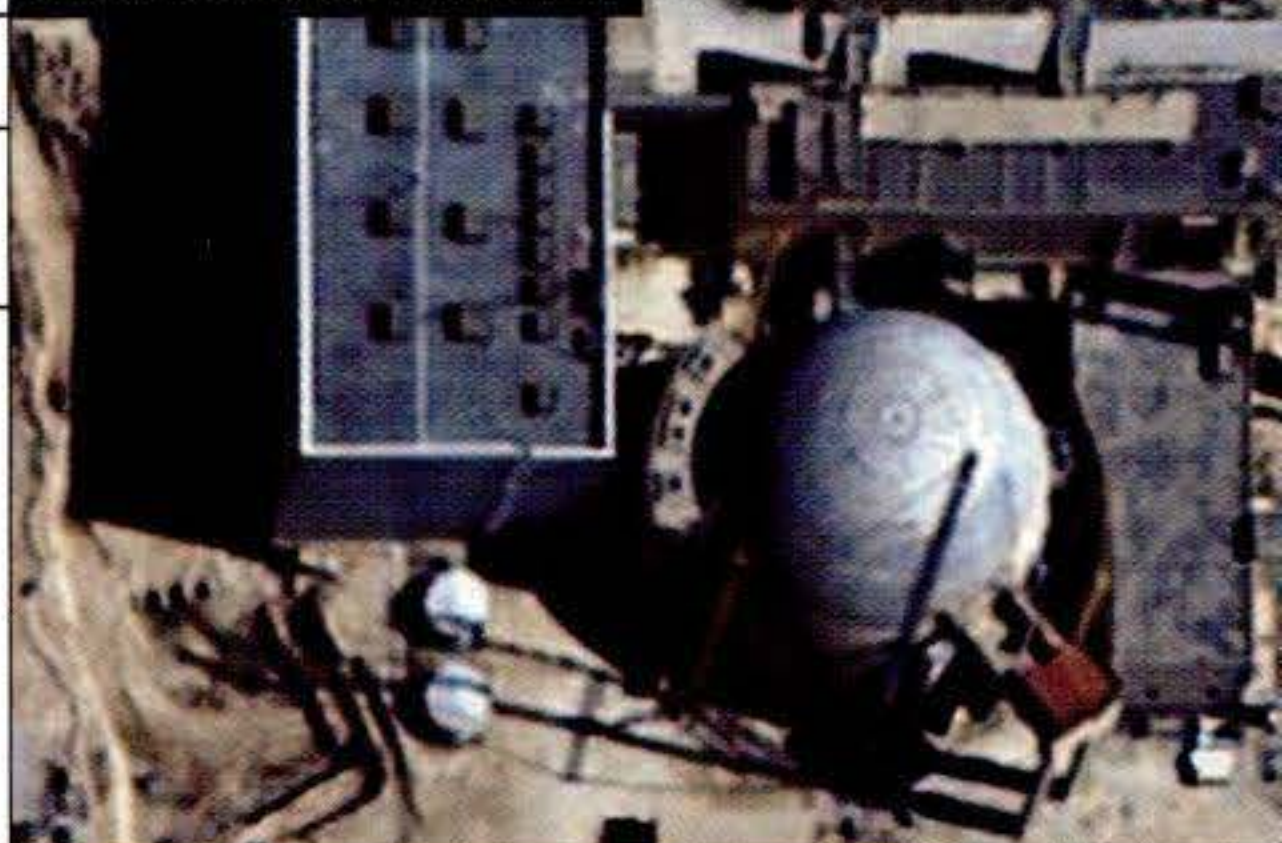
A portable, ultra-accurate nuke detector will help us find out

IRAN IS EXPECTED to finish construction of its first nuclear power reactor in just a few months, despite serious international suspicion that the country plans to use the facility to make bombs instead of electricity. One has only to siphon off plutonium, a radioactive by-product of nuclear fission, from the reactor's fuel rods to obtain a key ingredient for a warhead.

A portable detector under development by engineers at the National Institute of Standards and Technology could enable weapons inspectors to examine spent fuel rods on the spot for signs of

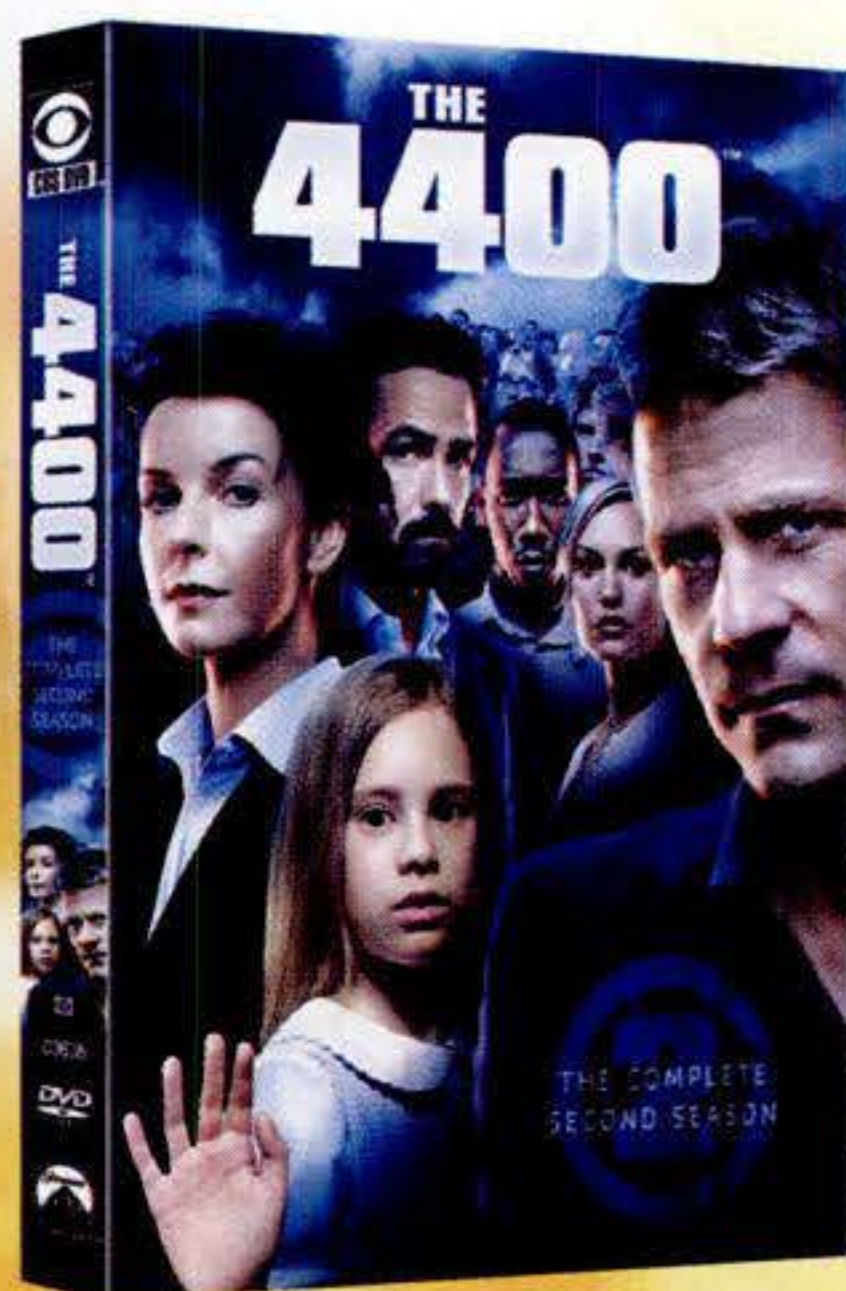
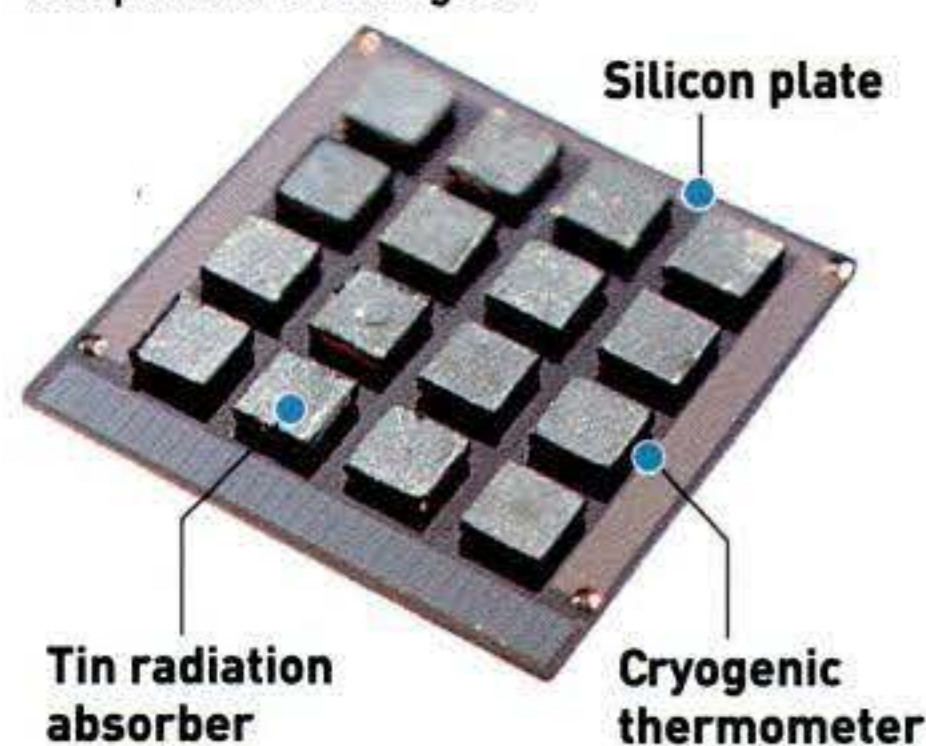
such tampering, reducing the need for dangerous sample collections and time-consuming laboratory analysis. With the NIST device [see photograph, right], an inspector scans the spent fuel rod from 10 to 20 feet away, and the detector pinpoints specific energy signatures of x-rays and gamma radiation emanating from material inside. If plutonium is missing, the device, unlike its predecessors, is sensitive enough to detect the corresponding low levels of radiation. The downside? NIST won't have a field-ready version for another few years.—RENA MARIE PACELLA

WMD? A nuclear reactor under construction in Iran



ANATOMY OF A NUKE SNIFFER

The NIST prototype consists of 16 sensors. Each sensor absorbs radiation and converts it to heat, then measures temperature changes.



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ARTIFICIAL INTELLIGENCE

BEND IT LIKE NIMBRO

Soccer-playing humanoids kick off one of the biggest robotics competitions of the year

AS WORLD CUP SOCCER rages in Germany this month, 350 teams from around the world will convene in the city of Bremen to compete in the robotic equivalent, the 10th annual RoboCup World Championship. The goal, so to speak, of this event is highly ambitious: to create android athletes that could whip the human world-champion soccer team by the year 2050—and, along the way, advance the field of artificial intelligence.

David Beckham need not worry anytime soon. The players,

which range from Sony Aibo dogs to dwarf-size bipedal 'bots, tend to topple easily, botch passes, and quit when their batteries run low. Still, by robot standards, they've got game: The humanoids can play a 20-minute match, replete with holding penalties and goal thrashing, and teams of networked 'bots can score without any human interference. Give them 44 more years of practice, and they might well be signing autographs, not to mention million-dollar contracts. Here, our favorite players.—PATRICK DI JUSTO

ROBOT	THE PLAYER	STANDINGS	STRENGTH
ROBOCUP LAVAL University of Laval Quebec 	The darling of the Small Robot League, this 8.6-inch-tall 'bot guides a golf ball around the field, executing plays sent from a side-line computer. Two cameras above the field track teammates and foes.	A strong competitor since 2001, Laval's team of five networked 'bots are favored to win but will have to outmaneuver 27 other teams.	<i>Most nimble.</i> Redesigned wheels feature higher ground clearance, providing greater mobility on uneven surfaces. For extra traction, Laval sports tires made of the rubber O-rings used in car engines.
 NIMBRO University of Freiburg Germany	Competing in the Humanoid League, NimbRo is a 3.3-foot-tall, 11-pound autonomous bipedal that can run, dribble, kick, recover from falls, and strategize with teammates.	Last year's runner-up, this veteran team is poised to dethrone the reigning champ Team Osaka in two-on-two matches.	<i>Greatest dexterity.</i> NimbRo can get up from falls quickly, thanks to attitude sensors, ultra-strong carbon-composite feet and 21 actuator-controlled joints.
NORTHERN BITES Bowdoin College Maine 	This reprogrammed Sony Aibo robot dog is our pick in the Four-Legged League. Like humans, the pooch masters ball handling through practice, using corrective software to learn from mistakes.	The first-time championship competitor is a true underdog. It will pit its four-dog team against 23 others, most of which will be led by robotics powerhouses.	<i>Best navigator.</i> Northern Bites builds super-accurate models of the field by combining preprogrammed data, input from a video camera, touch sensors and communication from teammates.

HEADLINE FROM THE FUTURE

2030 YOUR DOCTOR MAKES MOUTH CALLS

Anup Singh, chemical engineer, Sandia National Laboratories, Livermore, California

Now there's one more thing to add to your morning regimen. After brushing and flossing, stick a saliva sensor onto your tooth (pre-fitted to the molar of your choice), and the paper-thin device will scan your spit for signs of lung cancer and flu, among other illnesses. Embedded in the sensor are dozens of antibodies designed to detect early-warning signs of disease by binding to molecular abnormalities in saliva. If the sensor picks up on any disease activity, it wirelessly transmits a diagnosis to your cellphone, which then dials your doctor for an appointment. Not just for medical diagnosis, the tooth cap also functions as a handy "intoximeter," measuring the alcohol content in your saliva, then alerting you when you've had too many cocktails to drive.

ANUP SINGH IS DEVELOPING A HANDHELD DETECTOR THAT TESTS SALIVA FOR GUM AND HEART DISEASE.



IF A WORK OF ART 100 MILLION YEARS IN THE MAKING TAKES YOUR BREATH AWAY,
YOU SHOULD SEE WHAT HAPPENS WHEN YOUR LIGHT QUILTS.

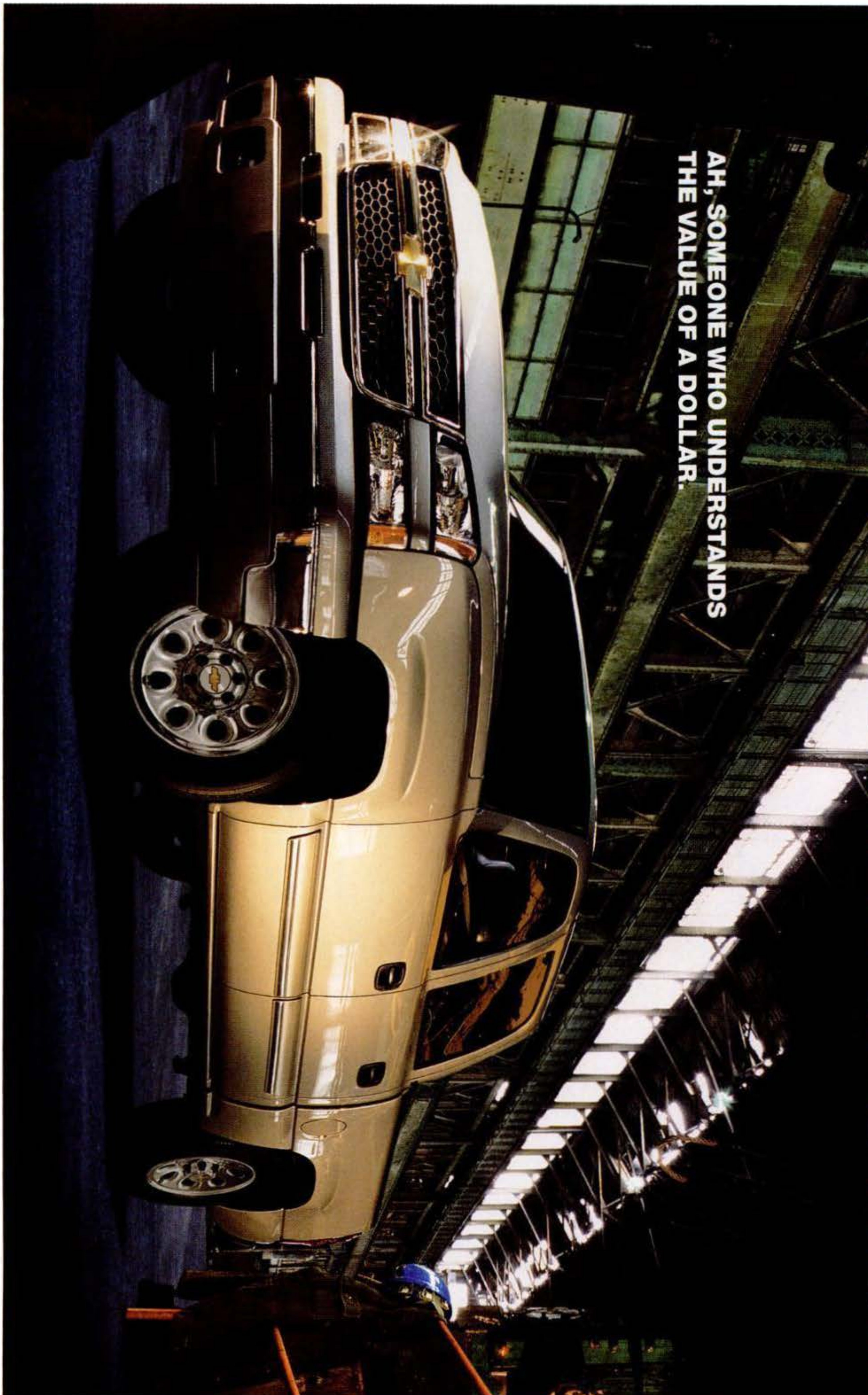
IT'S A FEAT JUST TO GET TO A PLACE LIKE THIS. WHICH
MEANS YOU WANT A LIGHT THAT LETS YOU SEE WHAT'S
REALLY THERE. IT ALSO MEANS, IF YOUR LIGHT QUILTS,
YOU'RE DEAD. BECAUSE THIS FAR UNDERGROUND, YOU
CAN'T MOVE SAFELY, YOU CAN'T FIND YOUR WAY OUT,
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YOUR HEALTH P.42
YOUR CAR P.44
YOUR GADGETS P.46

20 INCREDIBLE INVENTIONS

THAT ARE SET TO CHANGE YOUR WORLD

FROM A CAR THAT CAN'T CRASH to a bathroom that cleans itself to a gadget that gives you photographic memory, technology is poised to improve every aspect of your life. To find the ideas featured here, we looked at the most promising lab work going on today, then projected where that tech will be 5, 10 or 25 years down the road. Our conclusion: It will make your life easier, safer—and more fun. For the best of what's to come, read on.


YOUR HOME P.48
YOUR GEAR P.50

2021

YOU'LL GROW A NEW

Researchers are zeroing in on a long-sought goal of human healing: organs that can regenerate

ALTHOUGH DOCTORS may someday heal weakened body parts by infusing them with stem cells that develop into specialized tissues, coaxing the body's own cells to become self-repairing would be an even bigger biological coup. What if we could simply prompt damaged organs to repair themselves?

Glenn Larsen, the chief scientific

be the first to take the revolutionary step of harnessing these natural processes to grow new tissue where and when it is needed. With restored heart-muscle function, patients would be able to resume swimming, running or just gardening much sooner. They would also be less prone to congestive heart failure, which kills more than

heart cells will begin to develop, filling in the dead-tissue gaps. The result: Within a few weeks, heart-muscle function will be permanently restored.

Human trials of Hydra's cardiac drugs won't begin for another few years, but experimental evidence already points to the treatment's potential. Last year, Hydra researchers induced heart attacks in rats, then dosed them with CRF-1, one of the protein compounds under investigation, for 10 days. A month after their heart attacks, the rats receiving treatment demonstrated heart-muscle function that was about 20 percent better than that of the control group.

"Can we get regeneration to work? The answer is yes," says Mark Keating, a Hydra co-founder and the head of human genetics at the Novartis Institutes for Biomedical Research in Cambridge, Massachusetts. "By releasing the genetic brakes, so to speak, it's possible to get different types of cells to proliferate." —Elizabeth Svoboda

"BY RELEASING THE GENETIC BRAKES, IT'S POSSIBLE TO GET DIFFERENT TYPES OF CELLS TO PROLIFERATE."

officer at Hydra Biosciences in Boston, has been chasing this regenerative dream for the past four years. With help from a team of Harvard University researchers, Larsen and his colleagues are developing protein-based drugs that encourage the regrowth of muscle tissue that has died after a heart attack.

"The heart is constantly secreting chemical factors it needs to maintain itself," Larsen explains. "All we're doing is trying to enhance that." Fair enough, but his company is likely to

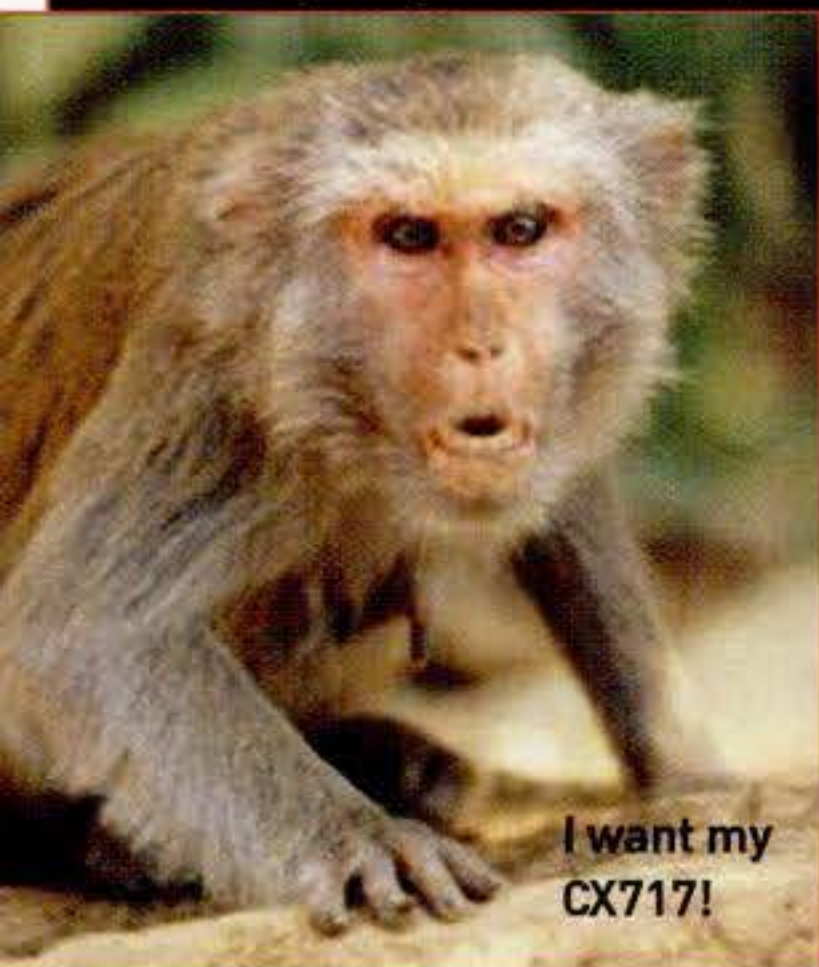
50,000 Americans every year.

The strategy Larsen envisions is simple, though groundbreaking. Patients will use a self-delivery device, such as an inhaler or supersonic drug gun, to propel the regenerative protein molecules into their bloodstream. The circulating molecules will bind to receptors on the surfaces of their damaged heart-muscle cells, touching off a chemical reaction that mutes the activity of genes inhibiting cell division. Once this biological switch has been thrown, new

10 YEARS: 72-HOUR NoD0z

STAY AWAKE—AND ALERT—FOR DAYS

Eye-opening stimulant Provigil is today's wake-up drug of choice, but the experimental compound CX717 may help the bleary stay awake and productive for days—that's right,



I want my CX717!

days—on end. In tests at Wake Forest University last year, the drug, which revs up the activity of brain neurotransmitters, kept rhesus monkeys up and about for as long as 36 hours. Afterward they performed better in alertness tests than non-drugged monkeys did after a full night's sleep. Best of all, there were no lingering side effects.

20 YEARS: BUG-BASED WEIGHT LOSS

SLIM-FAST—WITH A BACTERIA BOOST!

Thanks to Washington University researchers' recent identification of naturally-occurring intestinal bacteria that influence fat storage, bacteria-containing shakes may emerge as a slim-down solution. To maintain the ideal gut-flora balance for optimum weight loss, dieters would chug a shake or two a day, possibly containing bacteria harvested from the stomachs of slim people.

25 YEARS: MALE BIRTH CONTROL

WOMEN DEVELOP A LOVE OF WORMS

Researchers at Keele University in England think they've found the basis for equal-opportunity birth control: a chemical derived from a tapeworm found in freshwater fish. The compound—potentially administered in patch or pill form—suppresses pituitary-gland function, preventing the secretion of sex hormones at levels necessary for either egg or sperm production.

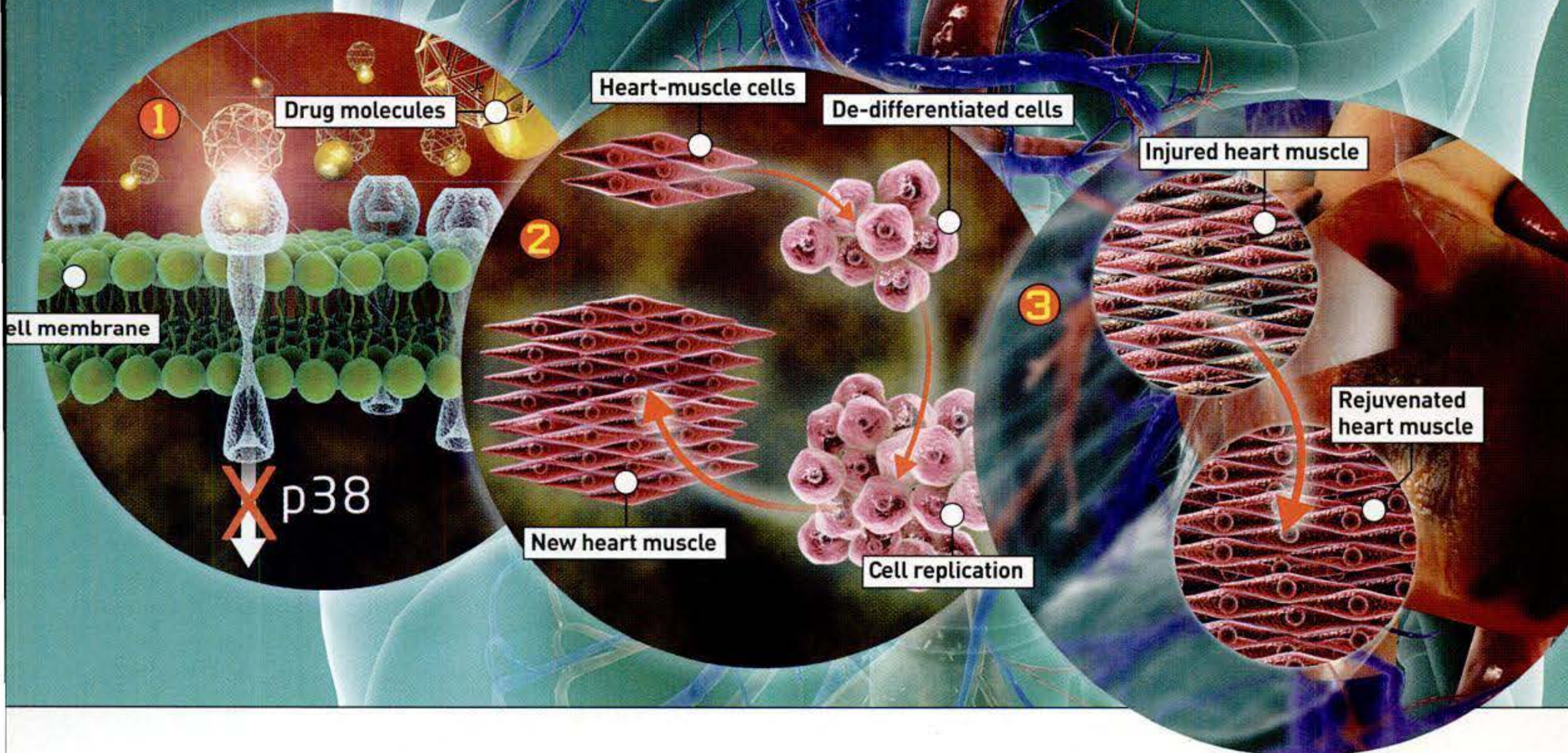
HEART

themselves from within

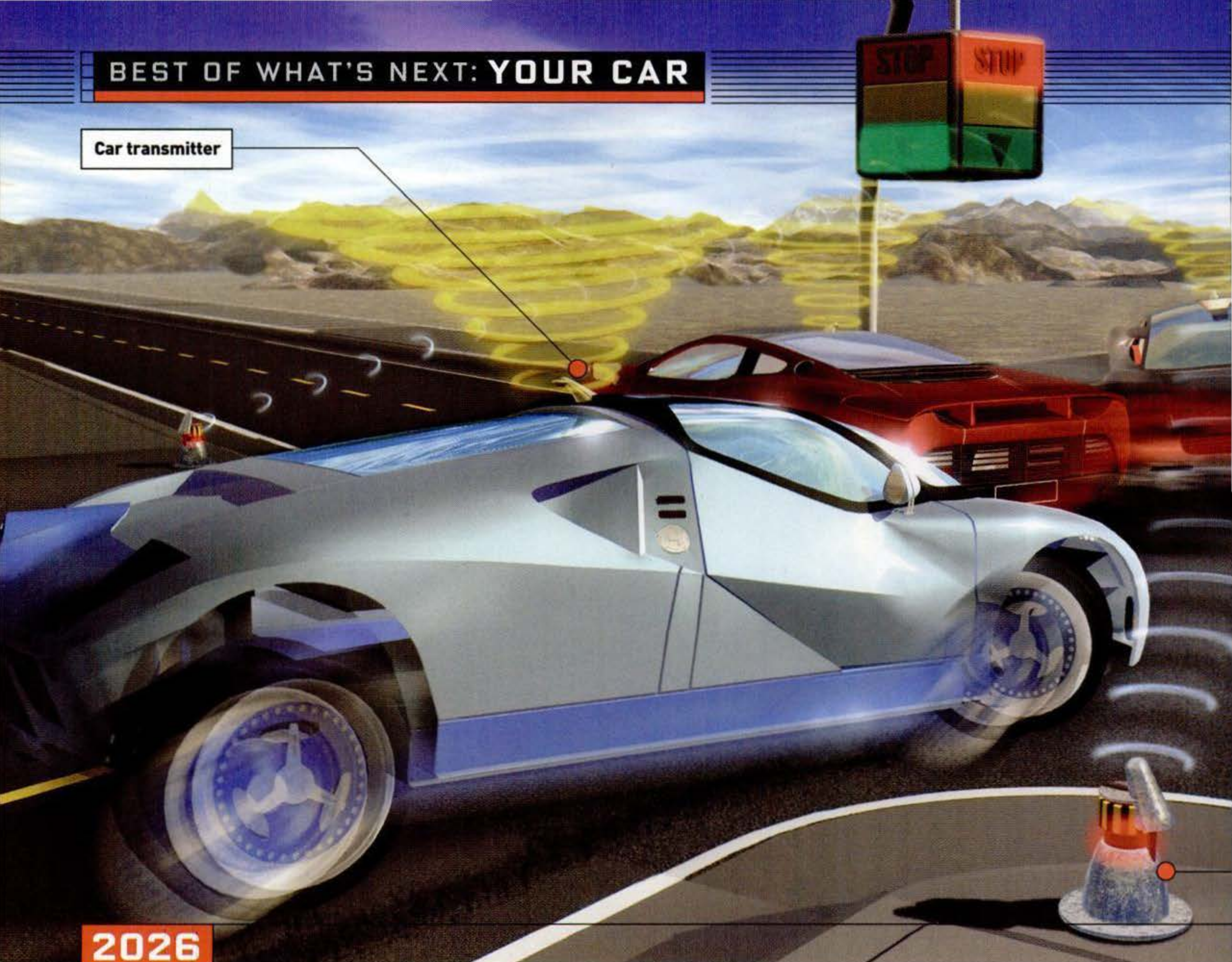
SHOT TO THE HEART

Cardiac patients could dose themselves using a pain-free, needle-less gun that employs supersonic speed to propel a regeneration drug into the skin.

1. The protein-based drug molecules penetrate heart-muscle cells and suppress production of an enzyme called p38 that ordinarily limits tissue growth.
2. With p38 turned off, mature heart-muscle cells de-differentiate, which allows them to multiply rapidly and mature into new heart muscle.
3. The dead tissue is replaced by brand-new healthy tissue.



Car transmitter



2026

YOU'LL OWN A CAR THAT CAN'T

An accident-free future is a matter of connecting the dots between today's cutting-

BLINDING RAIN. Careening traffic. Distracted drivers. There are lots of reasons why car crashes are America's leading cause of accidental death. And one way that most accidents could be prevented: with cars that predict a coming collision—and take action to stop it.

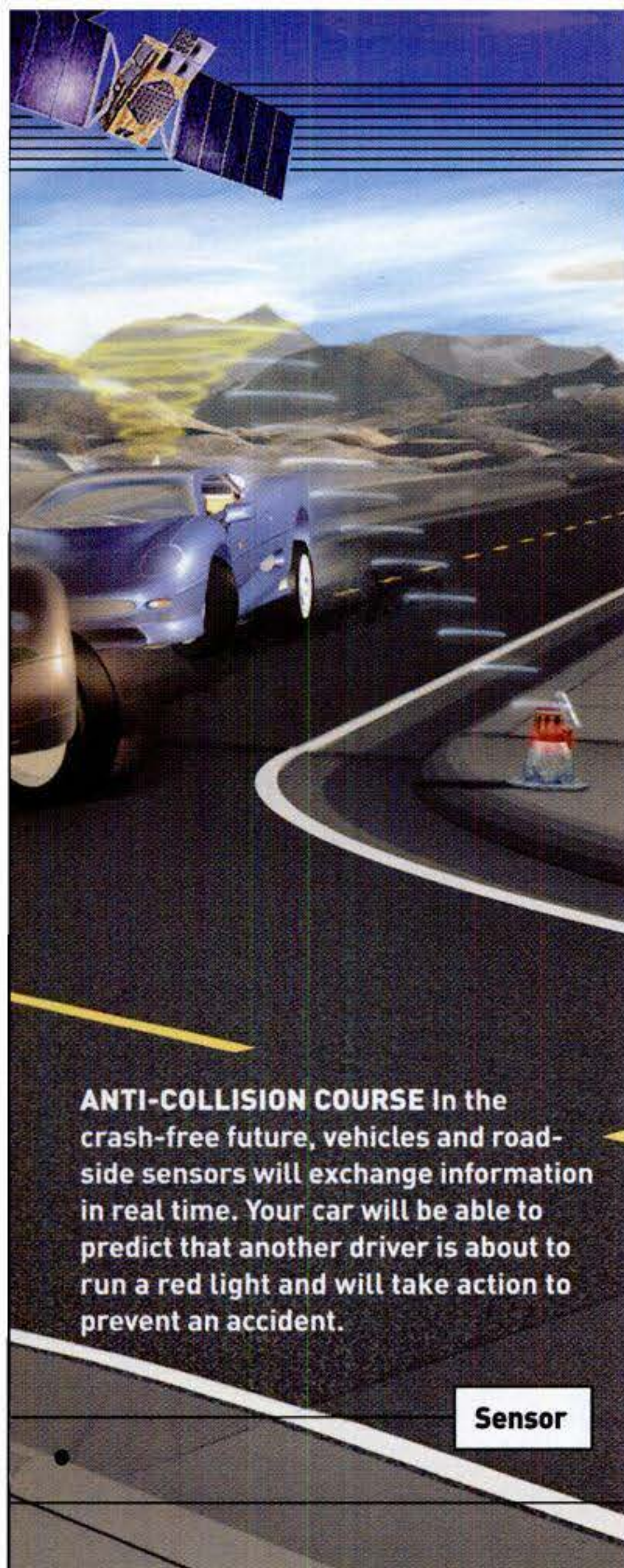
The key to the crash-free future is vehicle-to-vehicle communication, or V2V. Some advances that would make V2V possible are already on the way. Increasingly sophisticated GPS will soon allow you to pinpoint your vehicle's precise location at any given moment, and stability-control systems that track your car's speed and direction are even now feeding such information

to onboard computers. The primary remaining challenge is finding the means to communicate that data to cars in your projected path.

To encourage the development of V2V, the Federal Communications Commission has cleared the 5.9-gigahertz band for dedicated short-range communications (DSRC) among cars, other cars, and roadside transceivers. Volkswagen's Electronics Research Laboratory—which helped build the autonomous VW Touareg that won last year's Darpa Grand Challenge robotic race—recently fitted two Jettas and two Audi A3s with DSRC units and used V2V to successfully run them,

platoon-style, through San Francisco. "The technology is doable right now," says Carsten Bergmann, a VW lab manager. (Of course, getting the right data to the right car at the right time calls for fiendishly complicated threat-detection algorithms that are far easier with four cars than with hundreds of them.)

General Motors has gone one better than VW with a demonstration DSRC-equipped Cadillac CTS that stops itself to avoid accidents. Its enhanced stability-control system predicts where it's headed—like, into the rear end of another DSRC car stopped in the middle of the road—and prompts the onboard computer to apply the brakes



ANTI-COLLISION COURSE In the crash-free future, vehicles and road-side sensors will exchange information in real time. Your car will be able to predict that another driver is about to run a red light and will take action to prevent an accident.

Sensor

CRASH

edge technologies

without any input from the driver. The effect is very cool. It's also a little spooky, and many doubt that live-free-or-die Americans will ever sign off on fully autonomous vehicles.

Luckily, engineer Tomiji Sugimoto and his team at Honda R&D are working on a human-machine interface that will keep drivers in the loop. Head-up displays are a no-brainer. But Honda is also developing what's called haptic feedback, such as shaking steering wheels and pedals that vibrate. "We're talking about a system that acts like a backseat driver," Sugimoto says. Except it's a backseat driver that's always right. —Preston Lerner

FACING PAGE: DOUG CHEZEM; THIS PAGE: STEPHEN ROUNTREE

5 YEARS: SELF-DIAGNOSING CAR

FIX YOUR RIDE BEFORE IT BREAKS

Right now, BMW sedans feature teleservice: Your car sends a message to your mechanic when it's time for an oil change or other prescheduled service. But in the next few years, a company spokesperson says, "teleservice will become telediagnosics," and your car will e-mail you when, say, one of your fuel injectors is malfunctioning or when it detects trouble with the alternator.

5 YEARS: SMART GLASS

USE YOUR WINDSHIELD TO DIAL BACK THE SUN

You may finally be able to stop fiddling with your visor. The French company Saint-Gobain has developed an electrochromic glass that is infused with tungsten wires and darkens at the turn of a dial. The wires charge an oxide coating on the glass that blocks both ultraviolet rays and the sun's heat. Ferrari is using the material in the roof of its limited-edition 2005 Superamerica; expect to see the technology on your own sports car in less than a decade.

10 YEARS: JOY-DRIVE

LOOK, MA, NO STEERING WHEEL!

Advances in computer processing have led automakers to develop new and better controls, like electronic antilock brakes, that minimize driver error. Mercedes has taken the trend to its logical conclusion with an SL-Class concept car controlled by a joystick. Their "sidesticks" are more precise and intuitive than conventional steering wheels, Mercedes engineers say, but the public isn't yet ready to let go of the wheel. Our bet: When today's kids reach driving age, they will be.

HOW IT WORKS

Tire treading made of electroactive polymer changes shape automatically as road conditions change.

Regular tire rubber surrounds the electroactive polymer segments.

An assembly of steel wires transmits voltage from the engine to the electroactive polymer.

A conditions sensor detects changes in the road.

15 YEARS: MORPHING TIRES

ON-ROAD OR OFF-ROAD? HOW ABOUT BOTH?

Drivers will ultimately be able to swap smooth, high-performance road tires with knobby dirt treads in an instant, thanks to the powers of electroactive polymers. The material, which has a muscle-like ability to change shape with an electrical charge, is now the hottest thing in robotics. Industrial designer James Owen thinks the same tech can be used on the road, siphoning power from the hybrid-electric motors he believes will soon become ubiquitous. Michelin agrees: Owen's plan won an award in the company's 2006 design challenge.

2021

YOU'LL ENJOY TOTAL

Software will allow you to easily carry years' worth of searchable memories—

HUMANS NATURALLY HAVE the power to remember almost two bits of information per second, or a few hundred megabytes over a lifetime. Compared with a DVD movie, which holds up to 17 gigabytes, that's nothing. Worse, you might easily recall the 40-year-old dialogue from *Hogan's Heroes* yet forget your mom's birthday. Or memorize reams of sports stats while spacing out on work you completed just last week.

It's a problem that's been bothering Gordon Bell for almost as long as he can remember. In 1998 Bell, a senior researcher at Microsoft, began digitally capturing his entire life for a project he calls MyLifeBits. First, he scanned his old photographs, research documents and notes. He began recording his meetings and phone calls and cataloguing his new photos and movies he saw. Every e-mail exchange he had was digitally archived, and he started using the company's prototype SenseCam, which he wears around his neck, to automatically snap photos throughout the day.

Bell now documents about one gigabyte of information every month,

all of which is stored in a searchable database on his PC. His is a highly manual process, but he expects that in as few as 15 years it will be common to carry nearly all our "memories" around with us in a single device that will automatically record the sound and video of our daily activities, creating an inventory of the conversations we have, the faces we see and the articles we read. That data would be tied to communications that are already tracked electronically, like e-mail and event calendars, as well as TV shows, movies and other media we take in. The end

than 30 seconds. Soon, when searching through meeting notes, for instance, photos of people attending those meetings and their contact information will appear side by side. The effort could be pushed along by Columbia University researchers who are using statistical-analysis programs to automatically sort hours of recorded audio by time and location (office, café, etcetera). Next, they'll tackle speaker recognition, which would allow for categorizing and searching conversation by who's talking.

Meanwhile, miniaturization and the falling cost of image sensors and data

A SINGLE DEVICE WILL AUTOMATICALLY RECORD THE SOUND AND VIDEO OF OUR DAILY ACTIVITIES.

result: on-demand total recall.

The biggest challenge to Bell's vision is developing the software required to search your memory database effectively. So far, MyLifeBits pulls together more than 20 data types to link various memories to one another. Using a full-text search, Bell tracks down what he's looking for in no more

storage will soon allow for unobtrusive recording, as well as on-person storage, of several terabytes—which means a vast upgrade in personal processing power. "Having a surrogate memory creates a freeing and secure feeling," Bell says of his self-experiment. "It's similar to having an assistant with perfect memory." —Michael Myser

5 YEARS: DIGITAL WINGMAN

DOES SHE LIKE YOU? ASK YOUR CELLPHONE

"You need advice," says Anmol Madan of MIT's Media Lab. "Your cellphone could do it." For the past year, Madan has been developing "socially aware" software that uses algorithms to analyze activity, stress and empathy in the human voice. The software (one version is dubbed the Jerk-O-Meter) determines if you sound suave or boorish—meaning, if you're about to score or strike out. A prototype won raves at speed-dating rounds, and Madan says it could be commercialized soon.

10 YEARS: DNA SCANNER

WHAT IS IT? CHECK ITS GENOME

Paul Hebert is working to put the field guide on the endangered-species list. The Canadian zoologist is developing a handheld genetic "bar code" reader that will test a small sample of DNA against a database, letting you know what you're looking at—or if you've stumbled across a new species altogether.

Know Kermit's real name.



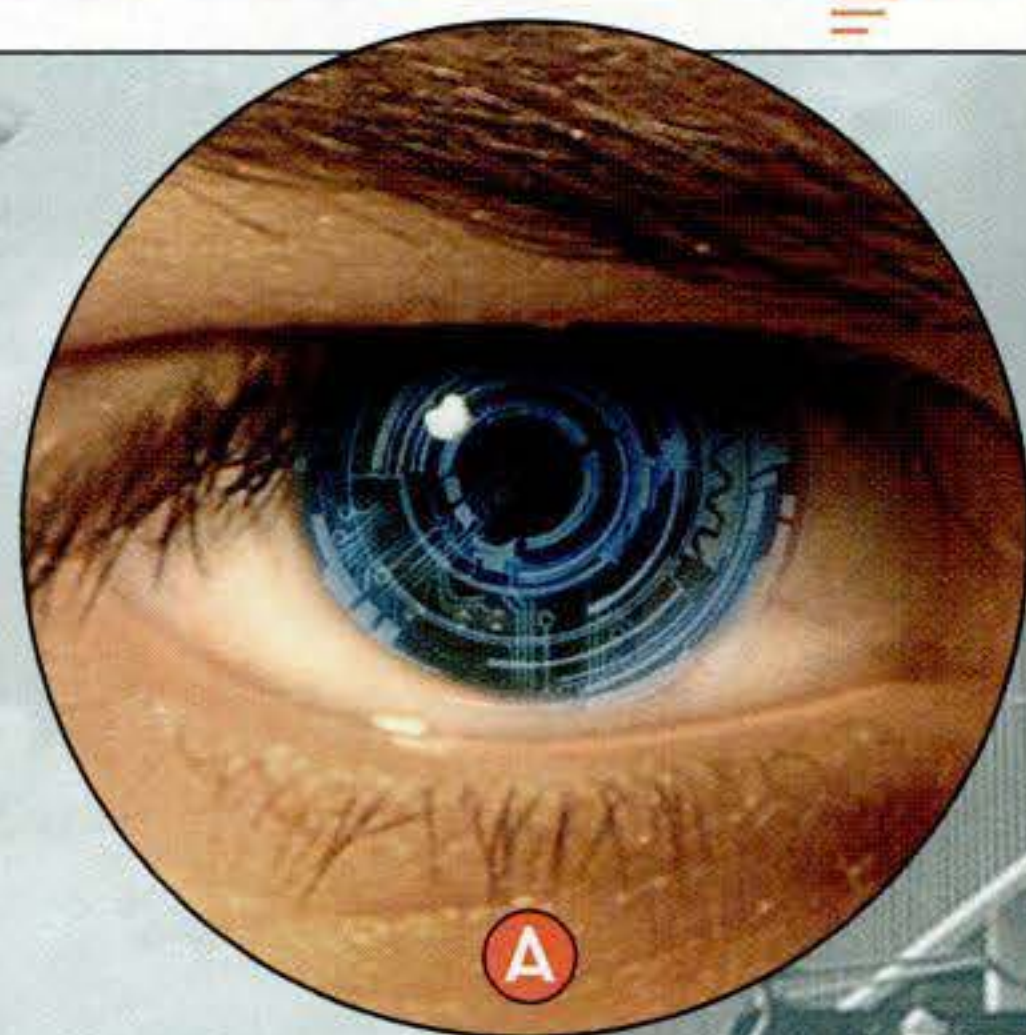
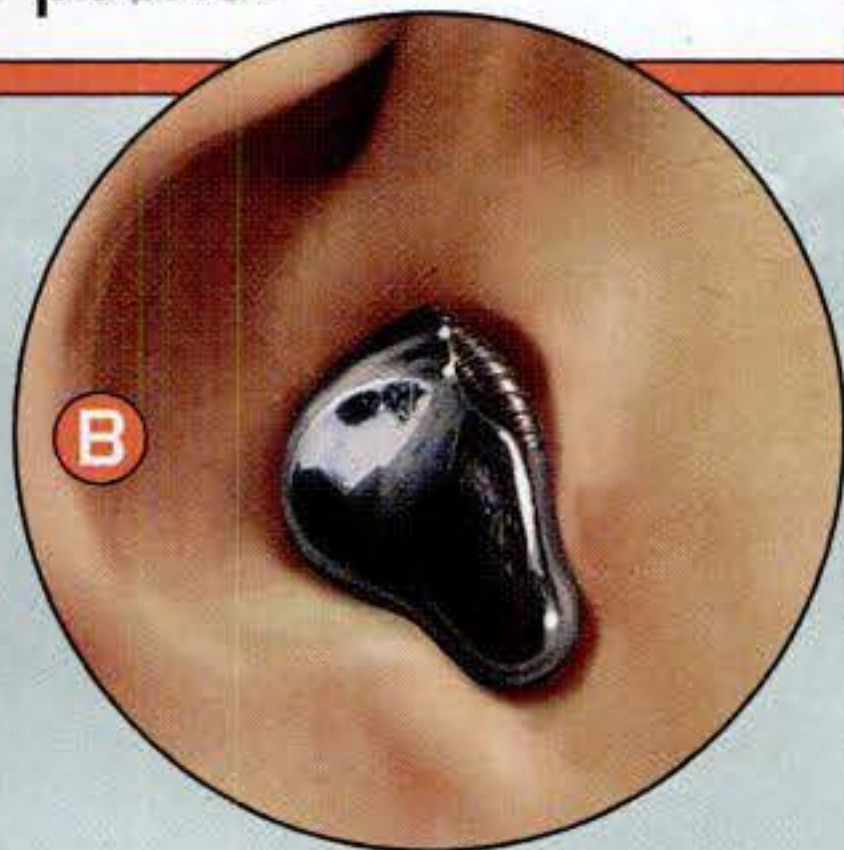
10 YEARS: E-NEWSPAPER

READING THE MONITOR

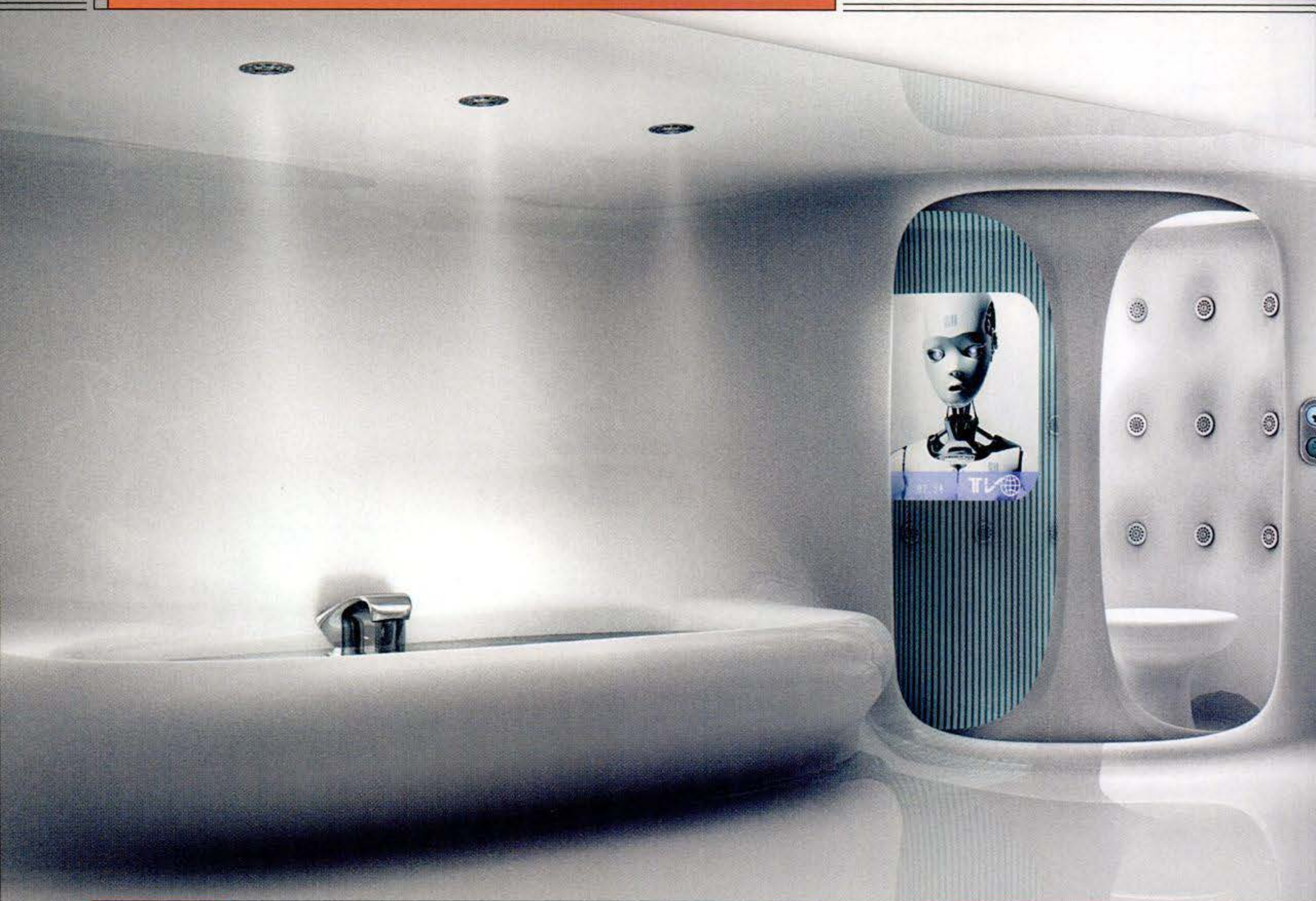
Forget buying the newspaper for your commute every morning. E-paper technologies will eventually allow for flexible screens the size and weight of a slim magazine that could be used for all your on-the-go reading. The company E Ink has already developed a type of rigid e-book that uses power only between virtual page turns and that's easy to read, even in direct sunlight. The next step is shrinking the technology down so that you can easily fold your "paper" into your back pocket just like the real thing.

RECALL

in your pocket



PROCESSING POWER Upgrading our memory is a matter of improving our recording and retrieving abilities. At the current pace of miniaturization, camera components could be made tiny enough to fit in a contact lens **(A)** in just a few years. A high-precision microphone could fit in your ear **(B)**. And the data could be downloaded to a searchable hand-held gadget **(C)**.

**2011**

YOU'LL NEVER HAVE TO CLEAN

Nanotechnology could soon allow you to sanitize your bathroom with a flip of a

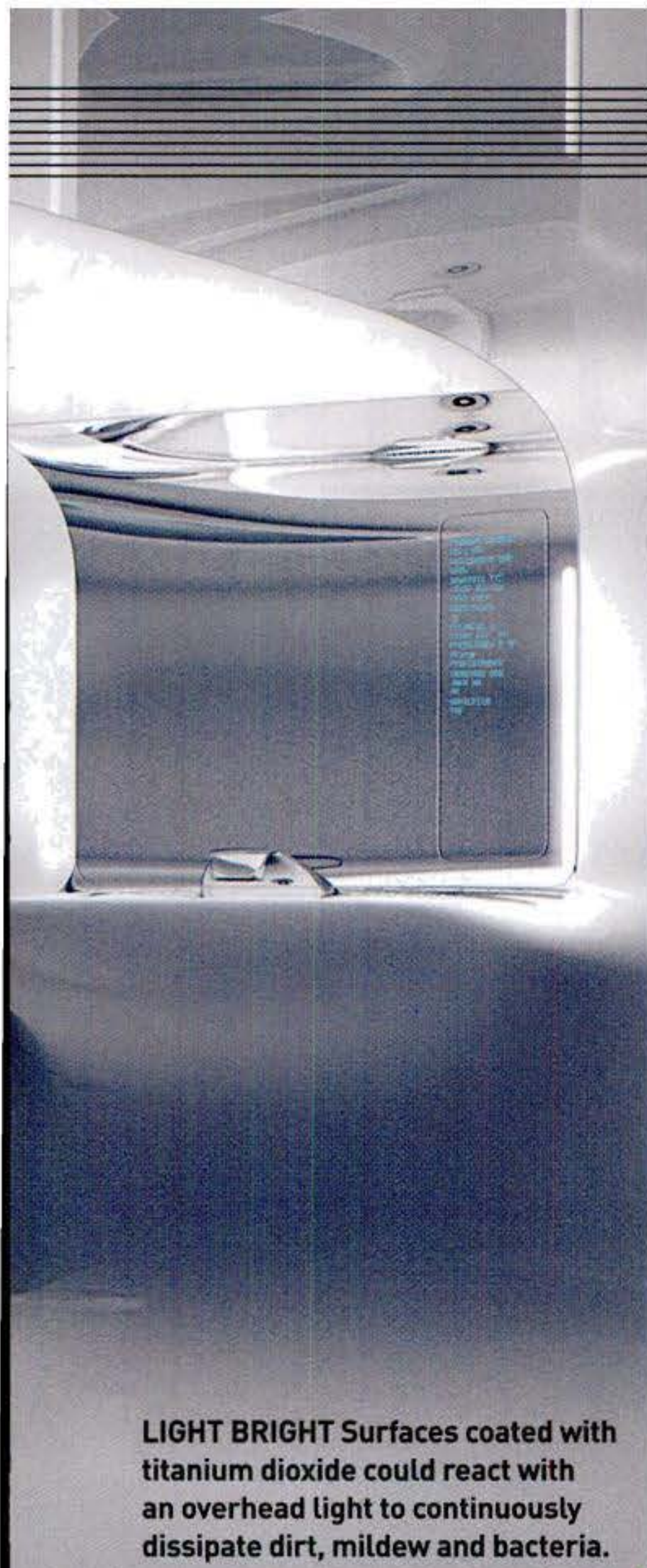
NOT SO LONG AGO, chemical engineers discovered how to use titanium dioxide to keep buildings free of discoloring pollution. Landmarks such as the virgin-white Dives in Misericordia Church in Rome and the Marunouchi Building in Tokyo were among the first to be coated with the semiconductor, which breaks down organic molecules—including those in grime and pollution—when exposed to light and water and then releases them into the air. Soon after, TiO_2 -based self-cleaning products, like SunClean windows from PPG Industries, hit the home market.

But to bring the technology *inside* the home, where it could eliminate the

need for hours of tedious housework every week, researchers must overcome a major limitation: The technology currently responds only to ultraviolet light from the sun. Enter materials engineer Michael Cortie and his colleagues at the Institute for Nanoscale Technology in Sydney, Australia, who are working to perfect a coating that can respond to the visible spectrum—that is, the light-bulb hanging from your bathroom ceiling. So long, toilet brush.

Two chemical qualities make TiO_2 an all-purpose cleaner. First, the chemical is light-sensitive. When it is struck by photons, it reacts with air and water vapor to accelerate the breakdown of

organic materials. It's a bit like an artificial photosynthesis, but whereas plants use sunlight to break down carbon dioxide and turn it into oxygen, TiO_2 uses light to turn scourges like grease and bacteria into carbon dioxide, hydrogen and other by-products that escape into the air. Second, TiO_2 is hydrophilic, or water-loving. Instead of repelling water—as tiles and glass do when they encourage water to bead—materials coated with TiO_2 attract water, causing it to “sheet” across the surface, taking by-products and over-size particles with it. The result: Guck rarely gets a chance to build up, and it washes away easily when it does.



LIGHT BRIGHT Surfaces coated with titanium dioxide could react with an overhead light to continuously dissipate dirt, mildew and bacteria.

10 YEARS: SMART FRIDGE

STOP LOOKING FOR THAT CHEESE

Radio-frequency identification (RFID) tags are already being used to track large items within stores. Before long, they could also help you track your own inventory. Companies like Royal Philips Electronics are working to make printable plastic RFID tags that are cheap enough to become ubiquitous in food packaging. Once that happens, a scanner-equipped refrigerator could record everything stuffed into it. You'd be able to check on your pickle supply from the grocery store with your cellphone, use your computer to find recipes that call for just the ingredients you have on hand—and know for sure how long that hunk of cheese has *really* been in there.



RFID is about to get cooler.

10 YEARS: ROBO GARAGE

STORAGE SPACE GOES THROUGH THE CEILING

"Space is the final frontier," opines Ted Selker, a computer scientist at MIT. He's not talking about the cosmos but about optimizing space in your home by roboticizing storage. First stop: the garage. Inspired by a robotic warehouse at IBM, Selker is designing a storage setup that would turn your unused garage ceiling into a big toolbox.

20 YEARS: INVISIBLE TV

TURN OFF THAT WALL!

Think you've seen flat-screen? Advances in organic light-emitting diode (OLED) displays will eventually allow large-screen TVs a fraction of an inch thick to unobtrusively blanket your walls. Flexible OLED screens are already possible; the next step is overcoming the current tech's short life span. The payoff: a paper-thin TV that disappears into the wall when the game's over.

THE JOHN

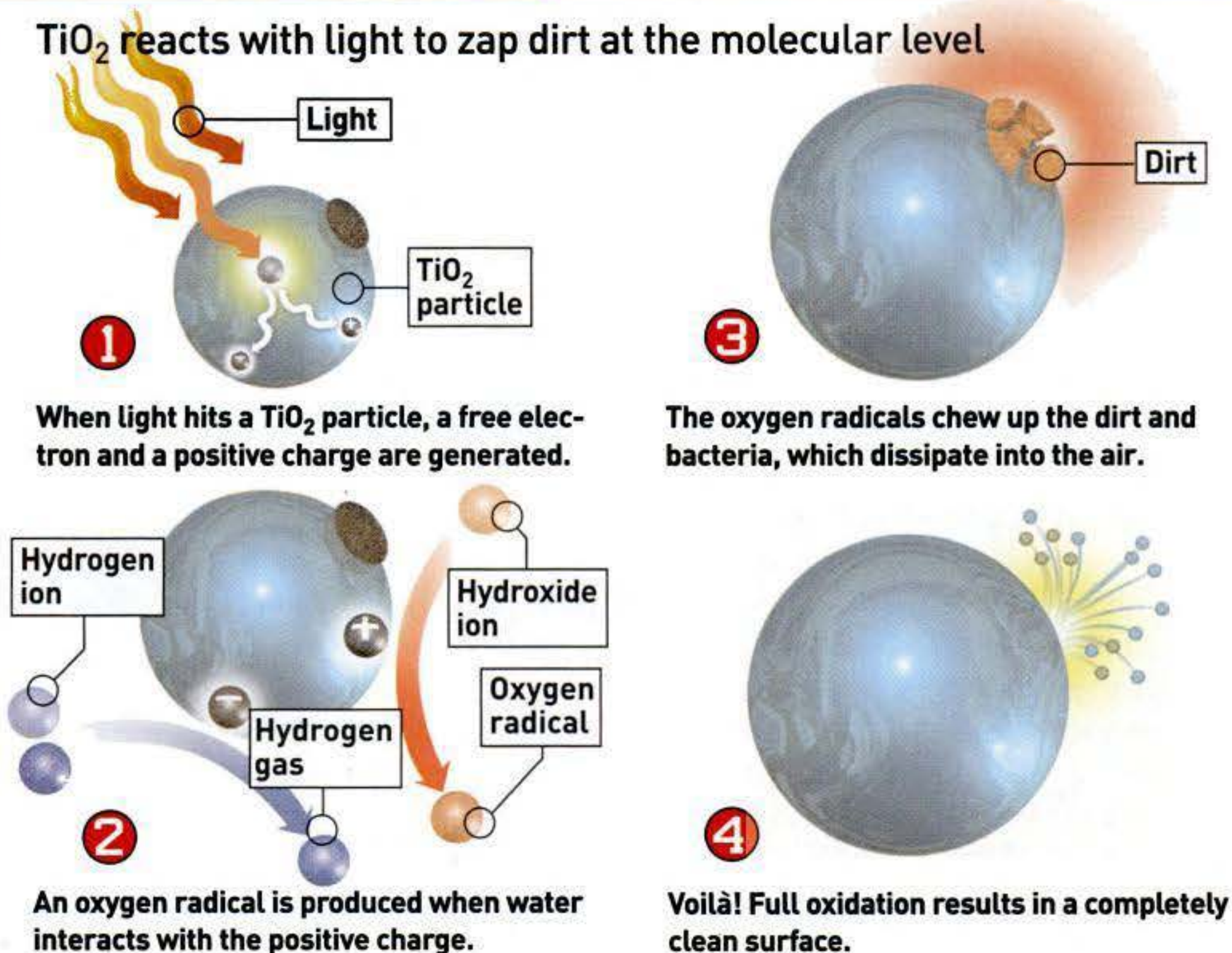
light switch

What's needed to take the sun out of the equation? Cortie says TiO_2 's atomic structure must be changed so that it's compatible with the energy spectrum of visible light—no easy task. Plus, that alteration must be made without disrupting its chemical inertness; otherwise, it might not stay put on whatever it's meant to coat.

Cortie is undeterred. And he's convinced that TiO_2 has a home market. "Just look at the range of antibacterial sprays and wipes out there," he says. "People are demons for cleanliness. If it's a product that doesn't need to be sprayed—that's just always *there*—even better." —Ethan Todras-Whitehill

HOW IT WORKS

TiO_2 reacts with light to zap dirt at the molecular level



2031

YOUR JACKET WILL THINK

Morphing materials will allow for fabrics that change their properties on the spot. The trick: mimicking nature

MATERIALS SCIENTISTS at Sandia National Laboratories in Albuquerque, New Mexico, have an unusual approach to developing fabrics of the future. They're looking at fish, and they're looking very, very closely.

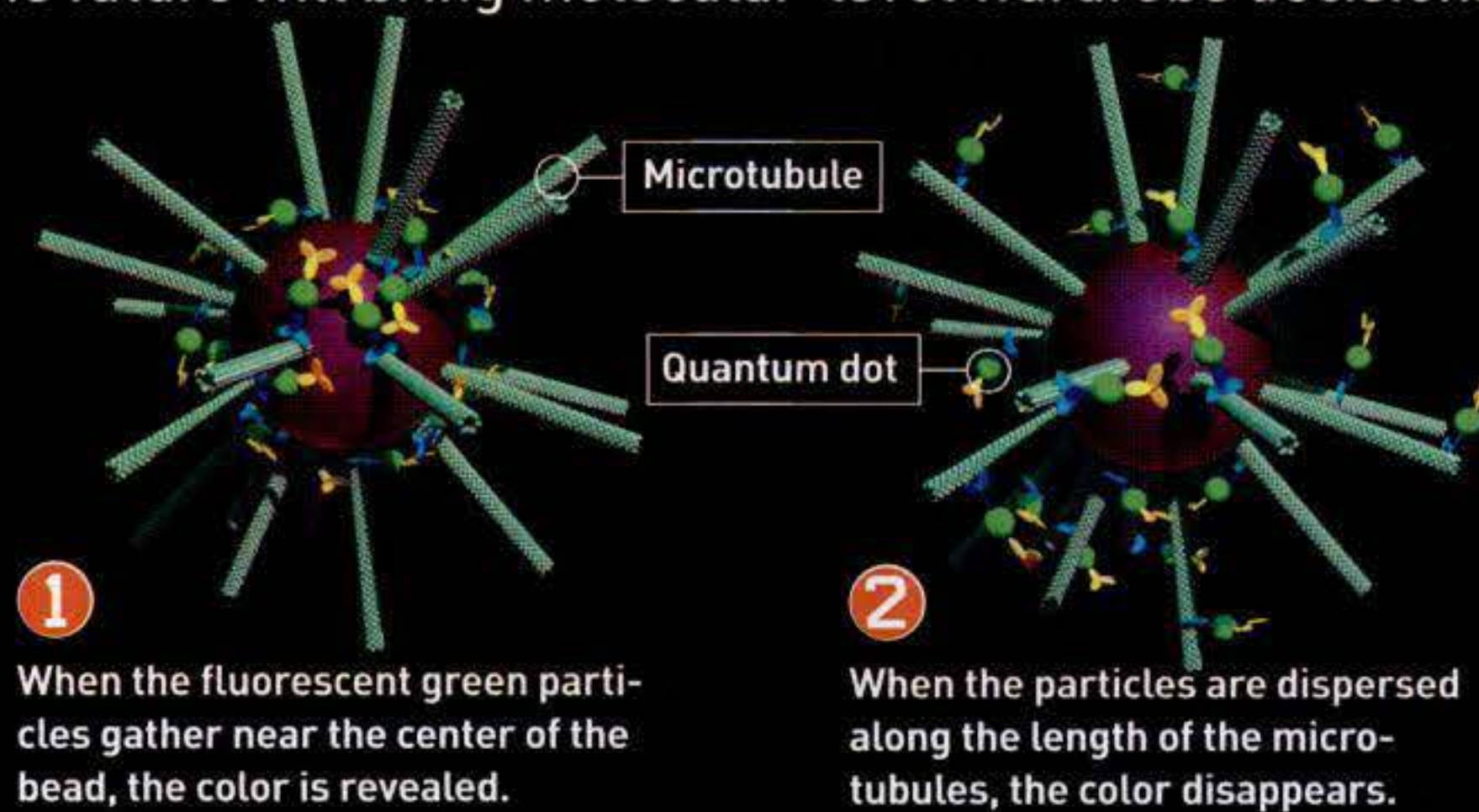
"In fish, we have molecules moving at the nanoscale that translate into something we can see at the macro-scale," says Sandia molecular biologist George Bachand of the color-change process many fish use to camouflage themselves against predators. Reproducing that process in the lab, he says, "offers the potential for [man-made] materials to take on unique properties that living materials possess, like self-healing or the ability to change color."

"Morphing" fabrics are hardly novel. Nike already sells high-performance clothing made from fabrics that become more breathable as the wearer heats up and sweats. But whereas existing technology involves structural changes—Nike likens it to a bird ruffling its feathers—future fabrics could alter on a molecular level in response to external stimuli such as temperature or light. Whereas current fabrics are static, future designs could depend on nano-level movements.

Here's a quick primer: In fish, light sets off biochemical changes that trigger the movement of motor proteins that carry pigment granules. The positioning of those granules—together or dispersed—determines the fish's color. The Sandia team is trying to mimic that process, called active transport, in the lab. The researchers' nanoscale setup resembles an overcrowded pincushion

HOW IT WORKS

The future will bring molecular-level wardrobe decisions



[see "How It Works," above]. Motor proteins carrying quantum dots (fluorescing particles) move along hair-like filaments called microtubules (the pins) that are anchored by a micron-size bead (the cushion). When the quantum dots move, a change in color results. The process is akin to a drop of black ink on a piece of paper. "As the drop radiates out, it colors the paper gray," Bachand

explains. "If the ink were to pull back into the dot, the paper would be white again." Similarly, when the motor proteins disperse, the color lightens; when they condense at the center, near the bead, it darkens.

The technology is still young. So far, scientists have triggered only changes visible through a microscope. To orchestrate a macroscopic change, they need

FOR ITSELF

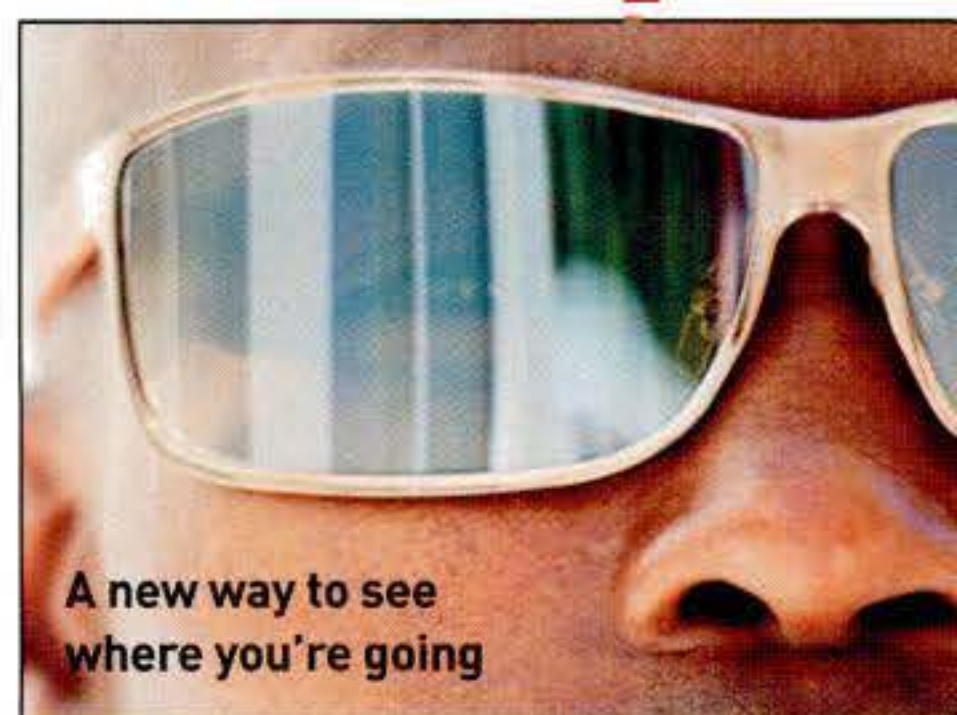


GLOW AND GO
Understanding how fish camouflage themselves could lead to fabrics that change in response to light—for instance, a bike jacket that goes from black to neon green as a car approaches.

more pincushion arrangements. Now they can produce up to 100 of them at a time; Bachand estimates that they will need between 10,000 and one million to effect a change visible without a microscope. “Currently, we engineer materials component by component, like building a watch,” he says. “We’re trying to understand how to take huge numbers of molecules and manipulate them in parallel so they’ll self-

assemble into highly complex structures.”

If things go as planned, the future could see military fatigues that respond to light stimuli and automatically camouflage themselves to match sand or snow. Or the headlights of an oncoming car could trigger neon stripes to appear on a black motorcycle jacket for safe night riding. And you might look more like a fish than you ever imagined.—*Melissa Wagenberg*



A new way to see where you're going

5 YEARS: **MAP-HEAD**

SHADES THAT GIVE YOU A HEADS-UP

Today's cutting-edge sunglasses are Bluetooth-enabled to support cell-phone service and wireless tunes. Next up: shades that screen images, including maps streamed from a GPS device. Microvision in Redmond, Washington, is already using head-up displays in helmets made for military tank commanders. The next challenge is miniaturizing that setup for glasses, which requires making the projector (now the size of a box of Tic Tacs) one tenth as large.

10 YEARS: **INK-FOOT**

FIT TO PRINT

As a result of a developing process called laser sintering, your future visit to Foot Locker will resemble a podiatrist's visit more than a shopping trip. Your foot will be scanned and your stride recorded, and the data will be fed into a laser printer that will build your shoe by layering out nylon powder the way an inkjet lays out ink. Prior 2 Lever Ltd. in London is now using the tech to “print” sneakers for pro soccer players. Mass-customization, the company says, is all about automating the evaluation process.

PETER BOLLINGER

WINNING—AND LOSING— THE FIRST



ADVANCED WARFIGHTERS New technology is rewriting combat-strategy books. This page, main image: a reflected view of the Blue Force Tracker (BFT) networking tool. Insets, clockwise from right: RG-31 Cougar armored vehicle, M1126 Stryker infantry carrier, Link 16 networking system. Facing page, from left: BFT in action, Raven surveillance drone, MarcBot bomb-detection robot.



WIRED WAR

U.S. FORCES IN IRAQ ARE WAGING A PIVOTAL CAMPAIGN IN MODERN WARFARE—COMBAT ON THE FIRST “NETWORKED” BATTLEFIELD. ONE PROBLEM: THE ENEMY HAS A FEW NETWORKS OF ITS OWN

BY NOAH SHACHTMAN, WITH REPORTING IN IRAQ BY DAVID AXE



THE MISSION CHANGES for Charlie Company seconds after the soldiers roll off the base. The dreary night patrol around Balad, a shambling Shi'ite town in north-central Iraq, has just been canceled. It's time instead to hightail it west, to the Sunni neighborhood of Ad Duluiyah. "Alpha Company is taking direct fire," a voice crackles over the radio in First Lt. Brian Feldmayer's Humvee. "I need you to expedite."

Feldmayer, a 24-year-old Virginian with the smooth cheeks of a teenager, tries to straighten out a smile of excitement and nervous anticipation. He stares into the glowing touchscreen at his left elbow. The Army calls this system Blue Force Tracker, or BFT. It's a militarized version of an automotive navigation aid, enhanced to track—and communicate with—other coalition vehicles. Firmly tapping the screen with

his gloved fingers, Feldmayer calls up the grid coordinate just radioed to him and marks it with white crosshairs. Zooming out, he studies the roads leading there. He plots a course, then radios the rest of his patrol—two tanks, three more Humvees and an Iraqi Army Nissan truck—with orders to haul ass.

THREE KEY FACTS

- 1 Networked combat works**, when the right people are plugged in.
- 2 Frontline soldiers** not only have no network; many have no radios.
- 3 Insurgents create** ad hoc networks using cell-phones and the Internet.

It doesn't take long for Feldmayer to regret it. Nobody on the patrol knows the roads, and he's wary of getting lost. Ordinarily, on his terminal, he should be able to track Charlie's other BFT-equipped vehicles and follow the route they're taking. But the satellite signal that feeds BFT is weak tonight. And the lieutenant doesn't exactly trust the system's maps: It can take the Army's cartographers up to a year to update them; in Iraq, a lot can change by then.

Feldmayer curses loudly. He calls his command post for help, but he hears only static.

This wasn't how the 75-man Charlie Company was supposed to operate. It's part of the Army's first "digital division," the Ft. Carson, Colorado-based Fourth Infantry Division (4ID), outfitted with the military's latest gear: new tanks, firearms and armored vehicles,

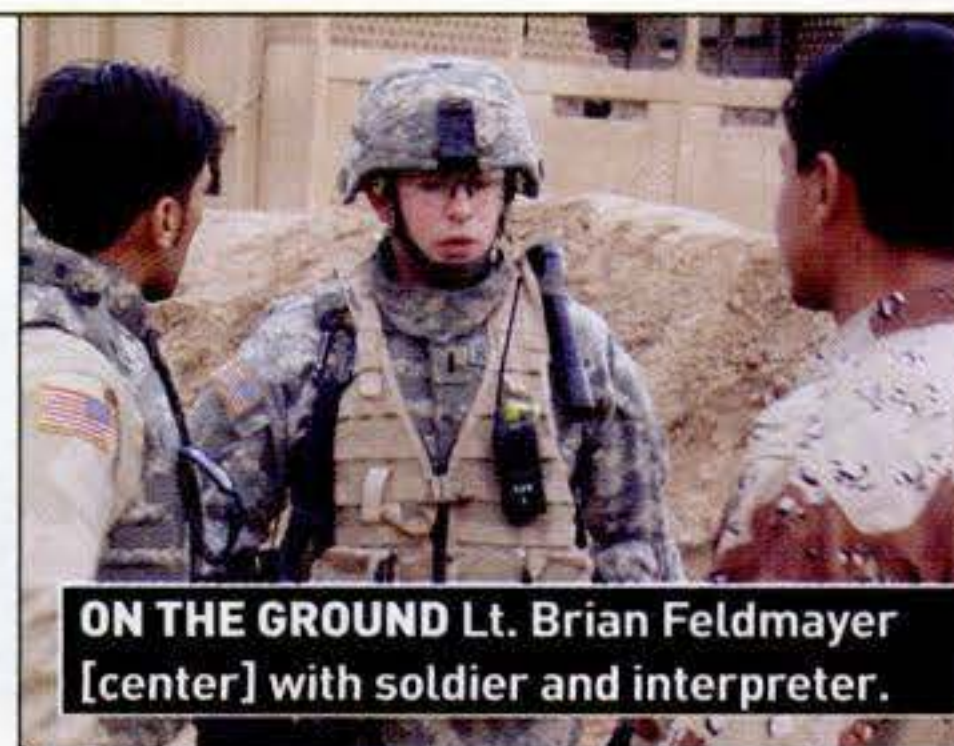
FROM LEFT: COURTESY DAVID AXE; COURTESY AV/ U.S. MILITARY PERSONNEL; COURTESY DAVID AXE

but also flying reconnaissance drones, advanced sensors, electronic jammers and battlefield data networks. All of which should make the 4ID a model for the Pentagon's vision for the future of combat—"network-centric warfare." With the right technologies, soldiers should be able to communicate better and have a clearer picture of the battlefield. Their movements become lightning-quick and lethally effective. Think of it as combat on Internet time.

DANGEROUS GAPS

Every war becomes a proving ground for new tactics and new technologies.

Battleships rose to prominence in World War I; tanks and bombers determined the course of World War II; Vietnam brought air power definitively into the Jet Age. The current conflict is no different. The Pentagon began this war believing its new, networked technologies would help make U.S. ground forces practically unstoppable in Iraq. Slow-moving, unwired armies like Saddam Hussein's were the kind of foe network-centric warriors were designed to carve up quickly. During the invasion in March 2003, that proved to be largely the case—despite most of the soldiers not being wired up at all. It was enough



ON THE GROUND Lt. Brian Feldmayer [center] with soldier and interpreter.

that their commanders had systems like BFT, which let them march to Baghdad faster than anyone imagined possible, with half the troops it took to fight the Gulf War in 1991. But now, more than three years into sectarian conflict and a violent insurgency that has cost nearly 2,400 American lives, an investigation of the current state of network-centric warfare reveals that frontline troops

TECHNOLOGY REPORT CARD TESTED IN BATTLE

War spurs innovation, and U.S. soldiers are seeing a lot of it. How well is the new equipment performing in Iraq?



M1A2 ABRAMS BATTLE TANK

Seventy-ton General Dynamics tank armed with machine guns and a 120-millimeter cannon. Has thermal sights and the latest battlefield network terminals.



MQ-1 PREDATOR UNMANNED AERIAL VEHICLE

General Atomics-built remote-controlled craft can circle above a target for 24 hours up to 400 miles from base. Equipped with sensors and Hellfire missiles.



M1114 UP-ARMORED HUMVEE

A more heavily armored version of AM General's basic Humvee four-door truck. Usually equipped with a turret-mounted machine gun.



LITENING TARGETING AND SENSOR POD

Carried on Air Force and Marine Corps aircraft, Northrop Grumman's Litening has day and night sensors, laser targeting, and a data link to transmit live imagery.



M-14 SNIPER RIFLE

Old is new again with this reliable 1950s-era rifle, refurbished from existing inventories due to a pressing need for a midrange sniper rifle in desert conditions.

WHAT IT IS

PROS

CONS

GRADE

C

A

B-

B+

A

Nearly invulnerable to attack. Fast and quiet (for a tank). Can see and shoot accurately in the dark—even at 40 mph.

Not suited to urban combat. Big, expensive, and sucks gas.

Provides excellent, real-time surveillance imagery and the ability to attack targets with little advance notice.

Only a handful are airborne at any time, so most units don't get them when they want.

Fast, reliable, easy to get into and out of. Can survive smaller improvised explosive devices (IEDs).

Engine and suspension are overloaded by the armor. It's still vulnerable to large IEDs.

Turns jets into sophisticated surveillance platforms at the flip of a switch.

Expensive, and available only in limited numbers.

Better range and stopping power than the M-16 and M-4 rifles that replaced the '50s "relic."

Fires more slowly than the M-16 and M-4, and requires different ammunition.

have a critical need for networked gear—gear that hasn't come yet. "There is a connectivity gap," states a recent Army War College report. "Information is not reaching the lowest levels."

This is a dangerous problem, because the insurgents are stitching together their own communications network. Using cellphones and e-mail accounts, these guerrillas rely on a loose web of connections rather than a top-down command structure. And they don't fight in large groups that can be easily tracked by high-tech command posts. They have to be hunted down in dark neighborhoods, amid thousands of civilians, and taken out one by one.

Even in the supposedly wired 4ID, it can take years for frontline soldiers to



NET WORTH Effectively networked M2A3 Bradley fighting vehicles helped the Fourth Infantry Division roll through Samarra during a sweep for weapons and insurgents.

BY DAVID AXE



TALON SMALL MOBILE ROBOT

Clawed ground robot, used to dismantle explosives. Multiple cameras, sensors and communication devices can be mounted between tracks.

Has saved lives by letting soldiers handle bombs remotely. Can be made waterproof for underwater detection.

Difficult to use at night, and sometimes gets tweaked by nearby radio jammers.

A



M1126 STRYKER TROOP TRANSPORT

General Dynamics-built eight-wheeled infantry carrier designed for the Army's new, more-mobile medium-force brigades.

Light, fast, quiet and comfortable. Equipped with the latest sensors and communications systems.

Armor is thin, and the vehicle is too big to fit in a C-130 aircraft without partial disassembly.

B



LINK 16 DATA EXCHANGE SYSTEM

Permits similarly-equipped aircraft to exchange location and targeting data. Also connects aircraft with Navy ships and Army missile batteries.

In theory, Link 16 enables a small number of vehicles to cover a vast territory.

Has evolved in fits and starts, so many vehicles use incompatible message formats.

D



MEERKAT MINE DETECTOR

Spindly mine-detection vehicles have been adapted for use against roadside bombs. They can be equipped with radar scanners and metal-detection gear.

Blast resistant, but also designed to break apart in places when hit by an explosion, to protect the operator.

They're available only in small numbers and require armed escorts.

B



AH-64D APACHE LONGBOW

An upgraded version of Boeing's original Apache chopper, featuring top-mounted radar, data links and better night sensors.

Fast, lethal support for ground troops. Radar above rotors allows it to scan over hills without detection.

Cost and complexity make it difficult to operate, and it's vulnerable to ground fire.

C

FROM LEFT: SCOTT NELSON/AP; JIM MACMILLAN/AP; ROCKWELL COLLINS; COURTESY DAVID AXE; BOEING

benefit from the technologies that high-ranking officers quickly take for granted. The finicky, incompatible equipment that's given to the infantrymen and tank drivers in Charlie Company—the guys who are spending this cold, wet February night on the front—is primitive in comparison with the gear at the sprawling military base outside of Balad, where battalion-level commanders oversee the 300 troops in Charlie and three other companies. There, things are beginning to work like the network-centric theorists predicted, with drone video feeds and sensor data and situation reports flying in constantly. But to the guys in Charlie Company, this technological wizardry and the Pentagon's futuristic hypotheses seem awfully far away.

There is a simple, but significant, reason why: Bringing frontline infantrymen into the network isn't as easy as wiring up a headquarters. Battlefield gear has to be wireless, durable, secure, and completely effortless to use in the chaos of combat. The network is

COVERED A soldier in the Fourth Infantry Division on guard during a bomb search.



slowly expanding to meet the grunts. But the Department of Defense's lumbering process for buying new equipment still virtually ensures that ground-level soldiers won't be linked-in until early next decade. "The fog, friction and uncertainty of war are still there, same as always," says retired Marine Col. T.X. Hammes, considered one of the leading authorities on counterinsurgency. "This net-centricity helps some, but it only goes as far as the battalion [the command echelon above the companies that do the actual fighting].

After that, these guys are on their own."

BLIND SPOTS AND INCOMPATIBLE SYSTEMS

Feldmayer radios the tank at the rear of his patrol and orders it to the front of the convoy. It's the latest M1A2 Abrams, one of the most advanced tanks in the world, equipped with new night-vision sensors, thicker armor and BFT's older (and, counterintuitively) more feature-packed cousin: Force XXI Battle Command Brigade-and-Below, or FBCB2. First built in the early 1990s for Cold War-style conflicts, where armies are tightly bunched together, FBCB2 relies on a classified radio band to communicate. BFT, designed later for more-dispersed, unconventional warfare, uses more-open satellite transmissions; troops can share information at greater distances, but they can't get the kind of secrecy that FBCB2 provides. The Army is working on a bridge between the two systems so that they will be able to share some basic information, but for now they are mostly incompatible. Feldmayer won't be able to see where the tank is leading them, and he won't be able to use FBCB2's Instant Messenger-like tool to quickly relay commands. He won't have access to any of the communications links that increase what the Pentagon calls "situational awareness" and that ultimately power network-centric warfare. If the navigation systems were working, every vehicle could split up or speed ahead if an attack came, without getting lost. But today they will all have to follow the tank's taillights in a neat line, just as it was done in 1944.

Charlie Company takes off, racing toward the fight at Ad Duluiyah. Careening around traffic circles, blowing past checkpoints, the company is primed for combat: weapons loaded, 120-millimeter cannon shells rammed into breaches. Radio-frequency jammers form a protective bubble around the convoy, keeping remote-controlled roadside bombs from detonating. "They better have that shit wrapped up by the time we get there," Feldmayer shouts, "or we're going to blow some shit up!"

Then, suddenly, the lead tank lurches to a halt. Through roiling clouds

TECHNOLOGY REPORT CARD MACK-TOUGH

Responding to threats from roadside explosives, the Army deployed this nearly indestructible 23-ton Buffalo route-clearance vehicle with tremendous success. Built by Force Protection Industries, it uses a clawed, 30-foot arm to move debris and examine potential explosives.

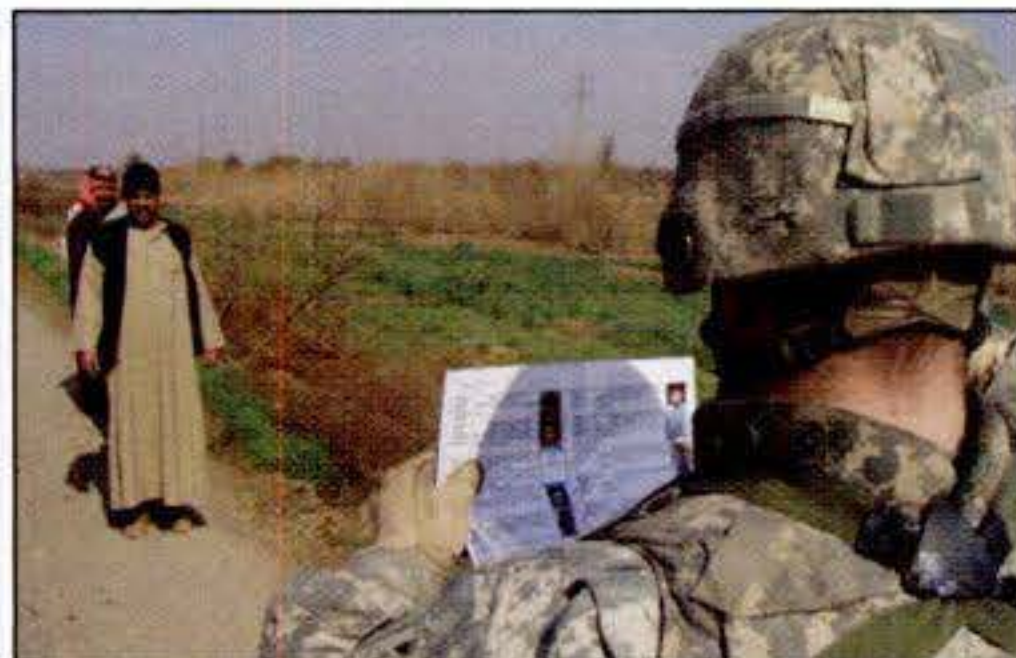
GRADE

A





COMBAT, UNPLUGGED As much as the Army struggles to wire-up the Fourth Infantry Division, the day-to-day process of fighting a war remains at heart a low-tech struggle. Above, Staff Sgt. John Lohnes scans the Balad area for potential lookout points. Staff Sgt. Colin Thompson [below left] clears a Baqubah road. At a checkpoint in Balad [below right], a soldier checks an Iraqi against a list of wanted men. In Tikrit [bottom right], soldiers secure the perimeter of a house as troops search for an alleged bomb maker.



of dust, illuminated by the tank's headlights, Feldmayer sees a pile of concrete and earth. The lead tank's fancy navigation system has just led them into a roadblock, too tall for the vehicles to climb. A dozen soldiers curse in unison.

By the time Charlie gets to Ad Duluiyah, 45 minutes later, the shooting is over. A dozen Humvees and Bradley fighting vehicles line a muddy road

leading to a rickety pontoon bridge that's nearly swamped by a surging stream. And all those soldiers' chatter is creating cacophony over the Single Channel Ground and Air Radio System, or Sincgars, the radio system connecting the Army's fleet of helicopters and ground vehicles. It's the buzzing, chirping sound of information overload.

An officer from Alpha Company

walks over to explain what's going on. Alpha was following up on leads about a stolen Iraqi police truck when the soldiers spotted a suspiciously large gathering of cars in front of a single house. When Alpha got close, Iraqis spilled out, sprinting for their cars and shooting off tracer rounds. Alpha didn't have enough men to pursue.

Now the idea is to start searching houses, one at a time, for insurgents. Charlie Company is assigned the northwest side of the stream. Feldmayer tells his tank commanders to use their infrared sights to watch over the foot patrols. Taking a last glance at his BFT, eyeballing the digital representation of the dark, foreboding neighborhood he's about to penetrate, Feldmayer mutters, "Don't need this anymore," and switches the system off.

INSPIRED BY WAL-MART

The Pentagon's pursuit of network-centric warfare began in the info-tech boom of the 1990s—largely influenced by, of all things, Wal-Mart. Ultra-wired retailers like that knew tons about their customers' needs and habits, and their suppliers' capabilities. And that helped the companies become more profitable, with less inventory and fewer employees, than their more-traditional rivals. This kind of "information superiority," Admiral Arthur Cebrowski and Pentagon scientific adviser John Garstka argued in a 1998 issue of the Naval Institute's *Proceedings*, would allow the military to streamline similarly. Fewer troops could cover wider areas when networked. Tanks and ships could carry less armor and fewer guns, because they would know exactly where their enemies were. Lower-level commanders could make key decisions. Conventional armies wouldn't stand a chance.

The Army's leadership quickly embraced the idea. In 1999 Gen. Eric Shinseki, then Army chief of staff, accelerated an overhaul of the organization, primarily along the network-centric model. Every soldier and every machine would be tapped into a giant, wireless intranet for combat. Presidential candidate George W. Bush embraced the

concept too, during the 2000 election. And when Bush entered office, Cebrowski was installed as the director of a new Pentagon department: the Office of Force Transformation.

Then came the invasions of Afghanistan and Iraq. The network wasn't done, but the slices that had been set up—like BFT, which enabled American commanders to see one another's locations—helped to decapitate Saddam's regime almost instantly. Individual troops still had trouble communicating with one another; some Marine squad leaders were forced to use five different radios to share information. In the early days of the Iraq war, it didn't seem to matter.

The gear was clearly saving lives. The number of friendly-fire incidents that plagued U.S. troops during the first Gulf War dropped significantly, for example, thanks to the new, networked equipment. In November 2004, 10,000 marines participated in the assault on Fallujah. With drones watching overhead and commanders communicating better, not one marine was killed by friendly fire. Faith in the new technologies ran so high, the Pentagon decided to cut troop levels in key areas. This part of Iraq was patrolled by 1,200 soldiers in 2004; now, a single battalion—300 troops—covers the same area.

THE SITUATION ROOM

At the battalion command post outside Balad, cables spill along the floor like the guts of an electronic beast. Flat-screen monitors display both grainy black-and-white and color surveillance footage, as many as 20 feeds at a time. Tower-mounted cameras, unmanned spy planes, even Air Force and Marine Corps fighter jets toting infrared targeting pods supply the images. It's an absolute torrent of information for the battalion's rumpled intelligence officer, Captain Pete Simpson, and his team of five analysts. With it, they keep watch over more than 1,000 square miles of Iraq from their desks.

A few years back, a division headquarters supporting 10,000 or 20,000 troops might not have had access to



TECHNOLOGY REPORT CARD

SUPER SPY PLANE

The RQ-4A Global Hawk unmanned air vehicle, designed by Northrop Grumman for high-altitude reconnaissance missions, is the first fully autonomous air vehicle used in combat. It was critical to identifying Iraqi defense systems early in the war.

GRADE

A

this much real-time footage. "We've got more stuff than we have any right to," Simpson jokes. But he can do more than get views from overhead. Thanks to the Sincgars radios, junior officers like him can quickly coordinate ad hoc missions with whatever jets and helicopters happen to be in the air—and order them to attack. "When I was a junior officer, this happened at the corps level," says Simpson's commanding officer, Lt. Col. Jeffrey Vuono, referring to an Army unit with 20,000 to 40,000 men. "Now we're doing it at the patrol level."

The air-ground collaboration is one of dozens of different ways that network-centric tools are slowly starting to rejigger the military's hidebound hierarchies. In the Gulf War, the various armed services didn't talk to one another much, except at the highest levels. That's partly why there was a six-week air campaign and then a ground attack. During the 2003 invasion, the air and ground assaults struck at once.

But one of the most powerful tools

in battalion command posts like these, notes Garstka, the network-centric theorist, may be one of the simplest: a Web browser, so junior officers can log into secure online forums. There captains and lieutenants can swap tactics, well before they appear in printed field manuals. This is critical in a place like Iraq, where insurgents' strategies change almost daily. When First Cavalry Division captain Chris Manglicmot first started seeing car bombs in his northeastern Baghdad sector, he turned to the division's collaborative site, Cavnet, for advice. Spread out your checkpoint, he learned, so the bombers don't have a central target. Look for vehicles that ride heavy and low. Watch for cars that drive aggressively, with shades pulled over the windows. There could be a bomb inside.

PAPER, NOT PIXELS

Picking his way through the crumbling houses of Ad Duluiyah, Feldmayer is tied to the American grid by only the

(CONTINUED ON PAGE 84)

George T. Morgan was one of America's greatest coin designers. His most famous coin is the legendary Morgan Silver Dollar that was first struck by the United States Mint in 1878.

At about the same time, Morgan also created what may be his ultimate masterpiece—a stunning design for a \$100 gold coin, the highest U.S. denomination ever proposed. But the coin was never made, and Morgan's original designs remained hidden for many decades...until recently discovered in a long-forgotten sketchbook. The designs may never have been seen by the public before!

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FLAWLESS MAN-MADE DIAMONDS

After decades of experimentation, scientists can finally grow diamonds that outshine even the rarest De Beers rocks **BY ELIZABETH SVOBODA ILLUSTRATION BY GRAHAM MURDOCH**

WHAT: Perfect single-crystal diamonds of more than two carats (the average engagement ring is less than a carat) churned out in a day. Scientists create the gemstones using a process called chemical vapor deposition (CVD), which grows diamond crystals one carbon atom at a time.

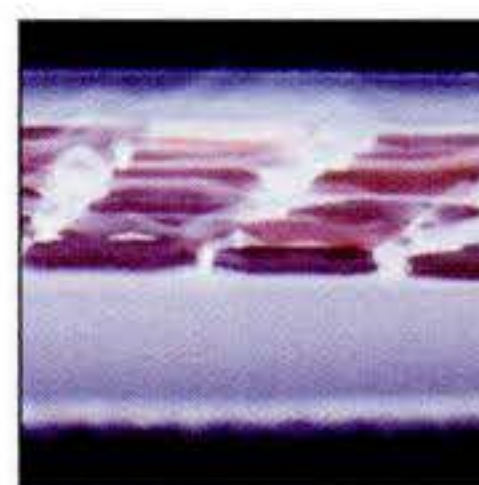
WHY: The jewelry industry has shown great interest in ersatz versions of the 45-carat Hope diamond, but other uses could prove more lucrative. Using CVD, scientists will be able to cheaply mass-produce diamond semiconductors that are hundreds of times as powerful as their silicon counterparts.

WHO: Russell Hemley of the Geophysical Laboratory of the Carnegie Institution of Washington and researchers at Apollo Diamond, Inc., in Boston, have produced the largest and some of the most flawless diamonds so far. And Europe's Carbon Power Electronics consortium, led by Dutch diamond maker Element Six, has created a synthetic diamond diode, the first step toward working diamond semiconductors.

WHEN: During the past year, scientists have mastered the ability to grow 10-carat single crystals with a color and clarity that surpass mined diamonds. Within a decade, they'll also be cheaper. Expect to see the first diamond semiconductors hit the market in 2011.

HOW TO GROW A DIAMOND >>>

Flood a small diamond seed with gases and microwave heat, then watch it grow, atom by atom, into nature's finest gem.



1 PLANT SEED Start with a tray of flawless, button-size diamonds. Just as an oyster deposits layers of calcium atop sand grains to form pearls, these "seeds" serve as the base on which larger stones will develop.



2 NOURISH IT Place the seeds in a microwave chamber, and feed them hydrogen and methane gases. When the temperature hits 1,300°F, the hydrogen combines with methane to produce a highly reactive form of carbon.



3 WATCH IT GROW These carbon "radicals" rain down from the cloud of hot plasma and bond to the carbon on the surface of the seed. A new diamond crystal soon begins to form [diamond and seed, above].

WHAT TO USE IT FOR



JEWELRY Gem-quality synthetics of various colors [above] are not new, but large colorless synthetics are. The De Beers diamond cartel is feeling the pres-

sure: To make it easy for jewelers to distinguish between mined and lab-bred stones, De Beers has started engraving logos on mined diamonds.

SEMICONDUCTORS

Fast processors generate lots of heat. Silicon semiconductors break down at around 250°F, but diamonds can take up to 1,300°. As a result, they can run as fast as 81 gigahertz without elaborate cooling mechanisms (the fastest silicon chips run at about 10).

OPTICS Because of their heat conductivity and chemical stability, diamond lenses [facing page] trans-

A REAL GEM

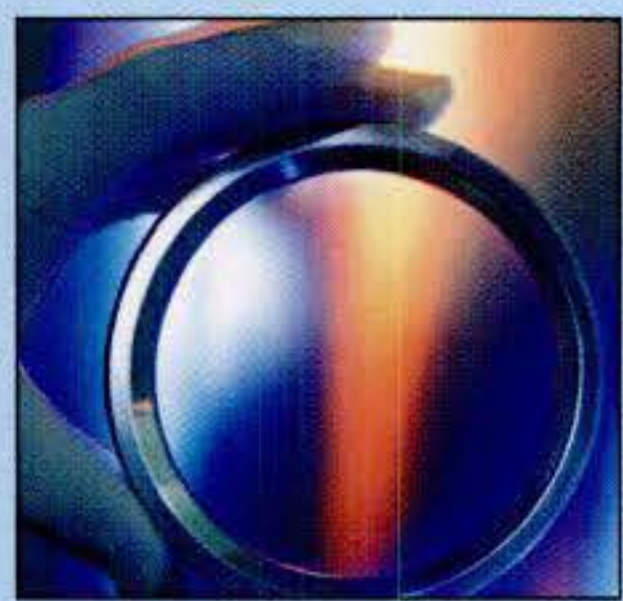
These lab-bred stones have the same atomic structure as mined diamonds.

4 TRIM STONE

Once the diamond reaches the desired size (12 hours for a full carat), separate the newly grown diamond crystal from the seed. Cut and polish the stone like you would a mined diamond.

FAQs

Because with diamonds, it's good to be crystal clear



mit sharper laser beams at higher temperatures than zinc selenide, the industry standard. Look for diamond lenses in CO₂ lasers used for precision cutting, welding and surgery.

BUT AREN'T THEY FAKES?

No. Created stones have the same atomic structure as diamonds that form inside the earth, so they are real diamonds in every sense. They are optically, chemically and physically identical. In fact, since scientists start with seeds of the purest stone and carefully control the growing environment, they can systematically produce colorless rocks with far fewer impurities than most mined diamonds.

ARE SYNTHETICS FASTER TO GROW?

No one knows for sure how long it takes diamonds to form inside the earth. Geologists do know, however, that it takes millions of years for the earth to transport them to the surface, where they can be mined.

WHY WOULD ANYONE WANT A SYNTHETIC?

Man-made diamonds are cheaper and have fewer flaws than most mined diamonds. Also, some people are uncomfortable support-

ing companies that prop up the African warlords that control many of the diamond mines.

HOW CHEAP?

Apollo is already selling near-colorless synthetics that are a quarter of a carat in size for as little as \$500 (versus \$750 for a mined gem), and prices of bigger stones will plummet as mass manufacturing gets underway. Engagement-ring-size colorless diamonds will be up to 30 percent cheaper than their mined equivalents.



THE FUTURE OF MOVIES

RETURN OF THE 3-D

As in, amazing 3-D movies,
without the '70s-era glasses.

Coming soon to a theater near you. Why Lucas, Spielberg, Cameron
and the rest of Hollywood may never work in two dimensions again

BY GREGORY MONE | PHOTOGRAPH BY DONALD MILLER | DIGITAL IMAGING BY ERIC HEINTZ

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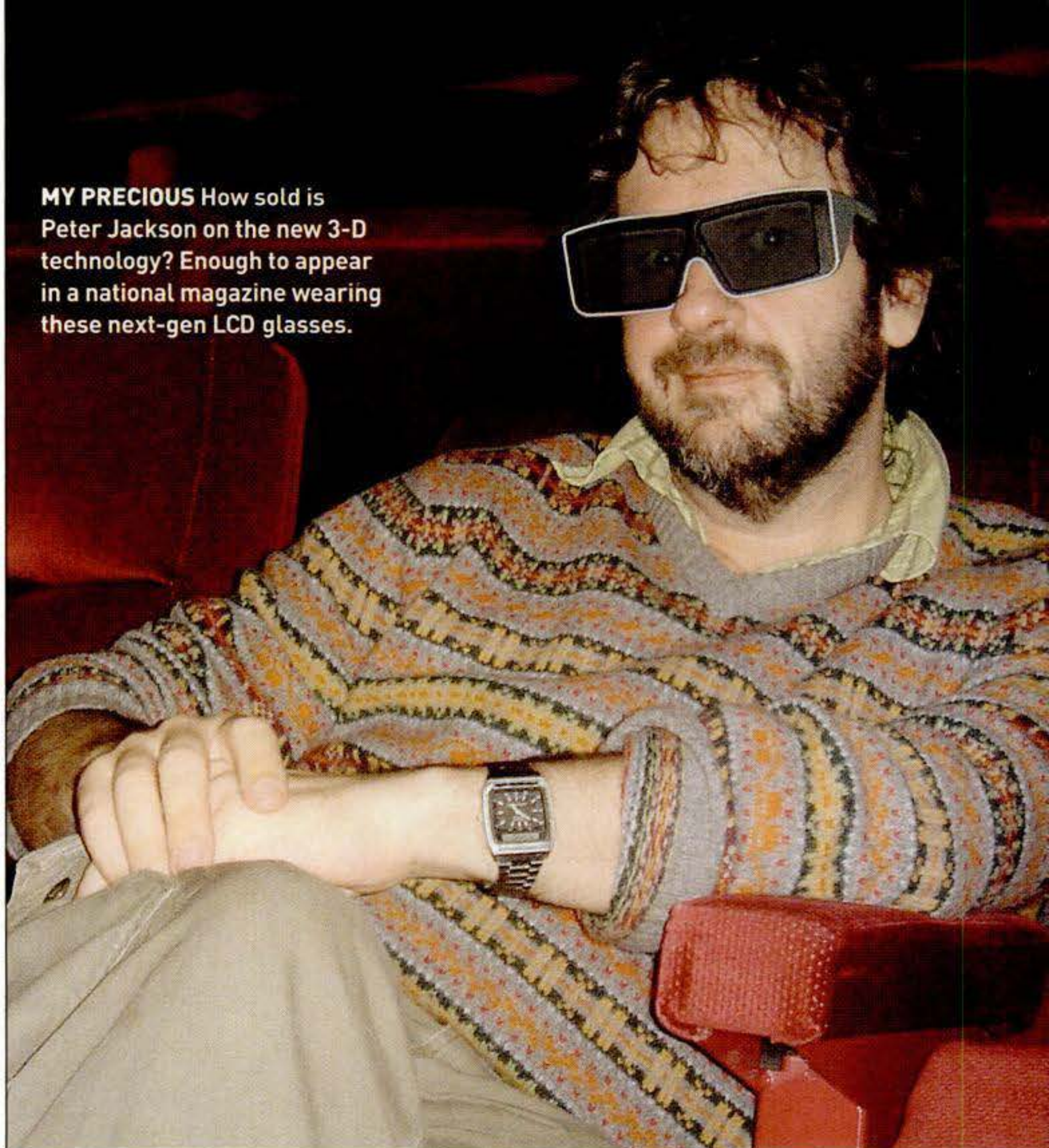
IN MARCH 2004, staffers at Industrial Light & Magic in San Rafael, California, filed in and out of a screening room, drawn by news of a technology demonstration. Tech breakthroughs on the ILM campus are nothing unusual, of course—this is, after all, the special-effects shop that George Lucas founded back in 1975 to create the never-before-seen visuals of *Star Wars*. But this was different. This time, outsiders had arrived to show ILM's own work in a whole new, trippy light.

The staffers put on pairs of thick glasses and watched as clips from *Star Wars* were played. Suddenly the screen itself seemed to dissolve away, as scenes stretched out toward the audience. Anakin Skywalker and Obi-Wan Kenobi's faces grew closer to viewers as the characters prepared to chase a would-be assassin. Pod cars buzzing in the background really appeared to be hundreds of feet away. It wasn't like watching a big screen on a wall; it was like looking through a massive picture window. Soon, the Jedi Master himself came in. George Lucas sat down, put on the glasses and, within a few minutes, passed judgment: "I'm sold! I'm sold! I'm sold!"

What Lucas witnessed that day was better than any 3-D he had ever seen. No shaky pictures. No color loss. No distortions that disconnect your eyes from your stomach. He was among the first to see the next generation of 3-D movies, marked not only by their clarity but by their range.

Now any film, from *Gone with the Wind* to *Gone in 60 Seconds*, can be transformed into high-quality 3-D. Filming in 3-D is also simpler and more effective than ever, thanks to new high-end cameras and postproduction tricks. And because the final product is so natural and realistic—more like the way we actually see—some in Hollywood are likening this 3-D to the introduction of sound in cinema. James Cameron, of *Titanic* and *Terminator* fame, has vowed to never direct another film in two dimensions again. Indeed, he plans to release in 2008 a big-budget sci-fi flick entirely in 3-D. And Lucas is expected to rerelease a fully 3-D version of *Star*

MY PRECIOUS How sold is Peter Jackson on the new 3-D technology? Enough to appear in a national magazine wearing these next-gen LCD glasses.



WHAT YOU'LL SEE IS BETTER THAN ANY PREVIOUS 3-D. NO VIBRATIONS. NO COLOR LOSS. NO DISTORTIONS THAT CAUSE YOUR BRAIN AND STOMACH TO REVOLT.

Wars: Episode I—The Phantom Menace next spring. (Moviegoers needn't wait that long for a taste of the technology. Sony Pictures is set to release its animated film *Monster House* in July with

a 2-D version for the multiplex crowds and a 3-D version to be seen on select screens; Warner Bros. will do likewise with *Superman Returns* on IMAX.) Even quintessential A-listers Steven Spielberg and Peter Jackson reportedly plan to make movies in 3-D or have their classics remastered with the technology. The ultimate story line here: We may soon look back and remember the 2-D movie theater as a quaint, hopelessly incomplete cinematic experience.

But first, a plot twist. Coupled with these directors' desire to make 3-D movies must be the expansion of 3-D theater technology beyond IMAX. And that's where both the trouble and opportunity begin. There are two main companies working to spread 3-D into theaters across the U.S., two separate visions of how the 3-D cinema revolution is to play out, and two unique

THREE KEY FACTS

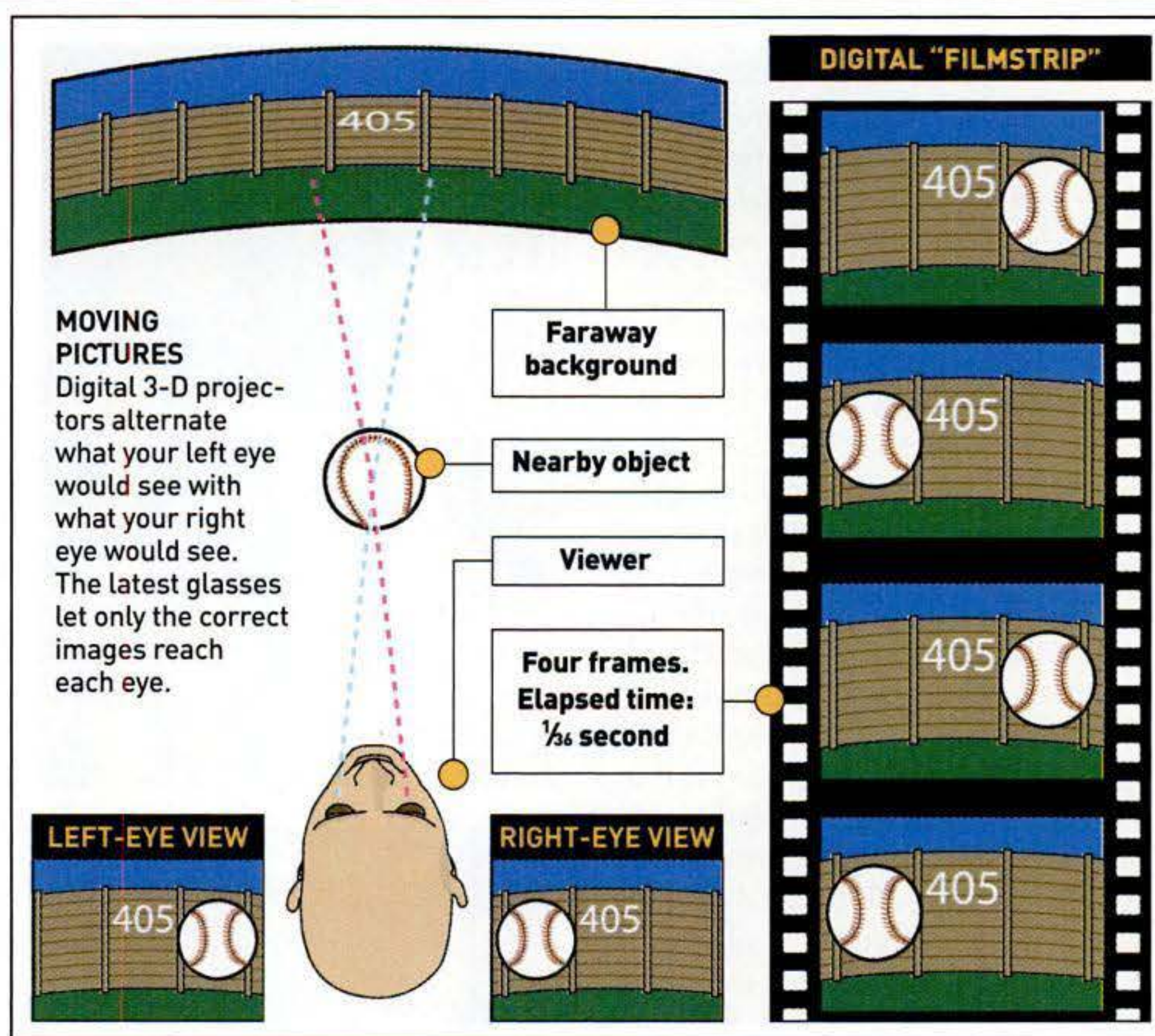
- 1 New techniques to convert 2-D to 3-D** will let you see any movie in 3-D.
- 2 Digital projectors avoid the color shifts** and vibrations of typical 3-D.
- 3 Real D uses polarized glasses** to filter images for each eye; In-Three's glasses use LCD technology.

HOW IT WORKS

3-D VISION: REAL AND DIGITAL

YOUR RIGHT EYE sees the world a little differently than your left. The effect is most pronounced for nearby objects seen against a faraway background. (See for yourself: Hold your thumb a foot away from your face, open and close each eye, and watch how it seems to move against the background.) When your brain combines the unique images from each eye, it translates the difference into perspective, or depth of vision.

3-D movies must give your brain the same input: a slightly different image coming into your left and right eyes. The newest 3-D technologies use digital projectors that flash up to 144 frames per second up on the screen. Half the frames are meant for your left eye, the other half for your right. Glasses serve as gatekeepers, blocking those frames not meant for each eye. Because there's no image overlap, these systems eliminate the headache-inducing "ghosting" that plagued earlier systems.



technologies to make it happen. The winner may well determine the way we watch movies in the future.

CLOSE ENCOUNTERS OF THE THIRD KIND

One of these companies, Real D, is from the somewhat humble world of industrial imaging. But it has quickly adapted to Hollywood. At its Beverly Hills office, the employees look and dress a good five years younger than they probably are, and the screening room is nicer than most movie theaters I've been to. Real D's CEO, Joshua Greer, a compact, enthusiastic man who could pass for a character in *Entourage*, gives me his two-minute pitch on the brilliance of his product before racing back to a deal-making session in the conference room. He's prepped me to be overwhelmed by the series of clips I'm about to see, a sort of 3-D highlight reel.

Last November, Disney quietly released a 3-D version of its animated *Chicken Little* using a new display sys-

tem developed by Real D. Disney and several partners fronted the cost for Real D's digital 3-D upgrade of 85 theaters, and on a per screen basis, those versions grossed three times as much as the 2-D film did. "3-D can offer something unique that people can't get at home today," says Richard Grief, an analyst at market-research firm Opinion Dynamics in Cambridge, Massachusetts, which recently conducted a study of the industry. "The audience is saying it would be something they'd be willing to pay more for. It would be something that would attract them to the theater."

With ticket sales down 13 percent since 2002, the movie biz needs a boost. And you can't really blame folks for staying on the couch. Home entertainment systems evolve monthly, it seems, but theaters haven't offered anything new since surround sound. "There has been no improvement in the visual presentation to the public in 50 years," says Jon Landau, a producer of *Titanic* and frequent Cameron collaborator.

You wouldn't know it, though, to see Real D's highlight reel: scenes from *The Polar Express*, a few shorts now showing at the Hershey amusement park, and plays from the 2005 Super Bowl captured with 3-D cameras. The colors are bright, the images perfectly clear. There's no double-image ghosting and, more importantly, no headache.

What's more, the 3-D isn't used for shock or surprise. No dinosaurs jump out of the screen. No cars screech to a halt in front of my face. The added depth simply makes me feel more involved in what's happening on the screen, whether it's a huddle in the football game or an animated version of an undersea scene. Also, just as the screen has limits in terms of height and width, the z axis doesn't go on forever. At one point, a snake stretches out over the first few rows, but it stops there, never getting too close. Most of the depth actually stretches back into the screen. It feels like I'm looking at a real, fully dimensional world.

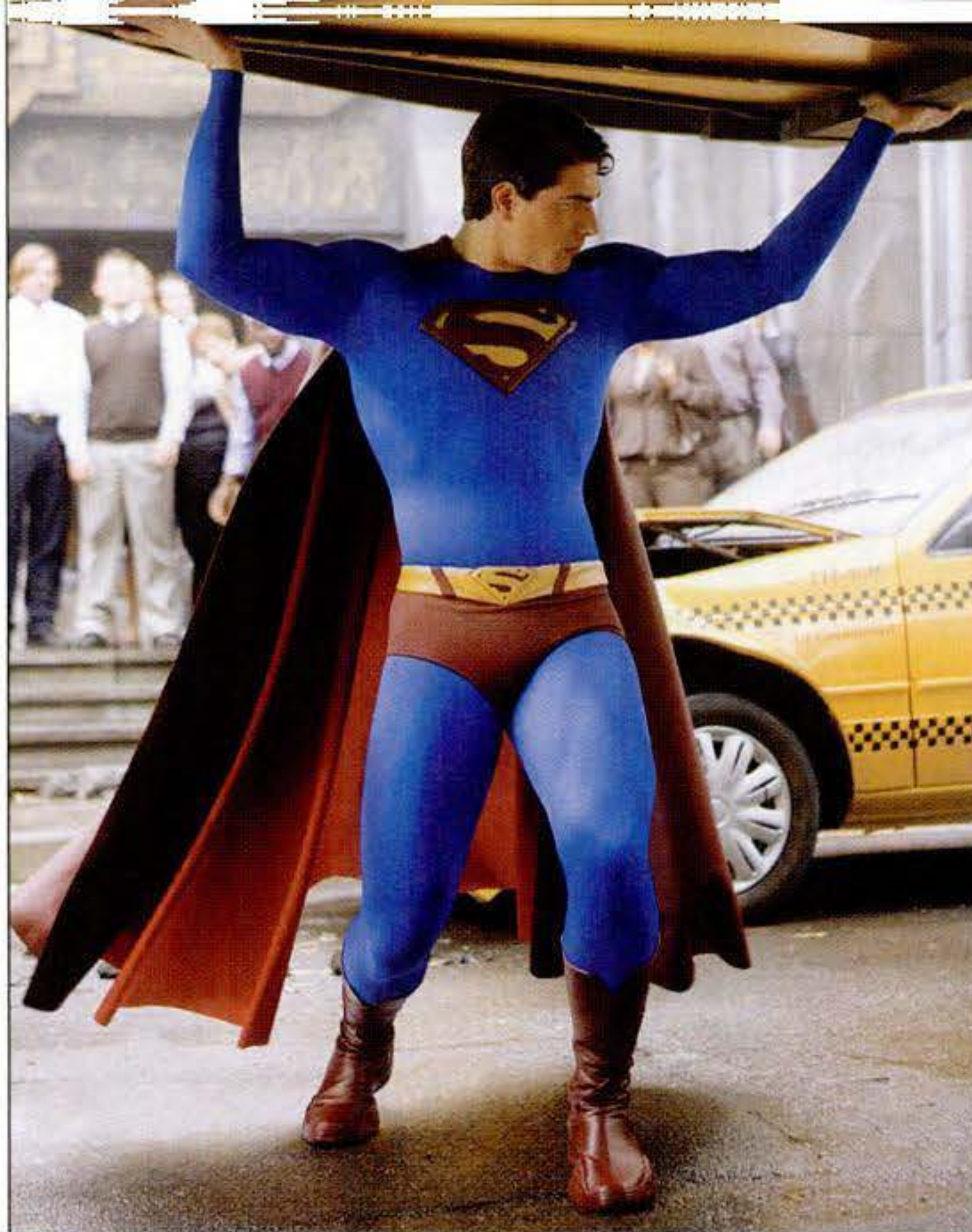
WHAT LIES BENEATH

Displaying 3-D is fairly simple stuff in principle. Humans have two eyes, and each eye captures a slightly different view of the world. We perceive depth in an object because our brain merges these two viewpoints [see "How It Works," preceding page]. To conjure a three-dimensional world in the moviegoer's brain, you have to mimic the natural process by sending a different image to each eye.

That's harder than it sounds. The old red/blue standard, called anaglyph, uses two side-by-side projectors to simultaneously shine the images meant for your left and right eye onto the screen. Each image is color-coded, and the filters in your paper glasses let through only the image meant for a specific eye. But anaglyph distorts the colors in the film, and the left eye's picture often leaks into the right, or vice versa, creating an effect called ghosting. Viewers are more often left rubbing their eyes in discomfort, not wonder. "Best-case scenario, people walk out annoyed," says Real D's Greer. "Worst-case scenario, they walk out sick."

A technology used by IMAX is similarly minded, but instead of red and blue images linked to red/blue filters, it uses polarized light and polarized filters. If you imagine light as a wave, polarized light vibrates in only one direction: either up/down or left/right. Shine one image on the screen with an up/down orientation, the other with a left/right orientation, and use a pair of polarized glasses to make sure the correct image reaches the right eye.

Real D's display system is a variation on the IMAX setup, with one key difference and a few small but critical technological tricks. The basic concept of polarized light bouncing off a silver screen is intact. (In both systems, the silver-coated screen is necessary because a matte screen would depolarize the light, ruining the effect.) But Real D also developed a lens that spins the light waves instead of pointing them in one direction—a process called circular polarization. This allows you to tilt your head up to 45 degrees while viewing. With standard polarization,



▼ **HARD WORK** See *Superman Returns* in an IMAX theater this summer, and you'll get 20 minutes of 3-D action. Why not more? Converting an entire live-action 2-D film into 3-D can take as long as a year.

▼ **KID'S PLAY** Digital animations, on the other hand, already exist in 3-D on their animators' computers. Conversion is straightforward, so you can see the 3-D version of *Monster House* in its entirety.



DIRECTOR JAMES CAMERON IS FILMING A SCI-FI EPIC AND A LOVE STORY IN 3-D. SAYS A PARTNER: "THE REAL QUESTION IS, WHY WOULDN'T YOU DO 3-D?"

you've got to keep your head straight.

But the main difference, the big leap forward, is the use of a digital projector. Instead of two projectors shining the left- and right-eye images on the screen at once, the digital system alternates left and right. Every $\frac{1}{144}$ of a second, the view switches: left, right, left, right. Because there's only one image on the screen at any given time, Real D ensures that there won't be any shadow images or double lines, all but eliminating the ghosting problem. And

although the high flicker rate might sound like it's more likely to cause an anxiety attack than a delightful cinematic experience, it happens so fast that your brain thinks it's seeing two continuous views, one captured by each eye.

BACK TO THE FUTURE

Of course, the finest 3-D technology in the world wouldn't matter one bit if it was used to show lackluster movies (*Jaws 3-D*, anyone?). After my visit to Real D, I take Highway 101 north to



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Westlake Village, California, home of In-Three, the company retrofitting *Star Wars*, among other films, for the new 3-D age. In-Three has swollen from two dozen people a year ago to 200-plus today. Its new headquarters' first-floor screening room isn't finished, so I'm driven across town to the old offices. The theater here is paltry compared with Real D's accommodations (my brother-in-law's home setup is nearly as big). Glasses hang on the back of each chair; they're thicker than Real D's, slightly stiffer and certainly more complex. My In-Three tour guides and I struggle for a minute trying to figure out whether or not they're turned on.

As the lights dim, the highlight reel, a collection of clips that In-Three has converted into 3-D, begins. Anakin and Obi-Wan chase a bounty hunter through a space city's aerial highways in *Star Wars: Episode II—Attack of the Clones*. Fire erupts out of an elevator bank in *The Matrix*, the flames billowing from the screen. There's even a brief scene from *Grease* in which John Travolta and crew take a break from car repair for a little song and dance. (Besides *Star Wars*, there are no immediate plans for any of these films to be rereleased in 3-D.) The images look much the same to me as Real D's, even though In-Three uses a different technology (more on that in a moment). The scenes also extend far back behind the screen to

create that desired effect of looking through the window. It's just as comfortable on the eyes, and although I've been told that this system produces a brighter picture, it doesn't look noticeably better.

That's less important than the simple fact that these live-action scenes even exist. Most new 3-D movies, like *Monster House* and *Chicken Little*, are animated. Since computer-generated characters are originally built in three dimensions, creating a 3-D version only requires you to go back into the animation files and restore that depth.

Converting a live-action movie into 3-D is much harder. There's no depth information, so each frame, and each object or person within the frame, must be carved up and moved around. To make a second eye's view, animators must shift objects in a scene relative to the background. This creates the sense that one object is closer to you than, say, a set of trees in the distance. To avoid a cardboard-cutout, View-Master-like effect, each object or person then has to be individually altered and given depth.

As for how this is done, and how the altered shots are mixed to ensure seamlessness between scenes, well, that's when the mouths clamp shut. The folks at In-Three would speak in only the vaguest of terms about how they "dimensionalize" a movie, and IMAX's vice president of technical production, Hugh Murray, was equally reluctant to reveal more. The two companies waged a now-settled patent war over the technique last year, so there may be legal reasons for this ambiguity. But it may just be that there's too much at stake for them to describe it openly. "We've been working on this for a long time," Murray says of IMAX's own conversion technology. "It's obviously the Holy Grail for a company that has a lot of 3-D theaters."

RISKY BUSINESS

Although In-Three's primary business is turning 2-D classics into 3-D hits, it has also allied itself with a small outfit called NuVision Technologies to create a pair of glasses that lets you see the third dimension on any screen, not just the \$25,000 silver screens that IMAX

(CONTINUED ON PAGE 87)

POPSCI PREVIEW

A SUMMER OF CINEPLEX SCIENCE

From time travel to rogue waves, the best (and worst) of this summer's movies. Now with PopSci's EGQ: Expected Gibberish Quotient



X-MEN: THE LAST STAND MAY 26

Genetic mutations let these superheroes sprout wings, manipulate metal, and control the weather. In this sequel, scientists discover a way to suppress the supergenes.

THE BIG DRAW Colossus: The metallic strongman required heavy special effects.

WORST FEAR That the resident biochemist, Beast, offers an RNA-based explanation for the gene silencing **EGQ** High. This franchise has less respect for evolution than Fred Flintstone.



CARS JUNE 9

Lightning McQueen gets lost on his way to a race and ends up in the town of Radiator Springs, a forgotten spot populated by, among other autos, a sexy 2002 Porsche 911 and a quiet 1951 Hudson Hornet.

THE BIG DRAW Driver Richard Petty's cameo as a 1970 Plymouth Superbird **WORST FEAR** That *Cars* won't live up to Pixar's last few movies **EGQ** Low. Someone could conjure an AI-run-amok backstory to explain this world run by autos, but why bother?



▲ **THE KING AND EYE** Though no flop, *King Kong* wasn't quite the box-office beast it was expected to be. Will a rerelease in 3-D coax viewers back into the theaters?



CLICK JUNE 30

A mad scientist in a *Bed Bath & Beyond* gives the ultimate remote to a time-crunched family man. The gadget offers a new twist on time travel: Instead of transporting him to the past or future, it changes the flow of time around him.

THE BIG DRAW

Watching Adam Sandler try to outsmart time-travel paradoxes

WORST FEAR Watching Adam Sandler try to outsmart time-travel paradoxes
EGQ Medium. Mad scientists are always good for a few mentions of string theory.



SUPERMAN RETURNS JUNE 30

After an extended hiatus away from Earth, Krypton's first son flies back to find that the people of Earth—not to mention Lois Lane—no longer need him.

THE BIG DRAW

Want to feel a little closer to the Man of Steel? In IMAX theaters, a 20-minute section of the movie will be shown in 3-D.

WORST FEAR

That the story line and acting, in contrast, will be one-dimensional

EGQ Low. Suspension of disbelief, people. There's no point trying to explain Superman.



A SCANNER DARKLY JULY 7

In this adaptation of a Philip K. Dick story, a cop becomes addicted to a mysterious drug and develops a split personality.

THE BIG DRAW

The film was shot with live actors, then tweaked by rotoscoping. Artists draw over the film's frames, creating oddly realistic animated scenes.

WORST FEAR

That the scramble suit, an outfit that makes someone look like any and all people, won't live up to Dick's description

EGQ High. This is Philip K. Dick, after all.



APOCALYPTO AUGUST 4

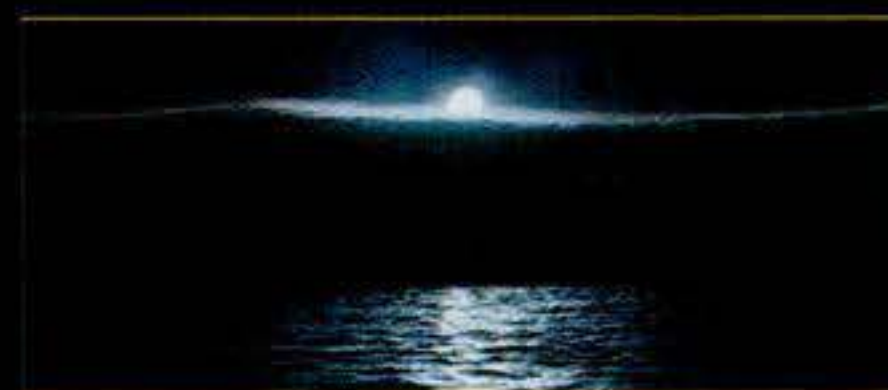
Director Mel Gibson hopes to transport audiences to the last days of the ancient Mayan empire. Concrete causes of the collapse of the Mayas have proved elusive, but some recent evidence suggests climate change—specifically, droughts—may have contributed.

THE BIG DRAW

Reconstructed Mayan cityscapes and reported scenes of human sacrifice

WORST FEAR

Mel Gibson
EGQ Astronomical. All the characters will speak Yucatec Maya.



WAVE BYE-BYE *Poseidon's* special-effects team did its homework before building the rogue wave, even consulting with experts at Stanford University.

POSEIDON

MAY 12

Sure, there will be plenty of heroes struggling for survival aboard the sinking cruise ship at the center of *Poseidon*, but the real star of this film may be the rogue wave that causes all the problems in the first place. Scientists believe that these ocean giants form when two wave fronts intersect. On rare occasions, the overlap focuses the combined wave energy to produce a wall of water up to 100 feet tall.

Naturally, narrative needs forced the filmmakers to stray from reality in places. For example, visual-effects supervisor Boyd Shermis notes that rogue waves typically form in turbulent seas, whereas *Poseidon's* monster strikes out of nowhere. Shermis says they also created a 170-foot wave—nearly twice as tall as the largest rogue on record.

THE BIG DRAW The bulk of the filmmakers' science homework went into making water behave as it would in a real ocean. The physics models that drive the effects account for the water below the surface, not only on the ocean's skin. So when a wave breaks, Shermis says, "You're not just slapping foam particles onto the surface. You're actually spawning the foam from within the 3-D volume of water."

WORST FEAR The two hours that follow the two-minute wave sequence
EGQ Low. All they want is a way out, not an explanation of what happened.

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HOW 2.0

TIPS, TRICKS, HACKS AND DO-IT-YOURSELF PROJECTS



72

Send Wi-Fi to your backyard



74

Launch rockets with Oreo cookies

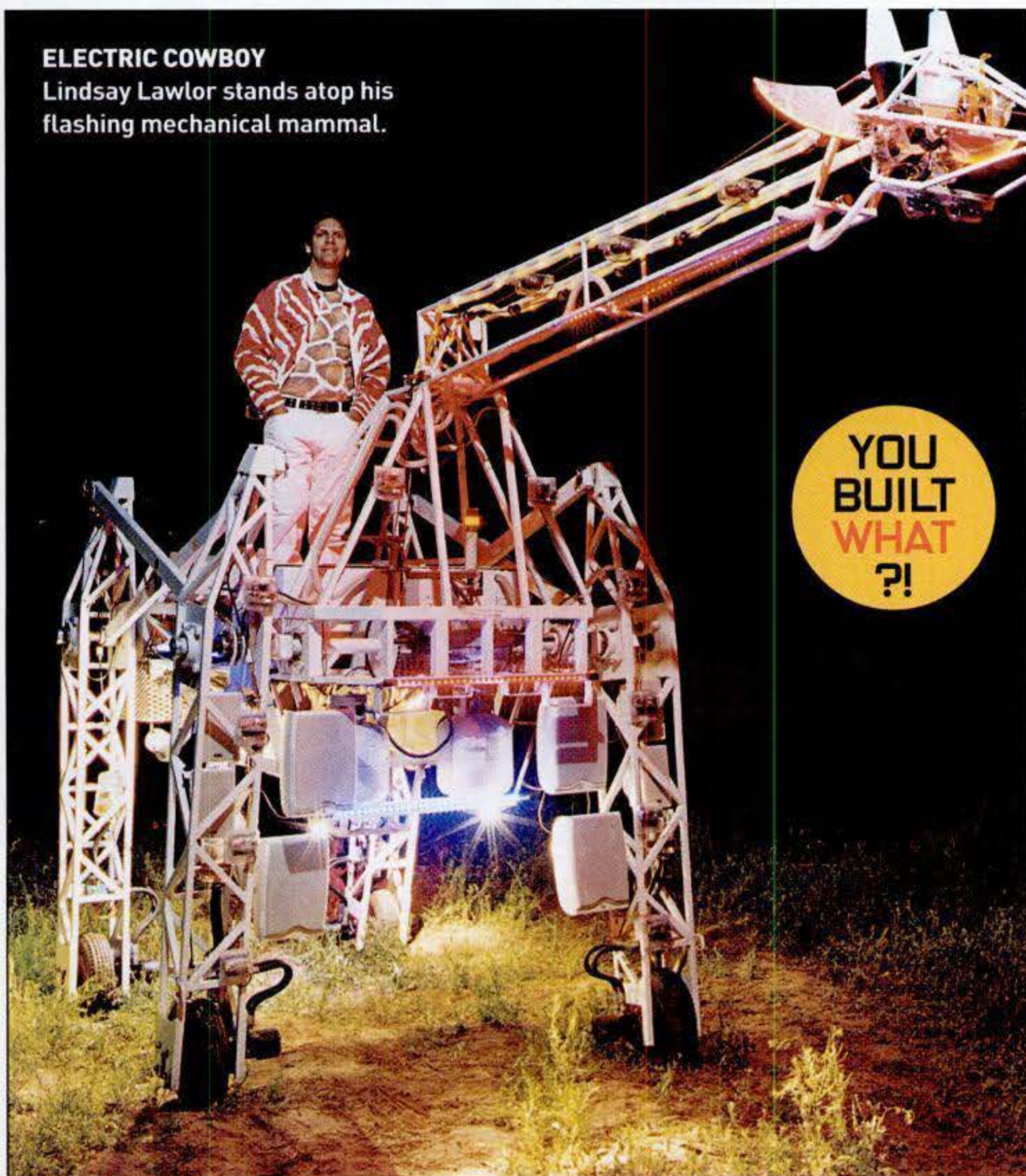


76

Share your home movies online

ELECTRIC COWBOY

Lindsay Lawlor stands atop his flashing mechanical mammal.



**YOU
BUILT
WHAT
?!**

THE ROBOTIC GIRAFFE

It walks, it blinks, it seats six, and it blasts Kraftwerk: Meet one man's 17-foot-tall pet project

IT STARTED WITH a seven-inch walking toy giraffe and a desire to see Burning Man from a higher vantage point. A year later, Lindsay Lawlor rode into the desert art festival atop Rave Raffe, a 1,700-pound robotic giraffe sporting 40 strobes, 400 LEDs and bone-shaking speakers.

Lawlor wanted his Burning Man ride to be a true walking vehicle, so with the help of his landlord, Gary Stadler, he copied that toy's locomotion system on a massive scale. The front and back legs opposite each other step ahead at the same time, propelled by an electric motor. When those legs land, hydraulic brakes lock the wheeled feet, and the other two legs take a step. Canting from side to side, Raffe lumbers ahead at about a mile an hour. A propane engine runs only to recharge the batteries, so the beast is quiet and efficient. When Lawlor let Raffe shuffle off alone in the desert, it walked for eight hours.

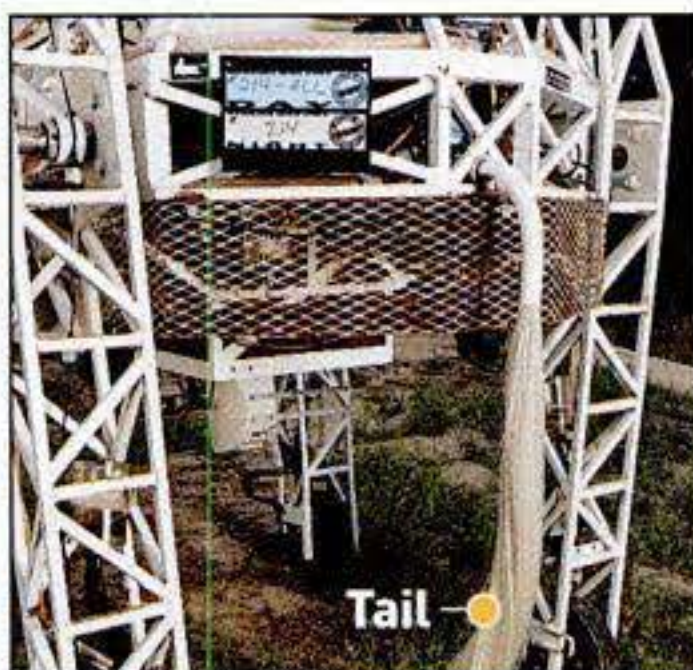
Now Lawlor, a part-time laser-light-show designer, is busy adding new features for this summer's Burning Man, including computer-controlled flashing giraffe spots, an electroluminescent circulatory system and a gas grill. Follow his progress at electricgiraffe.com. —MIKE HANEY

HOW IT WORKS

10 MONTHS **\$15,000**
PRACTICAL ■■■■ **POPCORN**

1. A 12-horsepower, propane-fueled engine drives three generators, which charge three 450-amp batteries, salvaged from an industrial floor scrubber. Many of the other parts, including the shoulder joints and LEDs, came from eBay.

2. Lawlor pushes the throttle forward to engage the variable-speed analog drive, which turns a 250-pound drive shaft to propel Raffe ahead. A pneumatic pump raises and lowers the eight-foot neck.



JUNK IN THE TRUNK
The tail—fiber-optic cable lit by LEDs—swings below a cage holding the generators.

Tail

NETWORK YOUR BACKYARD

HOME
IMPROVEMENT

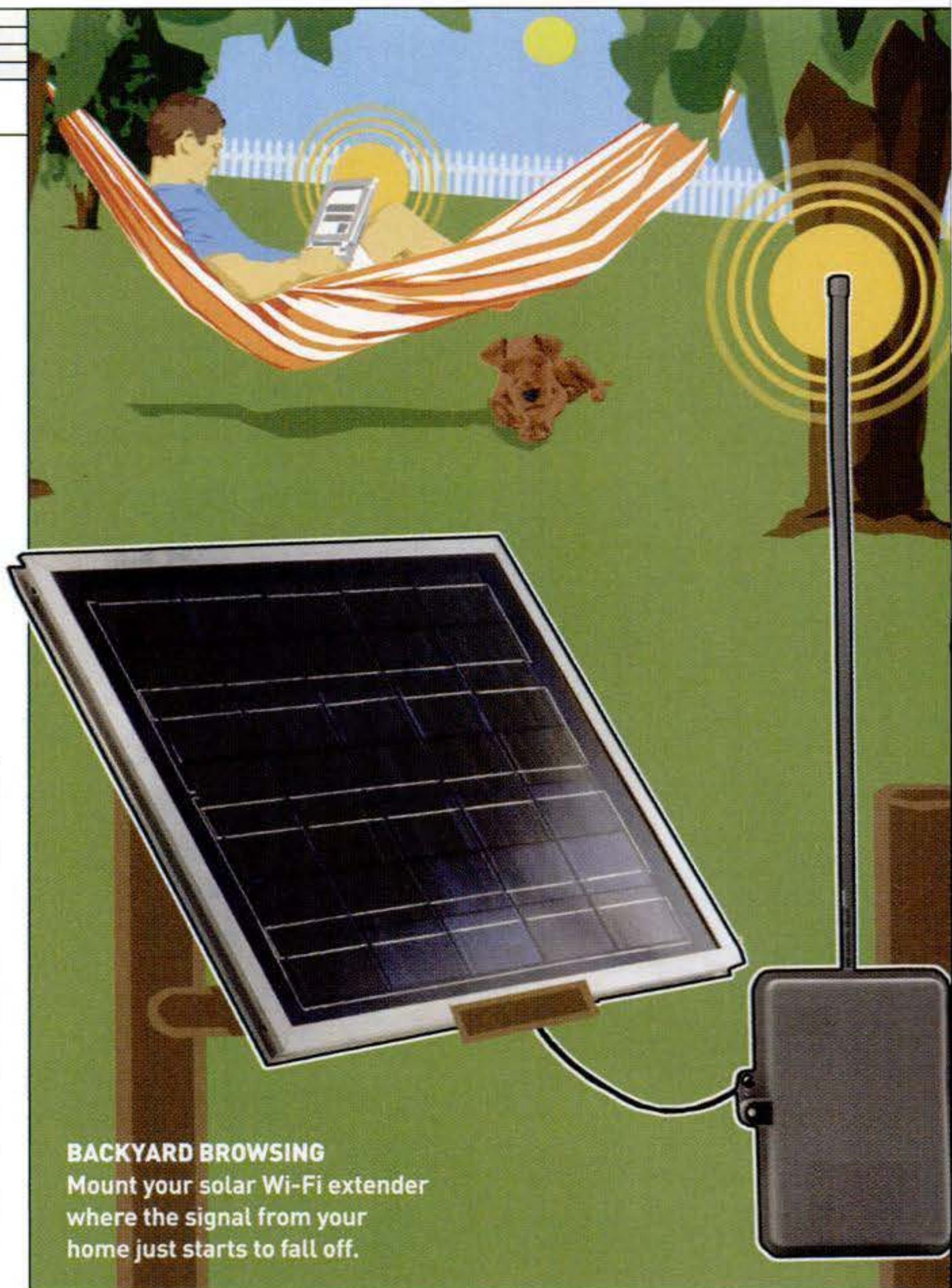
Surf the Web from the hammock out back (or the park down the block) with this solar-powered Wi-Fi extender

THE PROMISE OF WI-FI is freedom—the ability to bring your laptop or PDA away from the anchor that is your desk and into your life. With most wireless routers, however, your life had better stop at around 300 feet, and forget about heading outside. Between the noise generated by other local wireless devices and physical obstacles like furniture and walls, chances are your Wi-Fi signal is little more than a whisper by the time it hits your backyard. So I built a box that can pick up that signal and boost it another 200 to 300 feet. It uses a **Linksys Wi-Fi range expander** (\$100; linksys.com) modified with an **omnidirectional 9dBi antenna** (\$58; pacwireless.com). To avoid unsightly extension cords in the flower bed, I added a **lead-acid battery** (\$22; radioshack.com) and a **10-watt solar panel** (\$119; sundancesolar.com) to charge it.

My weatherproof box radiates the signal equally in all directions, but you could use a directional antenna instead to shoot your Wi-Fi to a more specific area of your yard or neighborhood (try wlanparts.com for more antennas). See the basic steps [right], and at popsci.com/wifi, find a detailed how-to, along with a parts list and more photos. Then brew some iced tea and start surfing outside.—MIKE OUTMESGUINE

INSTALLATION TIPS

- For best coverage, place your home's wireless router on the ground floor.
- Use a router and range expander that are the same brand to make setup easier.
- Don't forget to password-protect your network (see your devices' user manual for instructions).
- Mount the solar panel at around a 45-degree angle. For greatest efficiency, place it in an area of the yard where it will get direct sun at noon.



BACKYARD BROWSING

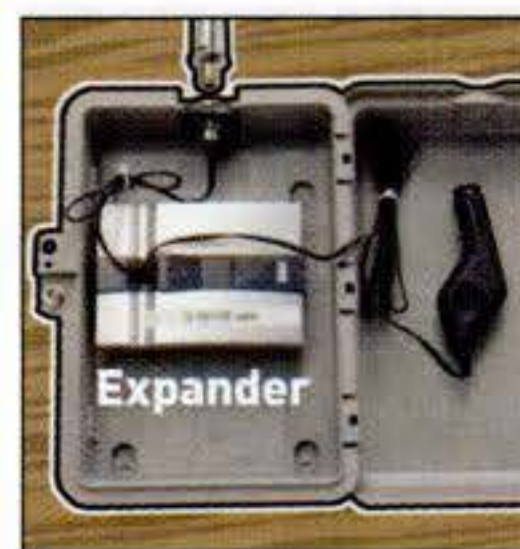
Mount your solar Wi-Fi extender where the signal from your home just starts to fall off.

BUILD AN OUTDOOR WI-FI BOX

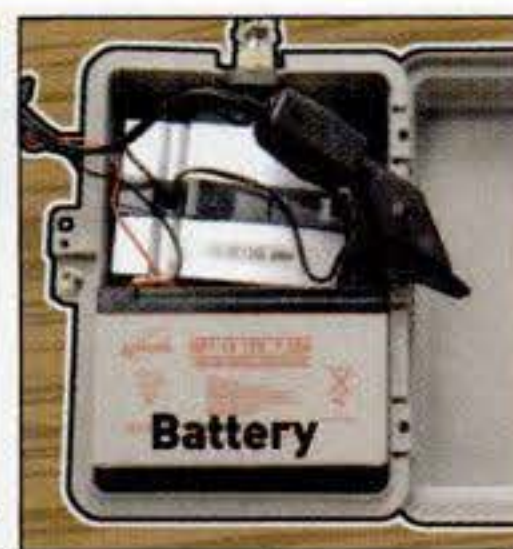
3 HOURS

\$375

EASY ■■■■ HARD



Expander



Battery



Solar panel

WIRE THE ANTENNA

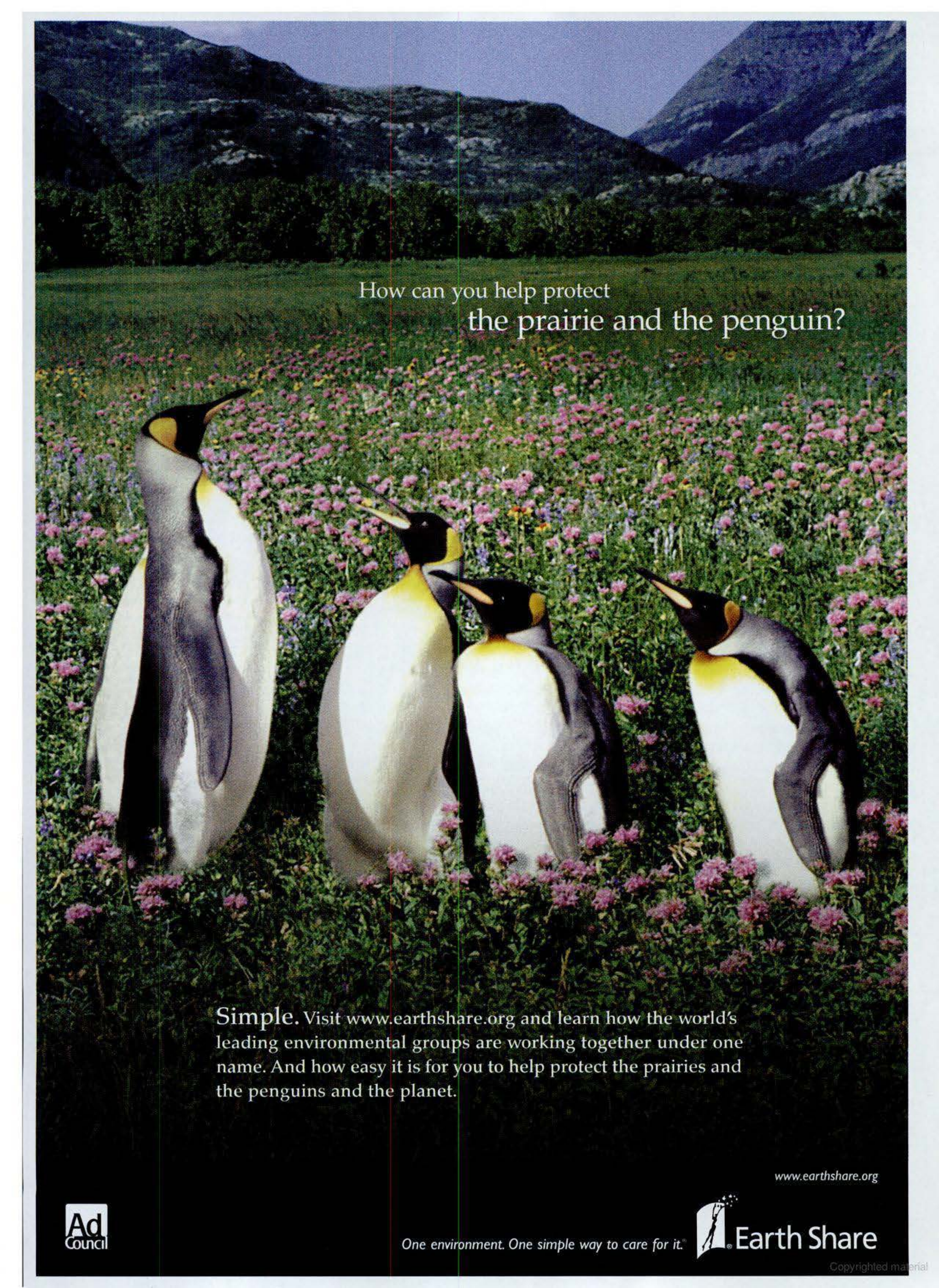
1. Open the expander by removing its rubber feet and the screws underneath them.
2. Remove the brown and blue power plugs and the brown power-supply board.
3. Desolder the existing antenna and replace it with an antenna mount.

ADD THE BATTERY

4. Install a fuse holder and a 10-amp fuse near the negative terminal of the battery.
5. Connect the negative lines, and separately the positive lines, from the cigarette-lighter socket, solar panel and battery.

ATTACH THE PANEL

6. Solder red and black leads from the circuit board to the DC-to-DC converter, and plug the converter into the lighter socket.
7. Stuff everything into a weatherproof box and mount it at head height, with the solar panel at a 45-degree angle.



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IN-FLIGHT SNACK

A rocket speeds away, fueled by an oxidizer and Oreo cookie filling.

GRAY
MATTER

ROCKET FOOD

Want to see a real sugar high? Launch a model rocket with Oreo cookies

FOOD CONTAINS an amazing amount of energy. If you don't believe it, feed some candy to a kid and watch him bounce off the walls. Of course, tot-baiting is only one way to turn food energy into noise and destruction.

A king-size Snickers has 541 Calories. That's calories with a capital "C," or 1,000 lowercase calories. A small "c" calorie represents the energy required to heat one gram of water by one degree Celsius. So that Snickers could theoretically heat a gram of water 541,000 degrees or, more realistically, bring a gallon and a half of water from nearly freezing to nearly boiling.

The energy in food is typically released when, through a complex biochemical pathway, sugars, starches and fats react with oxygen from the lungs. It's a form of slow-motion burning that, thankfully, rarely involves fire.

But you can liberate the same amount of energy in much less time by mixing the Snickers with a more concentrated source of oxygen—say, the potent oxidizer potassium perchlorate. The result is basically rocket fuel. Ignited on an open fireproof table, it burns

vigorously, consuming an entire candy bar in a few seconds with a rushing tower of fire. If you could bottle the energy of kids playing and turn it into a Molotov cocktail, this is what it would look like.

Of course, you can't actually fire a rocket with a Snickers bar; the nuts would clog the nozzle. Oreo cookie filling, however, works very nicely in standard model-rocket engines. (Caution: The Model Rocket Safety Code does not approve of filling rocket motors with highly reactive chlorate-Oreo mixtures.)

The thrust wasn't great, but my perchlorate-Oreo rocket did get off the ground—not bad for a half-baked confection. I could have used foods that are more sugary, including Pixy Sticks and Gummi Bears, to get a greater boost. But true so-called "candy rockets," an actual class of models launched by the more-enthusiasm-than-sense crowd, get the best thrust-to-burn-time ratio by using even purer sugar sources, such as sucrose and dextrose. Just don't try feeding those to the kids.—THEODORE GRAY

TURN SUGAR TO FUEL

2 HOURS | \$30

SAFE ||||| RISKY



1. Potassium perchlorate (the powder) provides oxygen for combustion just like air does, but in much more concentrated form, so the candy bar burns faster.



2. The fireball created by one king-size Snickers bar burns for about 10 seconds.

ACHTUNG! Theodore Gray is trained in lab safety procedures. Don't try this at home. See video of candy rockets at popsci.com/candy, and find more on Gray's scientific pursuits at periodictable.com.

I've slept
on air, springs,
water and
memory foams...



nothing beats my Tempur-Pedic!

Often imitated..never duplicated...
Tempur-Pedic makes other beds obsolete...

You've got to feel this miracle to believe it!
You'll enjoy luxurious comfort and rejuvenating sleep—like you've never experienced before with Tempur-Pedic's breakthrough technology.

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2 PANDORA

Tell Pandora (*pandora.com*) an artist or a song you love, and based on the "genes" of its sound—melody, orchestration and vocal character—the site will create a custom streaming radio station of other tunes you might like. Rate Pandora's choices, and it'll tweak future suggestions.

3 THE HYPE MACHINE

Pandora only lets you stream music; MP3 blogs give you downloadable files, often from new artists. The Hype Machine (*hype.non-standard.net*) culls the best songs daily from more than 100 blogs. Other sources for free downloads: Amazon.com offers dozens of free MP3s from all genres, and the iTunes Music Store gives away a song a week.

4 PODBOP

Built for live-music lovers, Podbop (*podbop.org*) finds bands playing in your area in the next few weeks, pulls free sample tracks from the band's site (or another legal source), and lets you stream or download them. You can even add bands to the site's database.

5 WEBJAY

Head to Webjay (*webjay.org*), a social playlist community owned by Yahoo, to stream tracks from thousands of user-created lists of songs with such themes as "Punk Rawk" and "Jazz Café Noir." —GINA TRAPANI

GEEK
GUIDE

CHANNEL YOU

You already have the tools to shoot short videos. Here's how to share them with the world online

HOME MOVIES DON'T have to be long and boring. Now that even the cheapest digital cameras can capture movies and nearly all computers come with free editing software, today's homemade flick can be just a few minutes—ideal for filming Johnny's first basket or making a hilarious short that'll turn you into a Web celebrity. Even these brief clips are too big to e-mail, but there are a number of free sites that host and play back your movies for you.

Google Video (*video.google.com*) and YouTube (*youtube.com*) are perfect for the occasional auteur; both let you upload individual movies and e-mail the link to family and friends. There's no limit to how

many videos you can post, and they stay up until you take them down. If you want to share flicks frequently, however—say, of Johnny's second, third and fourth baskets—you're better off setting up a video blog, or vlog, which gives you a fixed Web address that people can return to periodically. A vlog also gives visitors a subscribable feed, so grandma can get new movies automatically downloaded to her computer.

Playback on these sites isn't perfect, but that doesn't seem to matter. Already there are more than 7,000 vlogs, and some attract tens of thousands of visitors daily. So pull out your camera and start shooting. The world is waiting!—NICOLE DAVIS

POSTING YOUR VIDEOS ONLINE

10 MINUTES

FREE

EASY ■■■■ HARD

EDITING THE MOVIE If you have Windows XP, use Movie Maker, a free video-editing application in your Programs folder (Macs have iMovie), to edit footage and add titles or special effects. For optimum playback online, keep your final flick under 20 megabytes.

SHARE ONE VIDEO

1. Sign up at *youtube.com*, and enter the e-mail addresses of people with whom you want to share videos.
2. Click the "Upload" tab. Enter a title, a description and search keywords along with the "channel," or category, of film (for example, "family").
3. Select the movie you want to upload. Choose "Public" to share with everyone, or just pick people from your contacts.

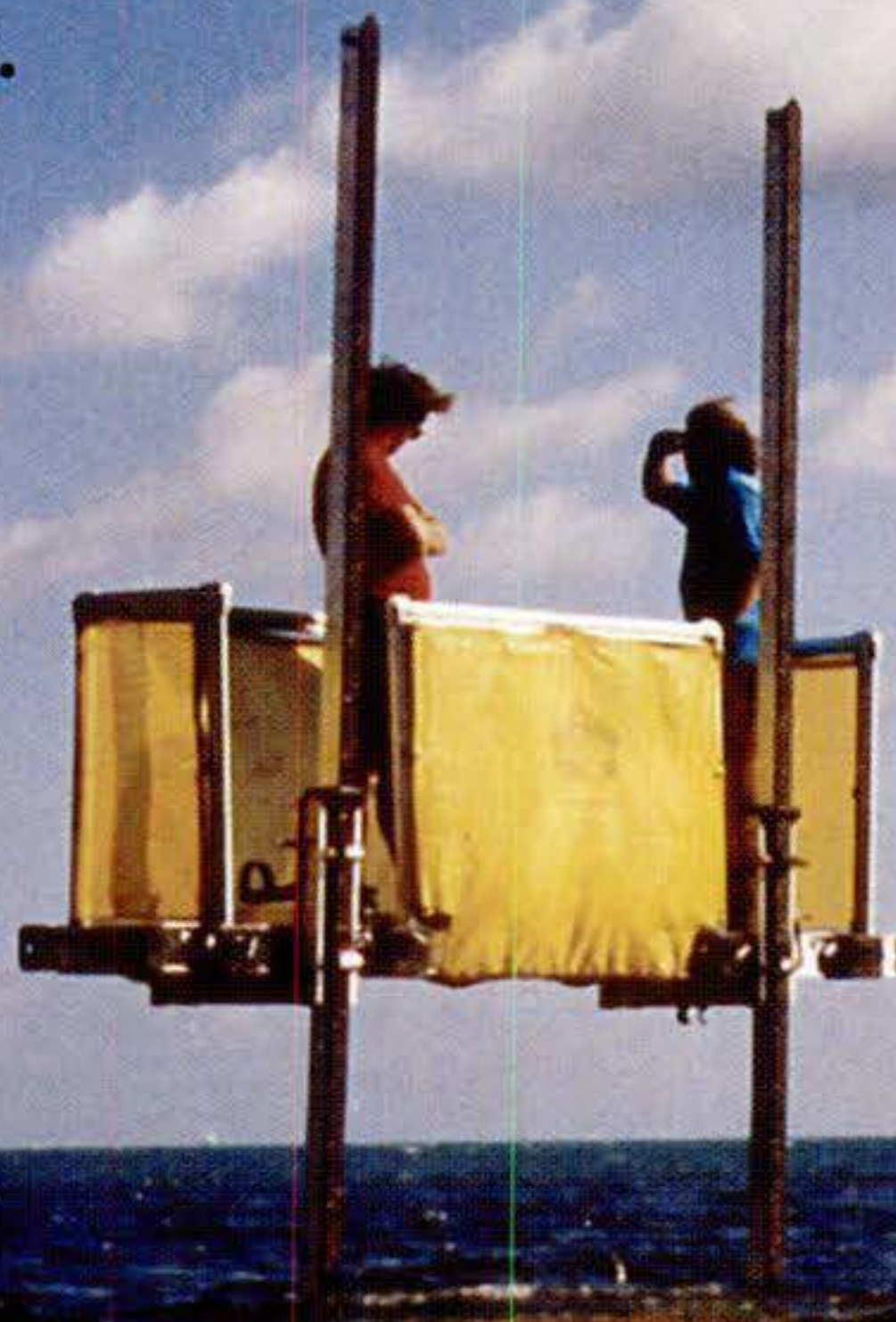
MAKE YOUR OWN VLOG

1. Create an account at *blip.tv*. Your screen name will be your URL (*screenname.blip.tv*).
2. Click "Upload Video," and enter the title and tags. Choose the file to upload. Click the "My Blog" tab on top, and e-mail the Web address to friends and family.
3. At the bottom of your page, visitors will find buttons that let them add a feed to iTunes, My Yahoo or an RSS reader to get automatic updates when you post videos.

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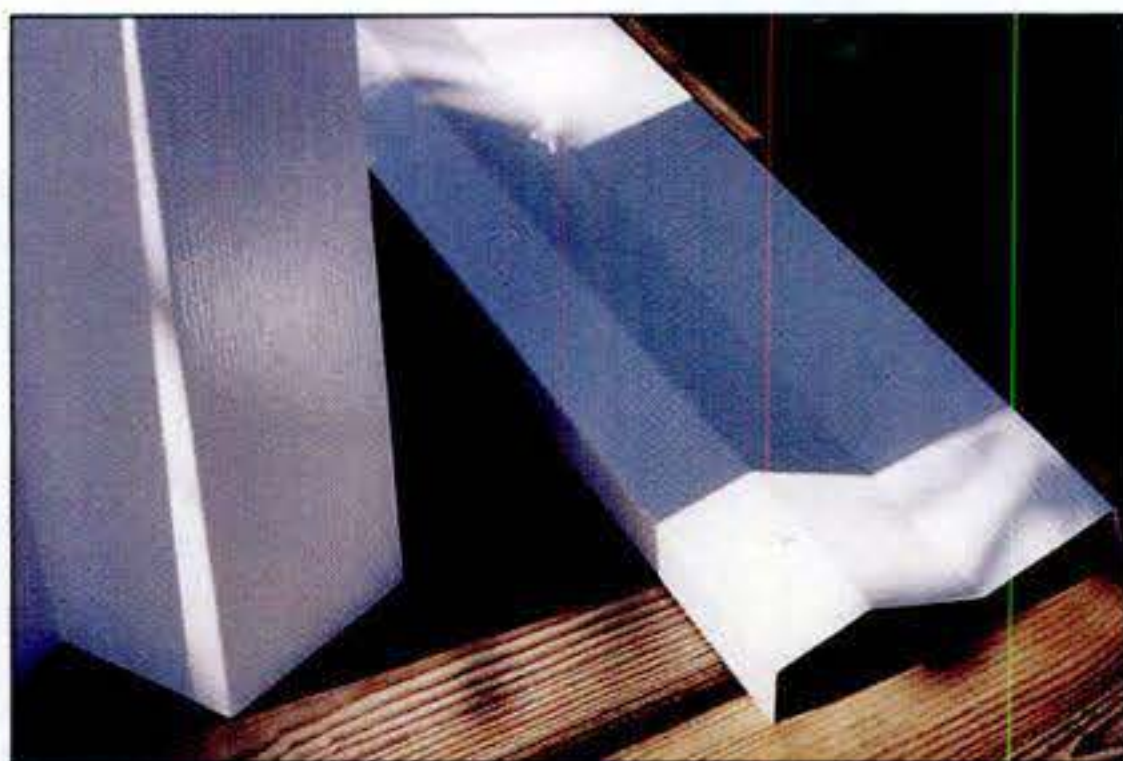
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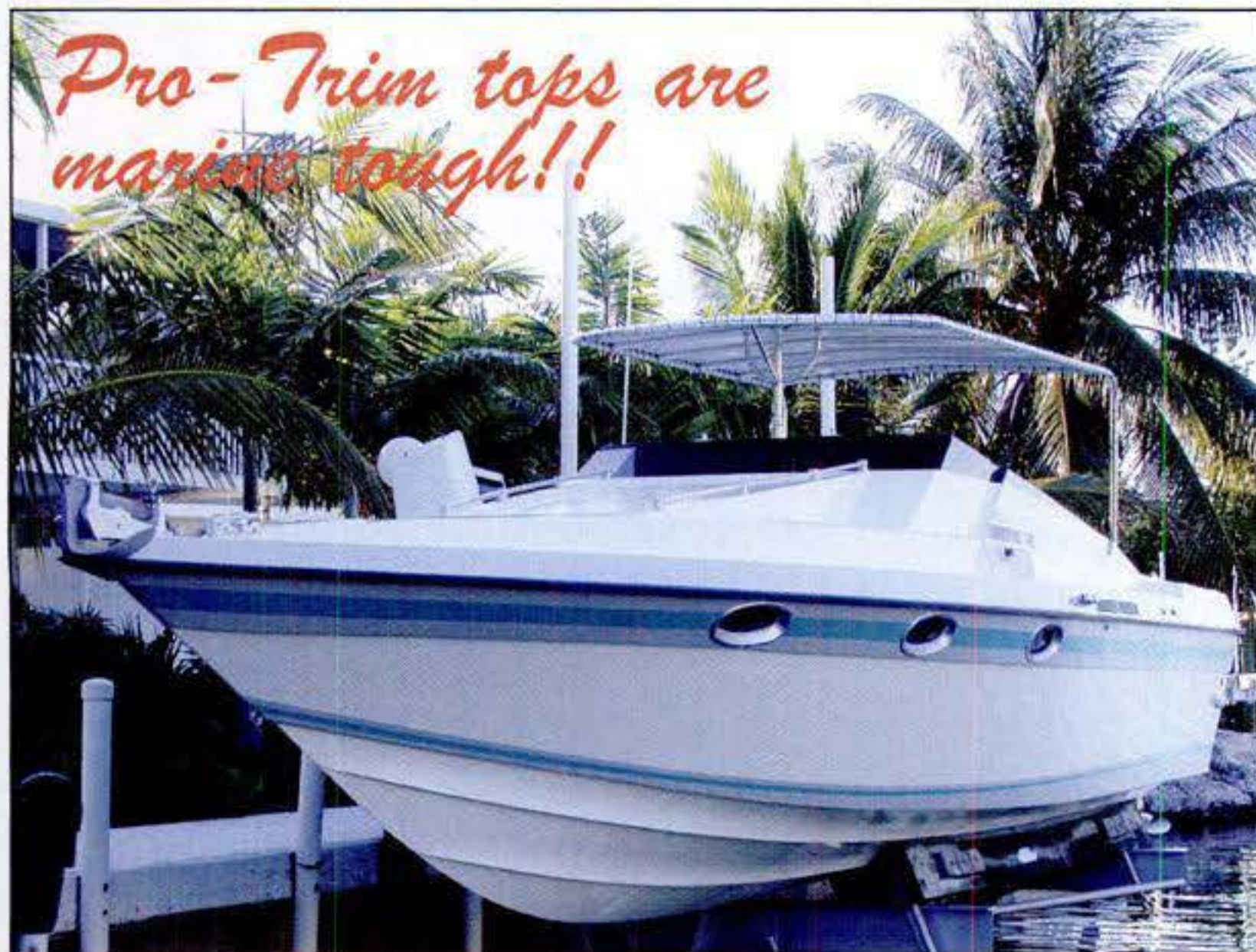


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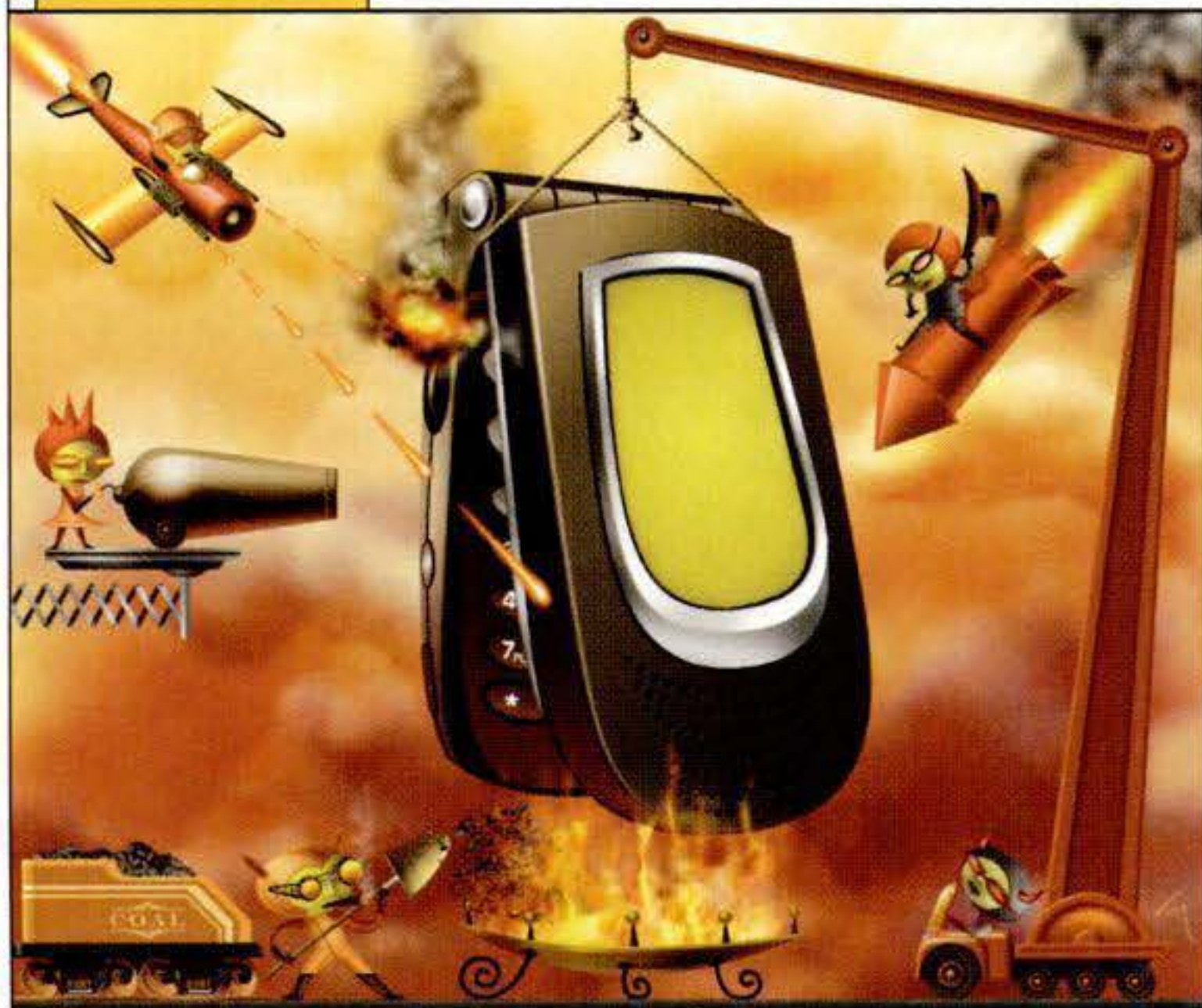
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ASK A GEEK

CAN VIRUSES ATTACK MY CELLPHONE?

IF IT'S A SMARTPHONE, you bet. In 2004, virus writers released Cabir, the first proof-of-concept virus that could infect smartphones through an open Bluetooth connection. So far, Cabir and the 175 other smartphone viruses in the wild haven't done enough damage to warrant headlines. But it's only a matter of time before there's enough financial upside for criminal hackers to begin seriously attacking smartphones. And then, watch out.

No smartphone? You're still not safe. A scam now common in Europe involves sending text-message spam that pretends to be a missed-call notice. Return the call, and you're unwittingly charged several dollars, just as if you'd called a 1-900 number.

A similar threat uses malicious code embedded in an innocent downloadable game. Once loaded, it secretly sends multiple text messages to costly premium numbers.

Here's how to protect yourself:

1. Never text or call back numbers you don't recognize.
2. Don't open unknown attachments or follow links from an e-mail.
3. Turn off Wi-Fi and Bluetooth connectivity until you need it.
4. Install smartphone anti-virus software, such as F-Secure Mobile Anti-Virus (\$35/year; f-secure.com).
5. Finally, read your phone's user manual to learn about its unique security features, and use them.

EUGENE KASPERSKY is head of virus research at Kaspersky Lab (kaspersky.com), an anti-virus software company.

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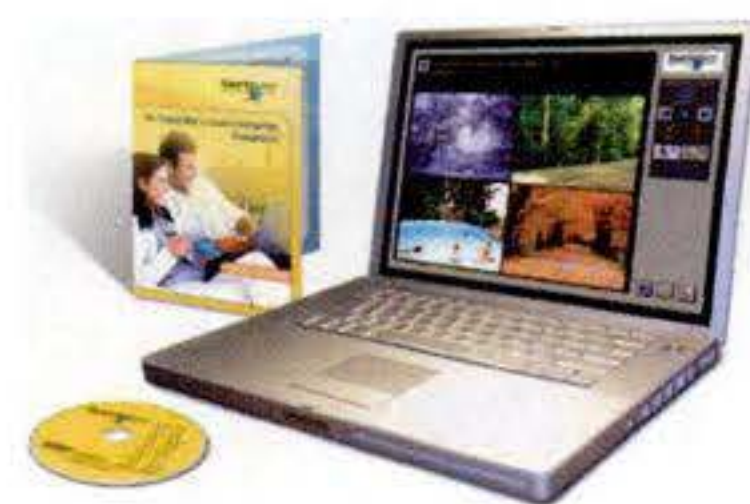
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3. Reading the ROM literature and reluctantly understanding it.
4. Taking a leap of faith and renting a ROM for 30 days.
5. Being highly impressed by the results and purchasing a ROM.
6. Becoming a ROM enthusiast and trying to persuade friends.
7. Being ignored and ridiculed by the friends who think you've lost your mind.
8. After a year of using the ROM your friends admiring your good shape.
9. You telling them (again) that you only exercise those 4 minutes per day.
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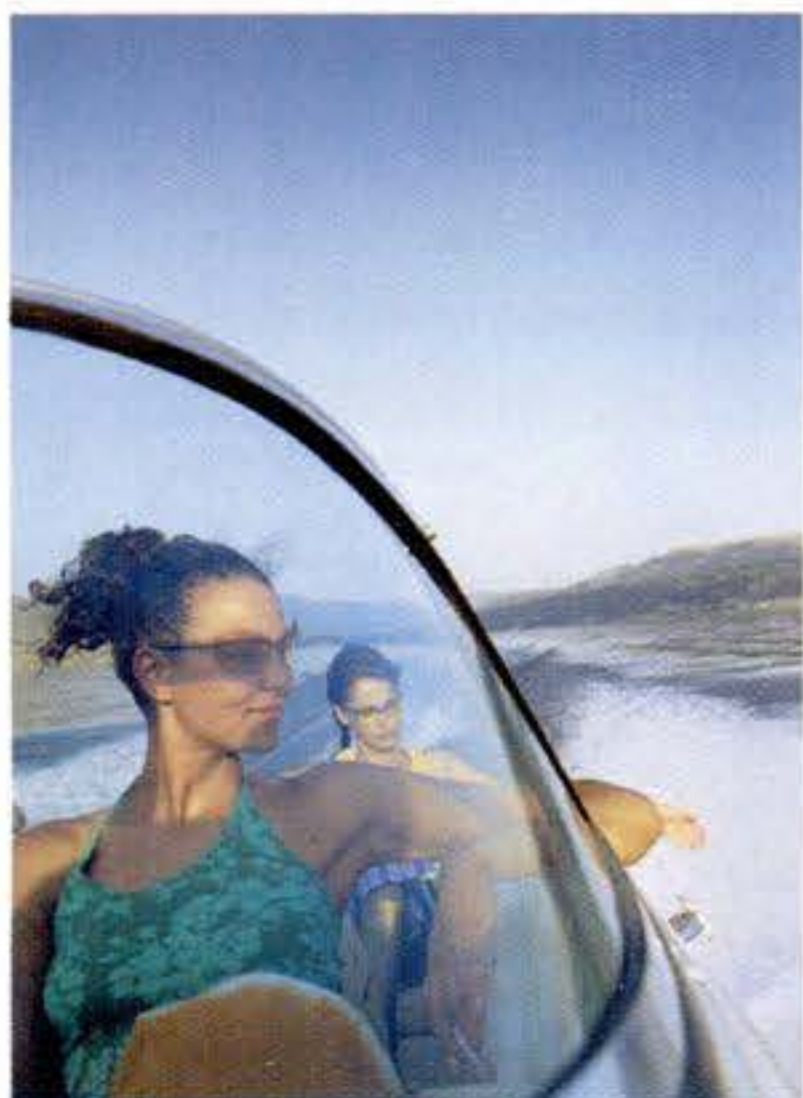
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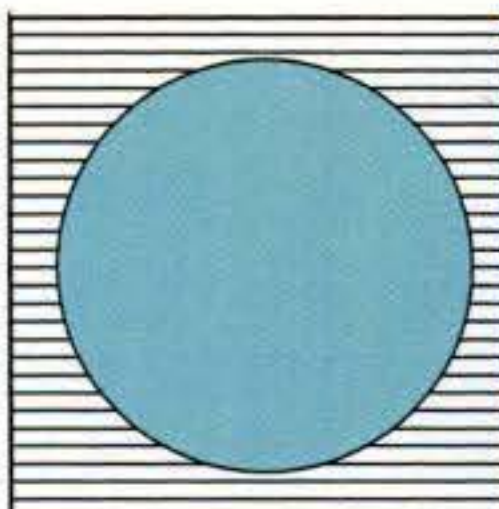
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FYI

81

For some scientists, size really does matter



MARS ATTACKS
Forget it. You'll never blow up Mars.



My brother and I have a bet: Would it be possible to blow up Mars?



In a word: no. It would be impossible to destroy the Red Planet with any device scientists can build, let alone finance. Planets can survive enormous assaults; the Hellas Basin, a Martian crater about 1,300 miles wide, testifies to the planet having once collided with an asteroid so massive that the impact generated well over a hundred million megatons of energy. If a meteoroid that size were to hit Earth, it could wipe out life on an entire continent. In contrast, the most powerful nuclear weapon ever tested, Russia's "Tsar Bomba," had a yield of only 50 megatons, and most countries' nuclear arsenals consist of bombs in the range of 200 kilotons to 400 kilotons—in planetary-impact terms, the equivalent of party poppers. Faced with an object as robust as a planet, there is no way a

nuke—or all nukes—would work. And even the mightiest of meteorite impacts haven't destroyed Mars or the Earth, explains planetary scientist Edward Scott of the University of Hawaii. "The amount of energy needed is so preposterous that it could never happen."

But what if we could build a radically more powerful weapon, one that would unleash, say, a billion *billion* megatons—roughly the amount of energy the sun produces in a month? According to planetologist Gary Peterson of San Diego State University, the strength of the gravitational field that Mars's mass creates would render even this colossal effort a failure. "You could have the biggest explosion possible, one that would tear the planet apart, but the pieces of rock would just clump right back together again," he says. A more realistic and productive endeavor for nukes in space, he adds, would be finding a way to pulverize smaller asteroids flying too close to Earth for comfort.

—ELIZABETH SVOBODA

Q What is the smallest animal found so far?

A It's complicated. When most people think "animal," they generally mean "vertebrate." As it turns out, scientists around the world are arguing over who has the smallest one—and all the contenders are fish.

The feud started in January when a team headed by biologists Maurice Kottelat of the National University of Singapore announced that it had discovered the world's smallest vertebrate, a miniature carp living in acidic peat swamp forests on the Indonesian island of Sumatra. The transparent *Paedocypris progenetica* is less than a third of an inch long and lacks the top of its skull.

But in their report on the new species, the scientists overlooked an earlier discovery by biologist Ted Pietsch of the University of Washington. A paper Pietsch published in September 2005 in *Ichthyological Research* describes a male anglerfish measuring a mere quarter of an inch. Collected in deep water in the Philippine Sea, *Photocorynus spin-*

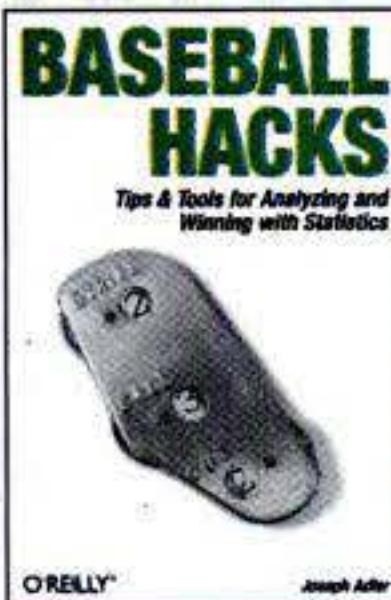
BOOK

BASEBALL HACKS

Looking for an edge in your Rotisserie league? Some way to better analyze players' statistics before you make a crucial mid-season trade? *Baseball Hacks*, by computer engineer and stalwart New York Yankees fan Joseph

Adler, will help you parse all that incoming data by teaching you how to 1) keep box scores, 2) build a database, and 3) automate the number crunching. The tech level required to

appreciate the book is high—there are Perl scripts and MySQL tips peppered throughout—but if you're willing to work through that, this tome will make you King of Baseball Stats. Not to mention win you all that cash and glory. O'Reilly; \$25

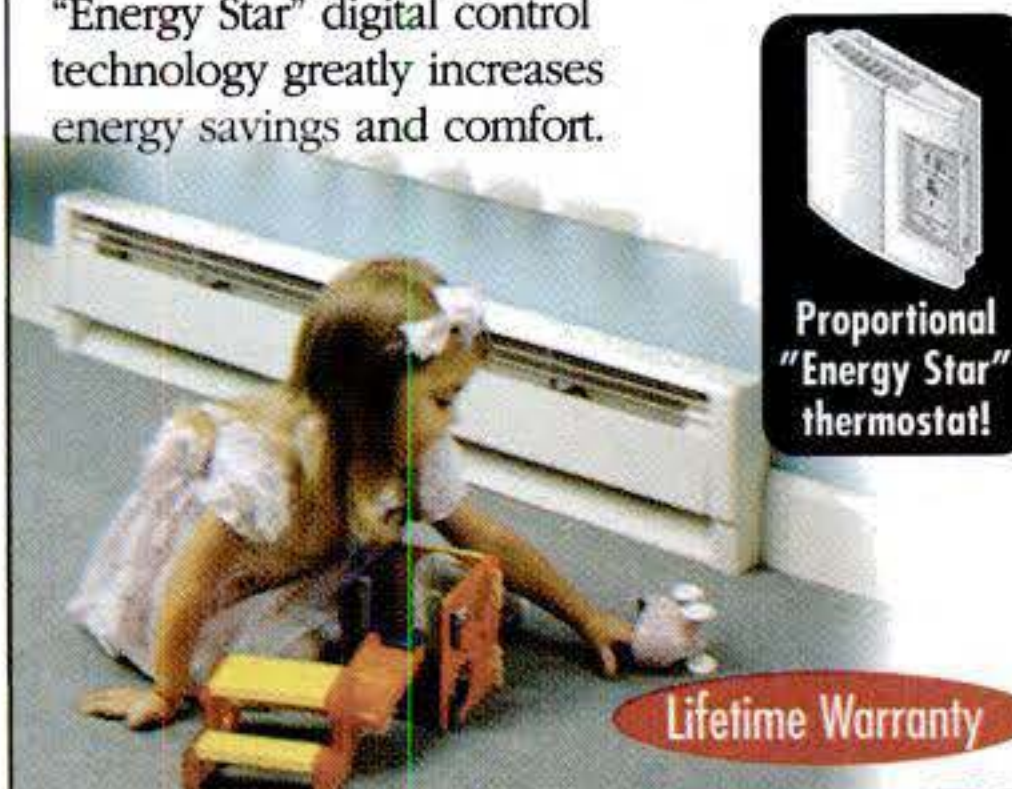


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ceps attaches itself to its mate for life by biting onto her side, back or belly.

Pietsch's fish may be the smallest on record, say his foreign rivals, but it doesn't qualify as the smallest fish *species* because the female anglerfish [photograph, right] is more than seven times the size (measured from tip to tail) of its mate. The male, which has huge eyes and testes, is basically just a parasite. (Pietsch is quick to point out that the male anglerfish is not a total degenerate—it does have other body parts; they're just less prominent.)

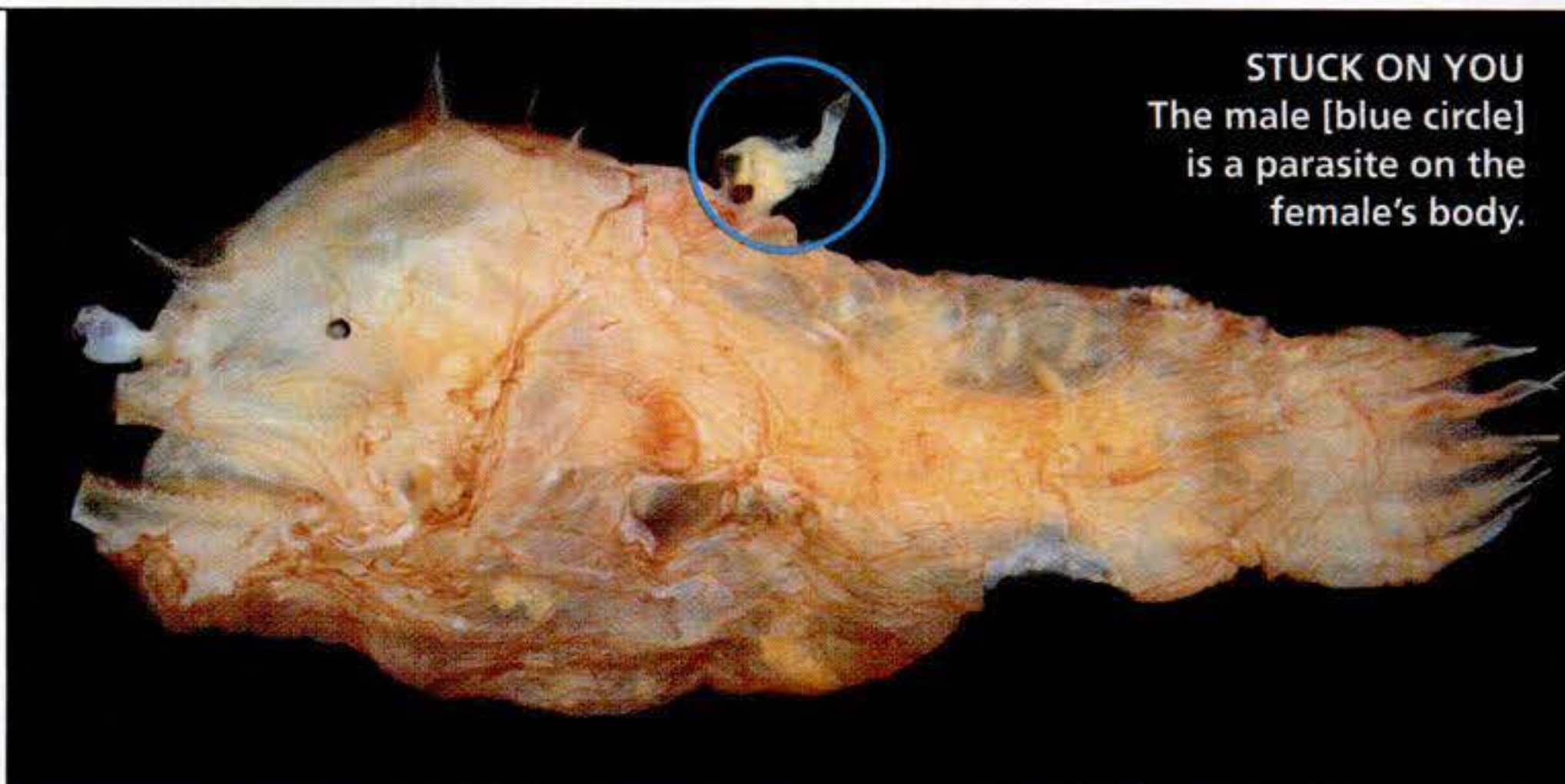
A third team of scientists who described yet another species of tiny fish in 2004 wonder why their colleagues are so hung up on length. H.J. Walker of the Scripps Institution of Oceanography and William Watson of the Southwest Fisheries Science Center, both in La Jolla, California, point out that even if *Schindleria brevipinguis*—a Great Barrier Reef inhabitant better known as the stout infantfish—isn't

shorter than the other contenders, males and females alike are so slender that some weigh as little as 0.7 milligram. That's less than a mosquito—and either of the other two species.

One may wonder why scientists care at all. In fact, they hope to understand the limits of vertebrate physiology and why some fish evolve to become so tiny. One theory is that small

size helps the fish survive in nutrient-poor habitats such as peat swamps and the deep ocean. Another theory posits that small size helps them evade predators.

As for the other end of the scale, there's no contest. The blue whale, which can grow to more than 100 feet long and weigh upward of 150 tons, is the biggest.—DAWN STOVER



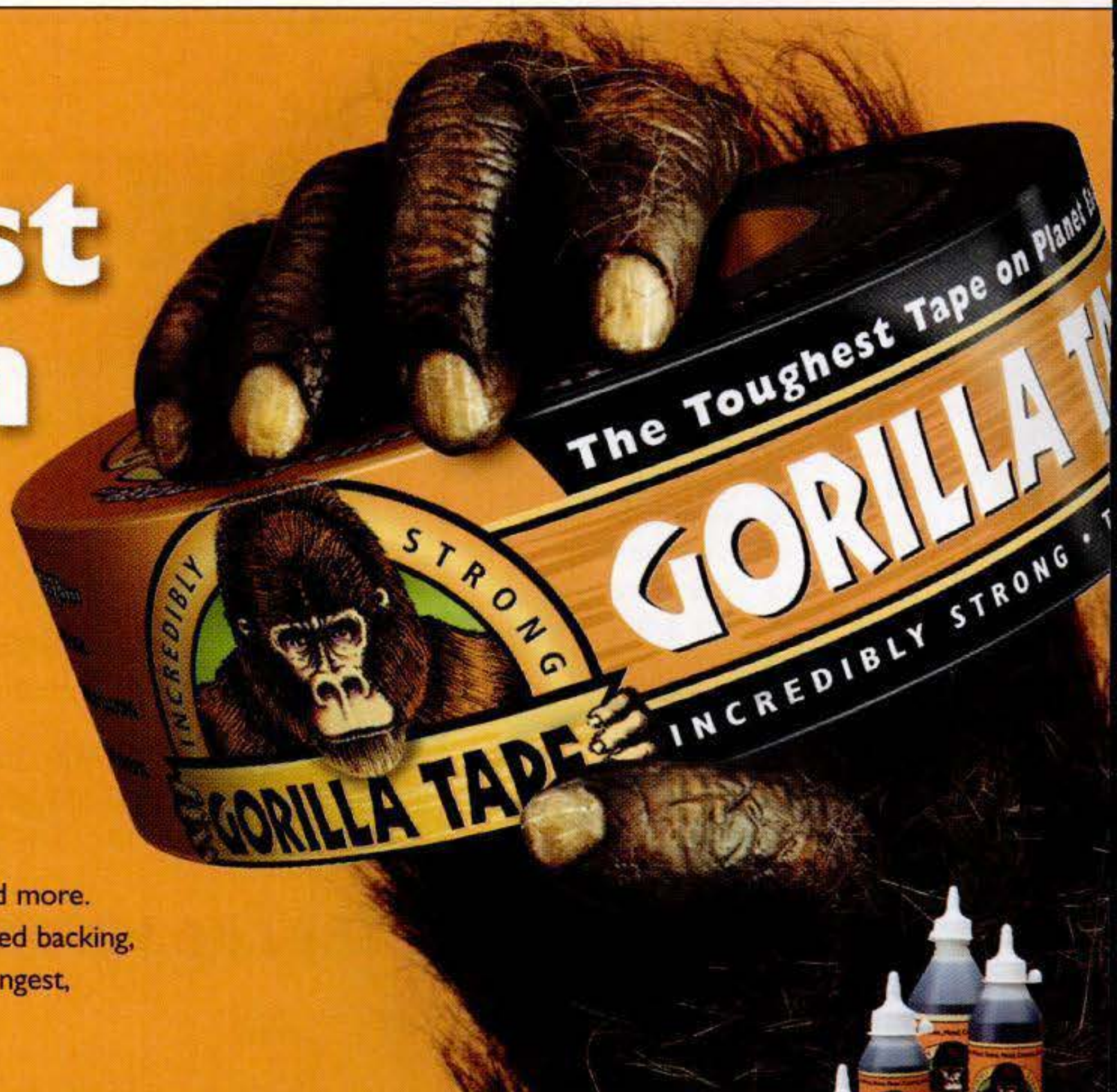
STUCK ON YOU
The male [blue circle] is a parasite on the female's body.

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Professor David Zarefsky's lectures are filled with examples of actual controversies, but his perspective takes us beyond individual disputes so we can see the structure of all disputes. This perspective orients us within any argument, so argumentation can be seen clearly as an exchange, and not just a flurry of words.

What You'll Learn

The lectures reveal several striking facts that can make argumentation accessible and familiar to you.

- The tools of formal logic, while essential and even definitive for mathematics and programming computers, are inadequate to decide most controversial issues. For example, the ideal of deductive reasoning, the syllogism ("All men are mortal. Socrates is a man. Therefore, Socrates is mortal.") is rarely used in real argument largely because it is useless.
- Arguments fall into a handful of distinct categories—and the same issues are at stake each time one of these patterns occurs.
- There are six kinds of evidence that can be advanced to prove an argument that something is true—and the same tests for truth can be applied to these types of evidence every time.
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Debating the meaning of courage. Alcibiades (wearing military garb) with Socrates (seated)

that seeks to persuade through reasoned judgment, and it is a deeply social and cooperative practice. (Although there are times when winning an argument rather than finding the truth is prized, that is not why most of us exchange arguments.)

The course does not require any special prior knowledge or training.

About Your Professor

Dr. Zarefsky is the Owen L. Coon Professor of Argumentation and Debate and Professor of Communication Studies at Northwestern University, where he has taught for more than 30 years. The Student Government of Northwestern has elected Professor Zarefsky to the Honor Roll for Teaching 13 times.

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(CONTINUED FROM PAGE 58)

WIRED WAR

thinnest of threads. There's no way for him to get on any collaborative Web site from here. Most of his men are out of reach, scattered throughout the town. Many don't have radios; traditional

spill into the yard in front of a large dwelling. Soldiers crowd the front door, pounding with closed fists and yelling in Arabic. Women and children dart around corners and disappear into rooms. Tired men scurry outside, obviously spooked.

Feldmayer doesn't like the aggression. "Just take it easy," he tells the Iraqi

conversation and urges the man and the interpreter around a corner. "He says he knows who the bad guys are around here," Feldmayer says. The interpreter takes notes as the informant rattles off names and addresses. If the Pentagon's vision of networked forces were realized here, he would be typing into a handheld computer, wirelessly connected to a network. The names would immediately be cross-checked with databases of known guerrillas and disseminated to local commanders. But for now, the patrol's interpreter writes down the Ad Duluiyah suspects on paper, using a pencil.

It's at this point, just beyond the edge of the American network, where the guerrillas are best connected. Using disposable cellphones, anonymous e-mail addresses at public Internet cafés, and "lessons learned" Web sites that rival Cavnet, disparate guerrilla groups coordinate attacks, share tactics, hire bomb makers, and draw in fresh recruits. It's an ad hoc, constantly changing web of connections, so it's

The insurgents in Iraq, observes one expert, "are more effectively wired than we are. They have a worldwide, secure communications network. And all it cost them was two dinars."

Army fighting doesn't call for individual soldiers to be separated from their squad very often.

Feldmayer follows the Iraqi soldiers he's been teamed with across a dark, muddy, pothole-riddled yard. A locked gate bars the way to a group of houses. One of Feldmayer's U.S. soldiers blasts it open with a shotgun, and the men

troops through the patrol's interpreter, to the civilians' palpable relief. One of the men gathered in the yard gestures to the lieutenant. Feldmayer grabs the interpreter and shakes the Iraqi man's hand. "Salaam," Feldmayer says. The three put their heads together, muttering in English and Arabic.

Suddenly Feldmayer cuts off the

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hard for U.S. spooks to know where to listen in next. It also lets the insurgents keep a loose command structure, without much hierarchy—just like the network-centric theorists call for. Even if their communications are compromised, only a small cell is exposed, not the entire insurgency. “They’re more effectively networked than we are,” says Hammes, the guerrilla-war expert. “They have a worldwide, secure communications network. And all it cost them was two dinars.”

To compensate, some American soldiers are buying their own gear: \$50 Motorola walkie-talkies, so they can talk to their squad mates; \$160 Garmin GPS receivers to make up for FBCB2’s gaps. It’s quicker than waiting for the wheels of the Pentagon bureaucracy to turn. At the Defense Department, there’s widespread recognition that it needs to get its frontline soldiers wired up. Pencil and paper just won’t do.

The technologies being readied, however sluggishly, could be a huge help to soldiers on patrol, like Feld-

mayer. The Warfighter Information Network–Tactical, or WIN-T, is a mobile wireless Internet for combat, scheduled to deploy early in the next decade.

Also in the next decade, the Joint Tactical Radio System (JTRS) should start replacing the military’s tangle of analog radios with compatible digital models. Another project, Land Warrior, is a new set of soldier uniforms, packed with electronics and communications gear. Once it’s completed—perhaps by 2008—FBCB2-style information will appear on more than just a Humvee screen. It will flow to the infantryman, through a monocle-like display mounted to his helmet. Every soldier will see where his fellow fighters are.

If only these programs were progressing as planned, but each has been bogged down by lengthening to-do lists and sets of system requirements. JTRS recently went through a massive reorganization after billions of dollars were wasted. Land Warrior, started in the mid-1990s, is years behind schedule; managers are hoping that a 440-soldier

test this summer will put it back on track. For now, all Army acquisition chief Lt. Gen. Joseph Yakovac will say is that “we continue to have that vision” of a networked infantryman.

MISSION’S END

After hours of barreling down highways, blasting open locked gates, and pressing terrified Iraqis for information, Charlie and Alpha companies trickle home from Ad Duluiyah. Feldmayer’s Humvee is the last to leave, towing the sniper section’s broken-down truck. Feldmayer stares into the cold dark of the early morning. His shoulders sag. In his pocket, he carries the insurgent list he coaxed out of the Iraqi informant. His sergeant gripes about missed firefights. But Feldmayer just nods, his arm draped on the blank screen of the BFT.

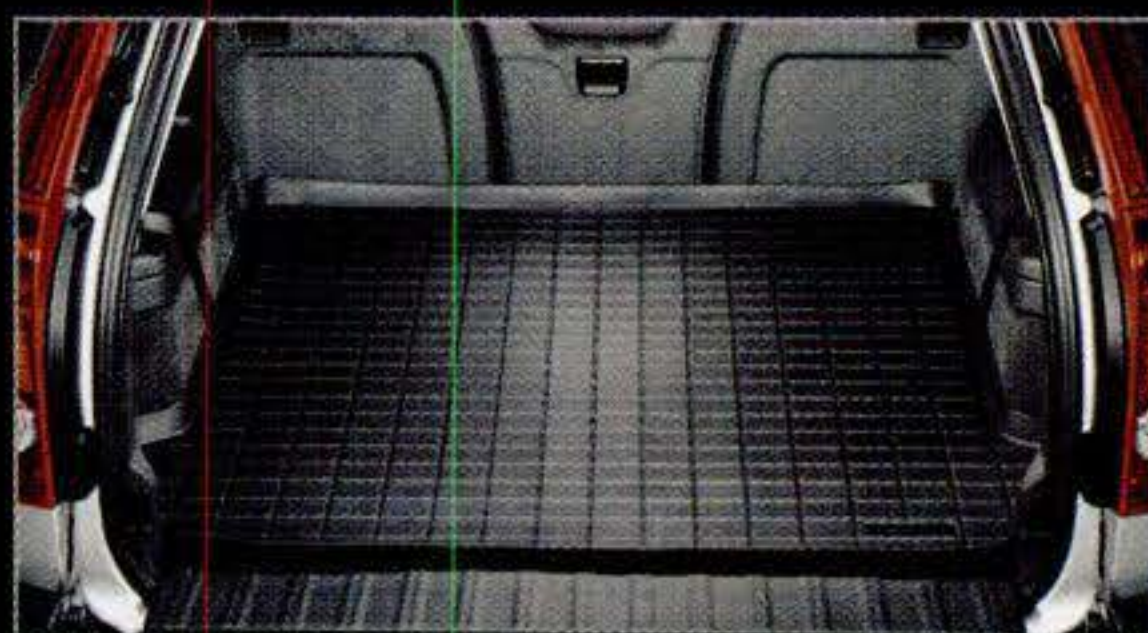
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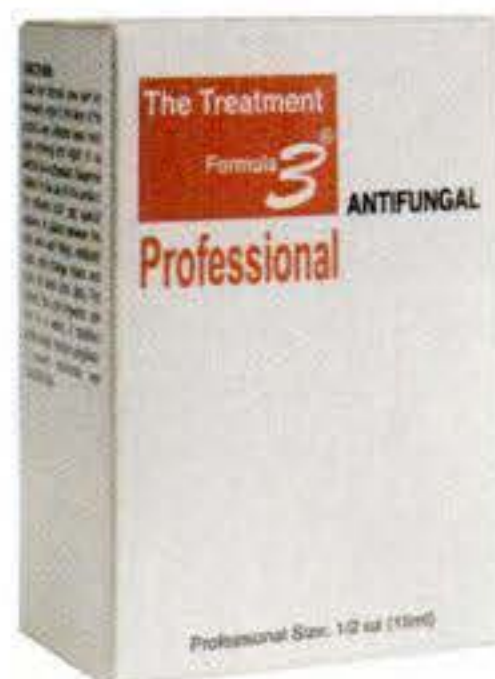
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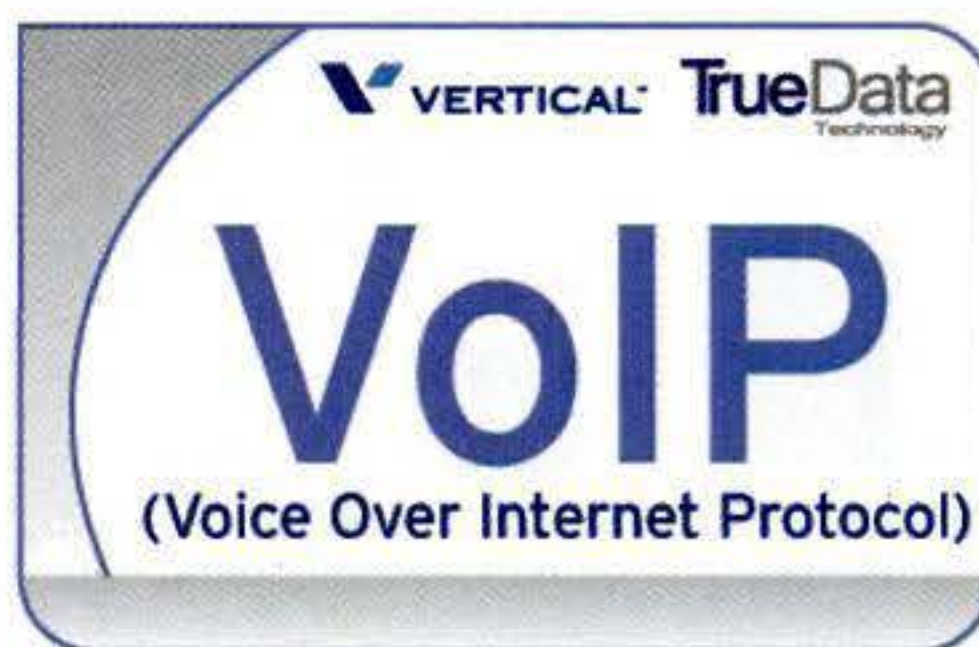
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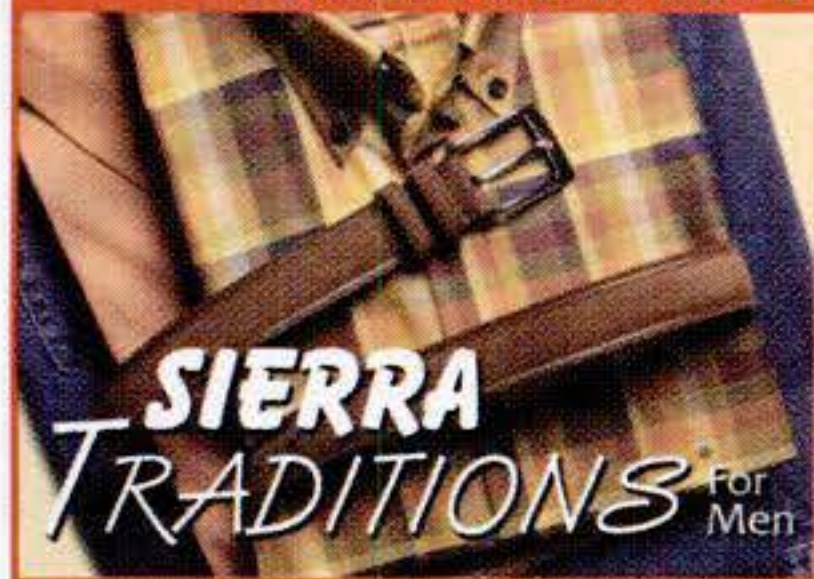


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THE FUTURE OF MOVIES

RETURN OF THE

(CONTINUED FROM PAGE 68)

3-D

and Real D films require. In-Three's system, like Real D's setup, uses a digital projector that fires alternating images at the screen. But instead of using polarized filters to distinguish frames meant for each eye, In-Three's glasses do the job electronically. Andrew Cleveland, In-Three's principal engineer, points out a small infrared emitter sitting at the base of the digital projector. When the frame for the left eye appears onscreen, this emitter sends a signal to the glasses to block light coming into the right eye. Within 300 microseconds, liquid-crystal cells turn the right lens opaque. One frame later, the process reverses—the right lens becomes clear while the cells block the left lens. The technology isn't entirely new, only the application. Professional versions of the glasses can sell for as much as \$800, but In-Three hopes to

get the price below \$20. The main advantage of this system is that theater owners won't have to install a costly silver screen. The downside is that they'll need to purchase several hundred pairs of the glasses, plus a cleaning machine to sterilize them after each use. They will save a few dollars (the numbers aren't solid just yet) but inherit a few more hassles.

THE RETURN OF THE KING

One of the first chances you'll get to experience In-Three's technology should be next spring, when the 3-D-remastered *Phantom Menace* is set to hit theaters; the five other movies in the *Star Wars* series will follow. Lucas spread the word to other major directors, and In-Three now has at least one more major project in the works, widely expected to be a 3-D rerelease of Peter Jackson's *King Kong*.

For the next few years, 3-D rereleases of old and new classics will be

(CONTINUED ON PAGE 90)

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THE FUTURE OF MOVIES

RETURN OF THE

(CONTINUED FROM PAGE 87)

3-D

the primary role of conversion. But with its work on *Superman Returns*, IMAX has accelerated the race for an even bigger prize: the ability to release converted films on the same day as the original movie. Right now it can take months, even a year, to convert a movie, and no studio will keep a film on ice that long while the "dimensionalists" do their magic. That's why IMAX is converting only 20 minutes of *Superman Returns*. Any more would be too time-consuming, Murray says. "It's a very tough thing to do when you want to do it quickly and you want it to be really good and imperceptible."

The other option for generating more content, of course, is filming in 3-D. In this case, too, the timing is right. 3-D cameras are smaller and easier to handle now than they were even five years ago. And directors will also be able to fix their 3-D



filming gaffes. One of the problems with shooting 3-D has been that what looks good through the camera's eye may prove uncomfortable for viewers in the theater. But these days, instead of reshooting the scene, directors can just take a 2-D version of the scene and have it dimensionalized. In-Three has been involved in several tests of the system, tweaking the film after the fact to create a 3-D effect that's visually pleasing but easy on the eyes.

And that is where all this may be headed: Give the moviegoer a more immersive experience by making a richer, more complete recording of the world. Cameron and Landau are already using 3-D for at least two upcoming feature releases: the sci-fi epic and a love story. As the technology matures, more players are sure to follow. "The real question is, Why wouldn't you do 3-D?" asks Landau. In the minds of many in Hollywood, that question has already been settled.

Gregory Mone wrote about Hollywood's star science adviser in the March issue.

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my foot and I wouldn't feel it! Now, my children tickle my feet! MS victims should e-mail me!" Also, it kills only bad bacteria smells in septic systems, wells and municipal waste lagoons... any other water allows bad bacteria to incubate and grow to alarming levels! Bottled sports drink manufacturer: "We added only 1% of your water to a tank with 6000 CFU's/ml of bacteria and let it incubate for 5 days. Instead of going up (as expected), it went below our QA standard of 10 CFU's/ml!! This is the only water we will use in our liquid products. Thanks for your contribution to the health and welfare of mankind!" Remember the FL AIDS dentist 1990 (CBS 60 minutes)? Also, 4,000

dental water lines averaged 375,000 CFU's/ml of water and some had 1,200,000 CFU/ml because in-house distilled water often had 100,000 CFU's/ml and the bacteria can double in only 20 minutes! People don't die in the chair because diseases have different incubation periods. Now, can you see the important of this discovery...the first in history?

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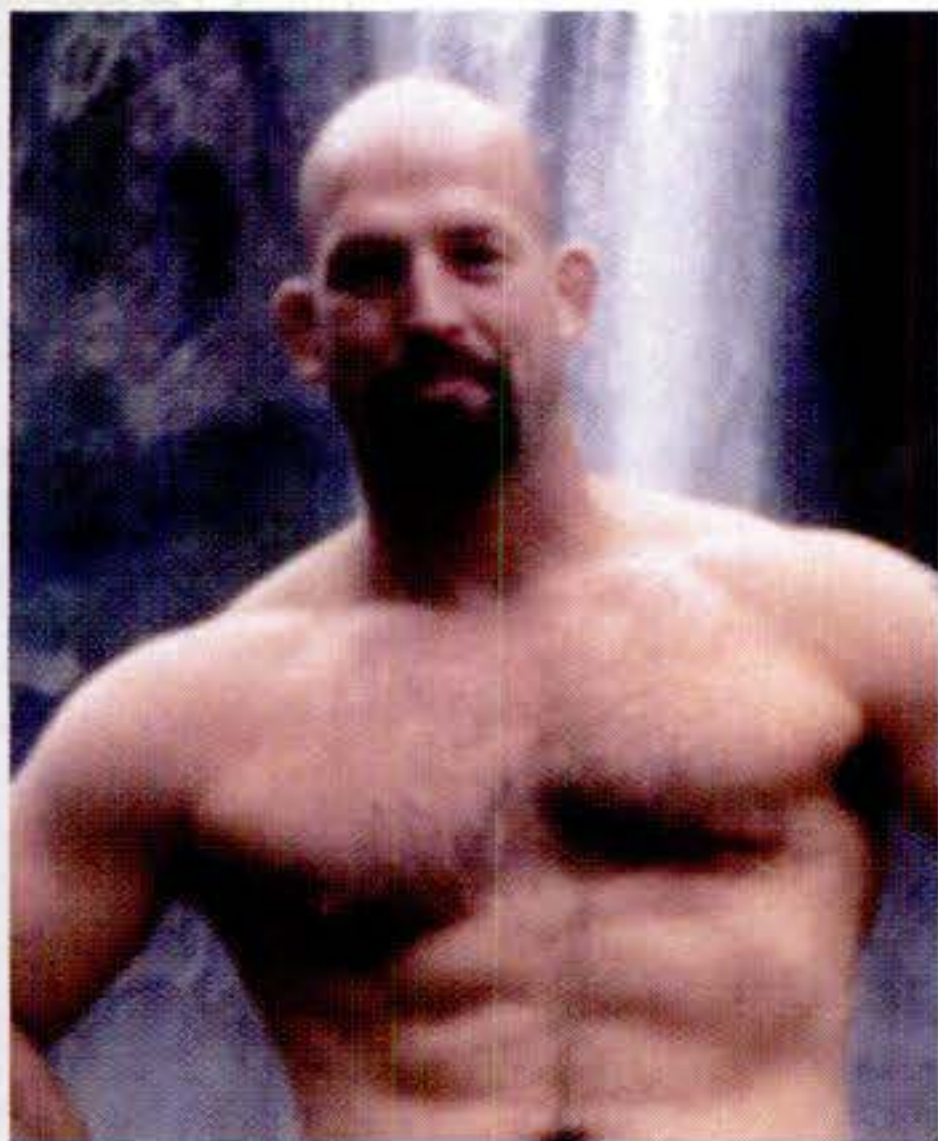
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By Matt Furey

Best-selling author of **Combat Conditioning**

I was the total skeptic. Not only had I lifted weights and run long distance for years, but I had major success under my belt, including a world kung fu championship and a national collegiate wrestling title.

So I just didn't want to believe what Karl, a 76-year old man told me about exercising **WITHOUT** weights... and **WITHOUT** long-distance running.

Most importantly, I didn't want to hear that a good exercise program only took a few minutes. Hate to admit it, but I was addicted to the "hard work or nothing" mentality and refused to believe you could get into the best shape of your life by doing **LESS**... not more.

Let me tell you, when I looked at this so-called "old man's" physique and watched him demonstrate his exercises, I could not look the other way. I had to check them out for myself, even if it meant saying, "Okay, I've wasted a lot of time doing it the wrong way."

What I discovered shocked me from head to toe!

Before I met Karl I **THOUGHT** I was strong. I thought I was tough. But the exercises he gave me exploited every weakness that weights and running could not cover. In a matter of minutes, I knew Karl "had me."

So I gave up the weights and began a routine of bodyweight calisthenics called **Combat Conditioning**. After all, when a man of 76 can do things that a 36-year old cannot do, that tells you that "Yes, there's gold in them there hills."

The exercises I learned had such a profound and dramatic effect on me, that for six years I have been introducing men and women of all ages and of all backgrounds to this extraordinary program – and the results are shocking, awe-inspiring and **PROOF** that this system works, and works **FAST**.

Who is Combat Conditioning for?

It's for the hard-working man or woman who often finds it difficult to squeeze in a quick workout.

It's for the traveling executive who sleeps in hotel rooms more than at home.

It's for those who have trained their whole lives on weights.

It's for athletes, martial artists and the military.

And .. **IT'S FOR** the man or woman who hasn't done a lick of exercise in decades.

Even One Minute a Day Brings Results!

Unlike other exercise program where you are told you **MUST** do 30 minutes of cardio per day and an hour of weights, to get results, **Combat Conditioning** is totally different. 15 minutes is all it takes to whoop the hardcore trainee. But for the total beginner, he or she can get results starting with **ONLY** one minute a day. And no, this is not a joke.

Time is not the issue!

Forget all those workouts that take all day. With **Combat Conditioning**, all that's required is your own



Matt Furey

won a national collegiate wrestling title in 1985 and a world shuai-chiao kung fu championship in 1997. Furey has a knack for taking the average and ordinary person and transforming him with his powerful programs. Furey was inducted into the Edinboro University Athletic Hall of Fame in 1998 and spends much time each year traveling

throughout the world, searching for the very best information available to his world-wide audience. His website, www.mattfurey.com, is one of the finest in the world, giving valuable information that changes lives.

body and a tiny "get started NOW" decision to **DO** a little something each day.

The key to your success is in the magical, transformative power of these exercises – not in your belief system about hard work. For many people, just one rep is all they can do at first, and they're shaking like a leaf on a windy day in Chicago. And so, that's all that person should do at first. Even if you think you're not doing enough – the exercises work their magic anyway. Your body has it's own intelligence and will work **FOR YOU** if you'll simply get out of the way and let it.

When you do, pretty soon you'll be the type of person who can do 2, 4, 8, 16, 32, 64 or 128 repetitions and feel no fatigue. Instead of tiredness you'll feel exhilaration and **ENERGY**. You're building strength and endurance from the **INSIDE-OUT**. And believe me, once you can do more than a few reps, inches of unsightly fat and pounds of excess flab will fly off your body at break-neck speed.

New Results from Forgotten Exercises

Are the exercises in **Combat Conditioning** **NEW**? Well, not really. They go back about 5,000 years – but for the most part, they got lost in the shuffle when weights, gadgets and gyms came around. So although they aren't **NEW**, they're "New to YOU!"

Before I learned these exercises, I read about the Great Gama of India, a wrestler who followed this program and was unbeaten in 5,000 matches. I also read that the legendary Bruce Lee did these exercises, too. And we all know about Lee's incredible martial arts skills. Then there was the All-Pro NFL running back, Hershell Walker, who did bodyweight exercises each day. The list goes on and on. The key is in having a proven program with a track record, and **Combat Conditioning** is just that.

Puts You into the Old Clothes You Dream of Wearing Again!

The main reason why **Combat Conditioning** works is because it targets all the weak links in your body. And when all those weak links are given a little attention, your entire body gets stronger, faster, more powerful and more energetic. Spend time each day doing a few functional exercises and the payoff is **HUGE**.

You get functional strength, endurance and flexibility – all at the same time. Not to mention seeing the excess inches flying off your body, making it easy for you to fit into the clothes you dream of wearing again. Stop dreaming. Start **DOING**. And get results.

12 Ways Combat Conditioning Will Change Your Life!

Follow this program and your body is going to change big time. In fact, I've made a list of 12 of the most powerful benefits that hundreds of thousands of others all over the world have gotten from the **Combat Conditioning** program. Let's take a look:

1. **Cranks up your metabolism so you**

burn excess body fat a lot, lot faster. This means fitting into the clothes you WANT to wear.

2. Packs attractive and healthy functional muscles (not grotesque) onto your entire body
3. **Simultaneously doubles your strength and flexibility – and does so without needing separate workouts for each.**
4. Quadruples your endurance inside of 30 days. Never get tired again.
5. **Within a couple weeks, it often eliminates chronic back and shoulder pain from years of heavy squats, deadlifts and bench pressing – or other forms of abuse.**
6. Sleep like a log. Eight hours of deep sleep is no longer a goal. It's automatic. As soon as you hit the rack you're out like a light.
7. **Your self-confidence will have no bounds. Especially when you got compliments from people who hardly paid attention to you before.**
8. You can train anywhere. You don't need more than a few square feet of carpet or pavement and you're all set. You don't need equipment. Just your own bodyweight.
9. **You get a kick-butt workout done in 15 minutes or less.**
10. You'll turn back the clock. Friends may tell you that you look 5–10 years younger.
11. **You'll have an explosive type of strength that weights cannot give you. Your every movement will be lively and full of vigor.**
12. Your muscles will be pliable and powerful, like a tiger's.

Here's How to Order

Combat Conditioning: Functional Exercises for Fitness has 48 super effective bodyweight exercises along with seven different programs that will get you into kick-butt shape fast. Order **NOW** and you'll receive 3 free Special Reports on how to eliminate knee, back and shoulder pain. Your total investment in this no-nonsense book is only \$29.95 plus \$6 S&H U.S. (foreign orders add \$12). Order online at www.mattfurey.com.

Or pick up the phone right now and call 1 813 994 8267 to order. You can also send a money order to Matt Furey Enterprises, Inc., 10339 Birdwatch Drive, Tampa, FL, 33647.

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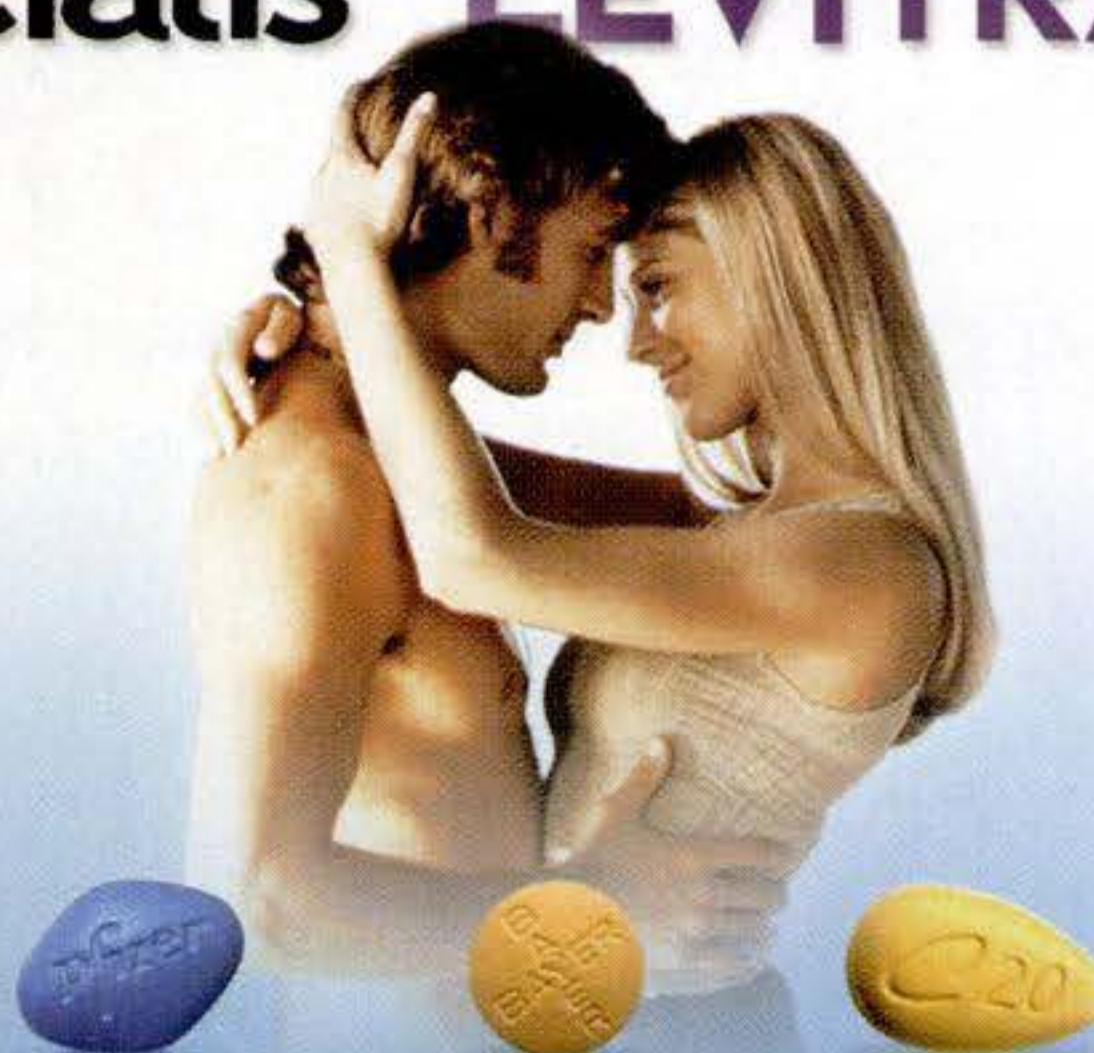
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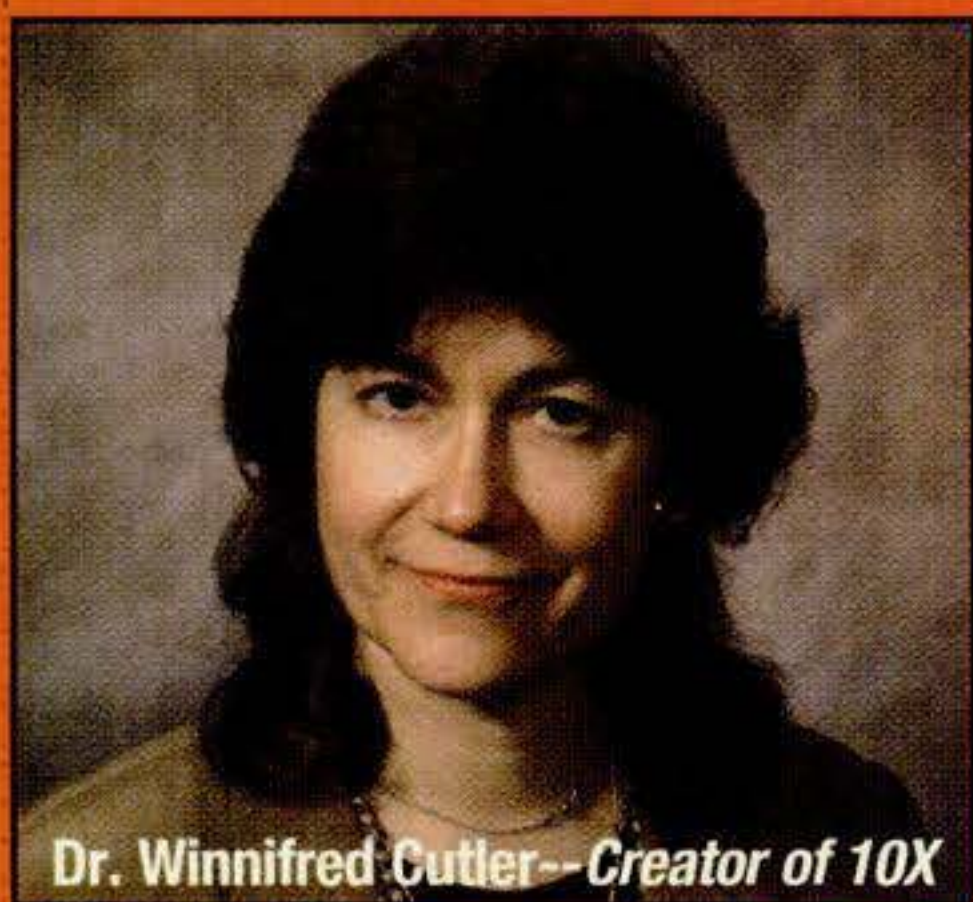
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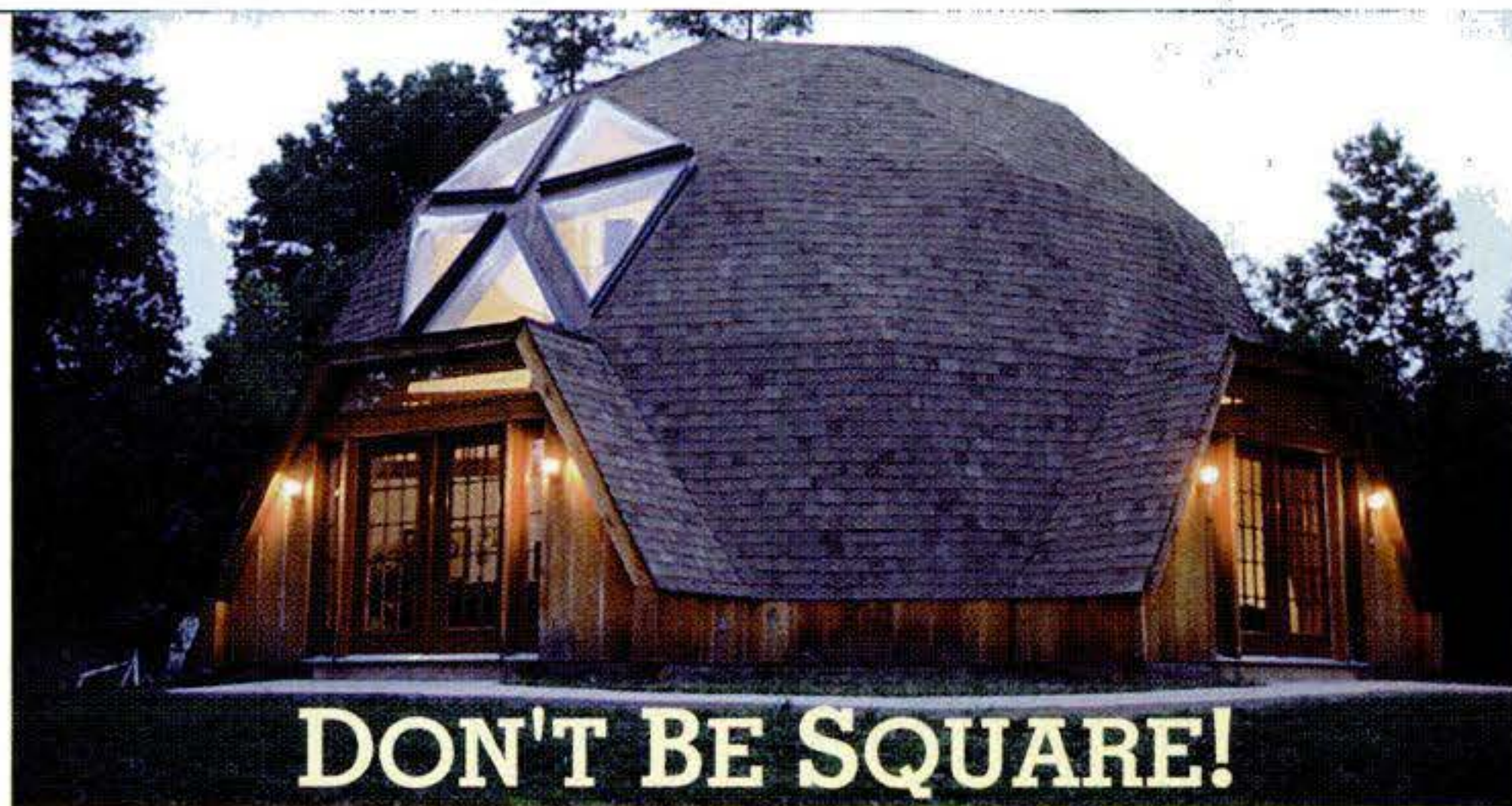
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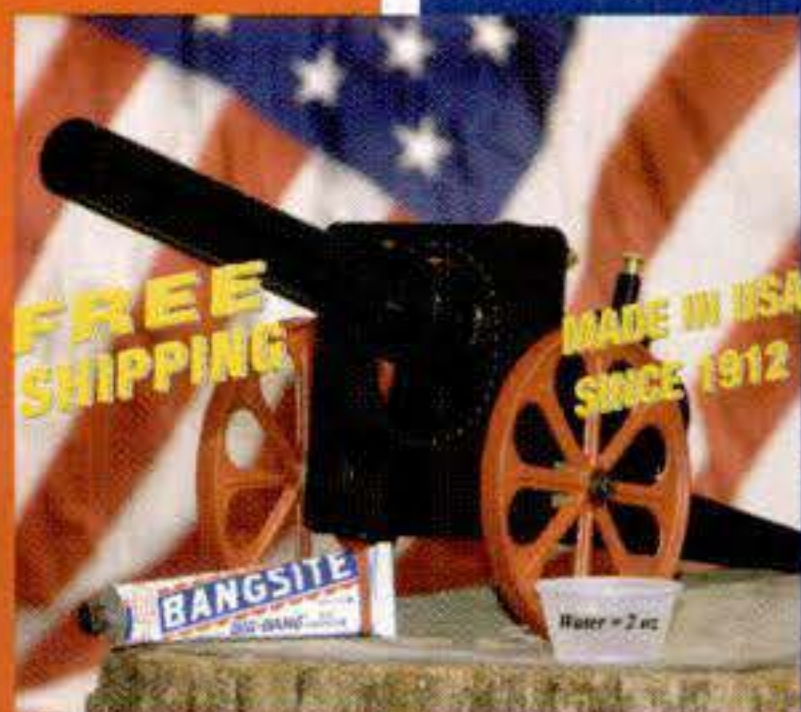


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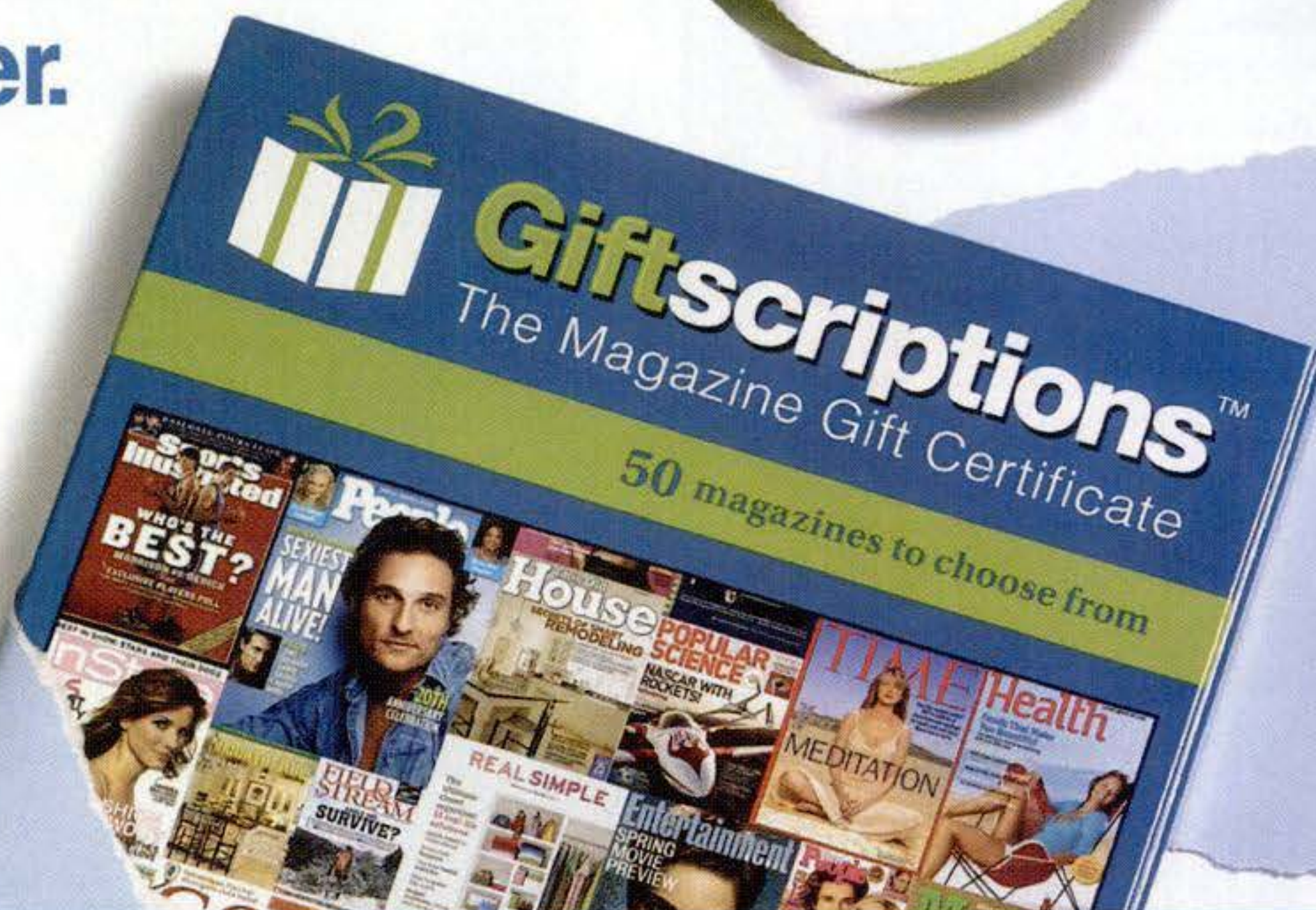
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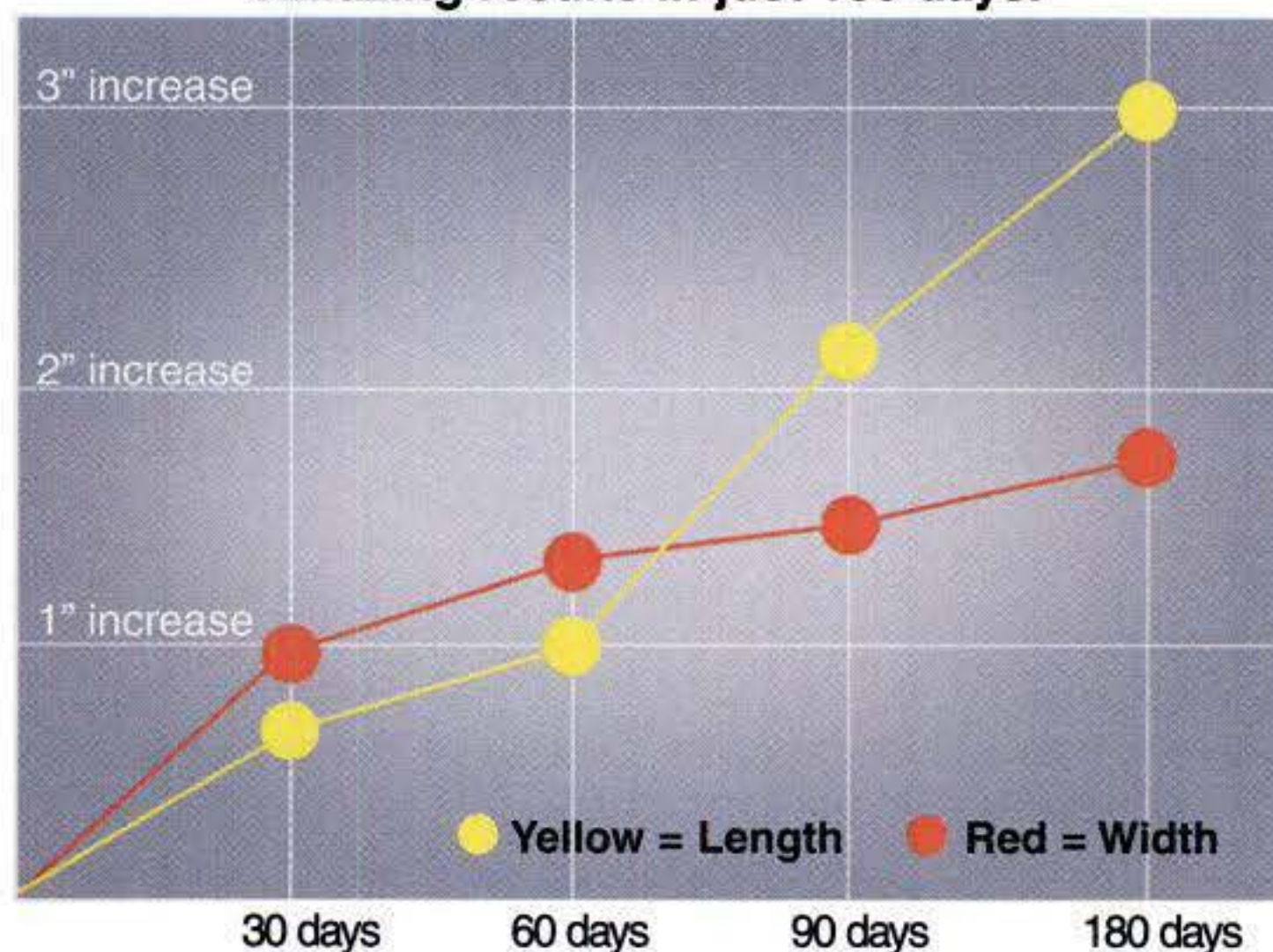
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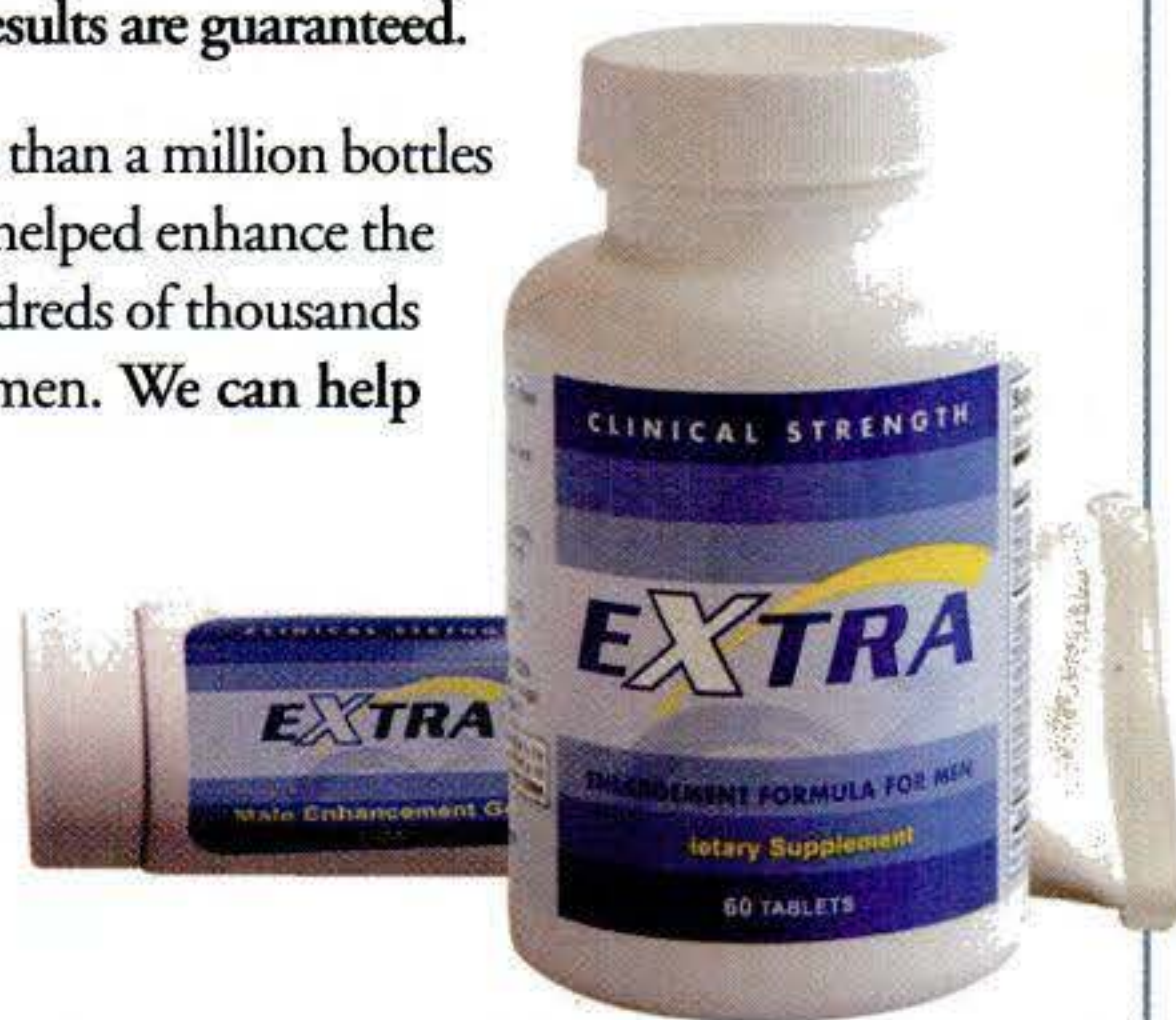
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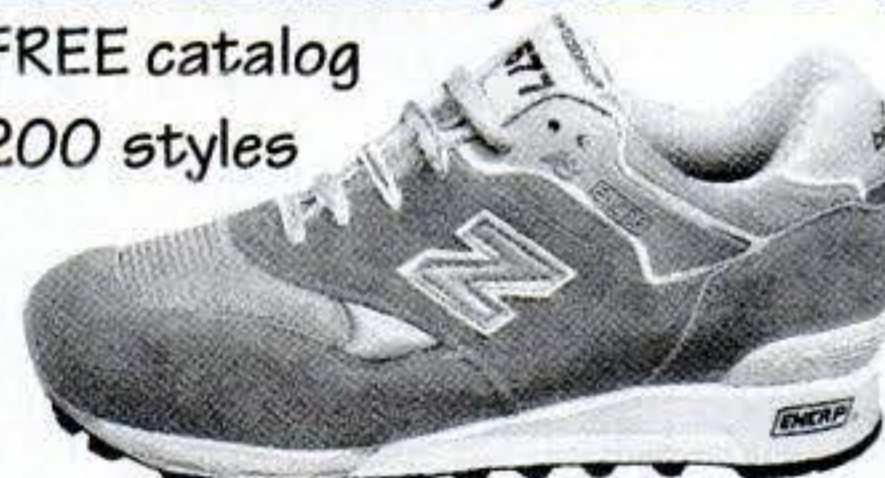
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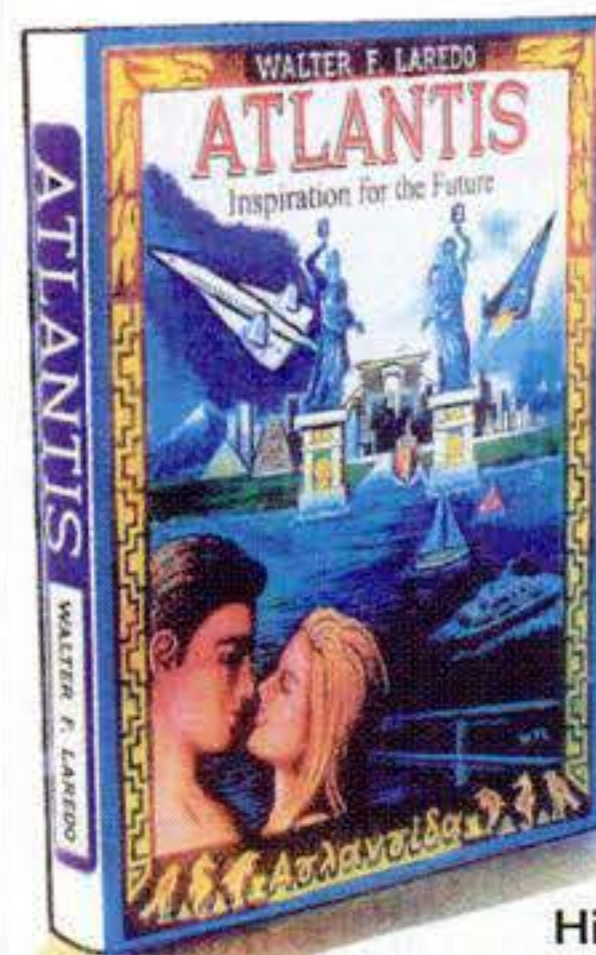
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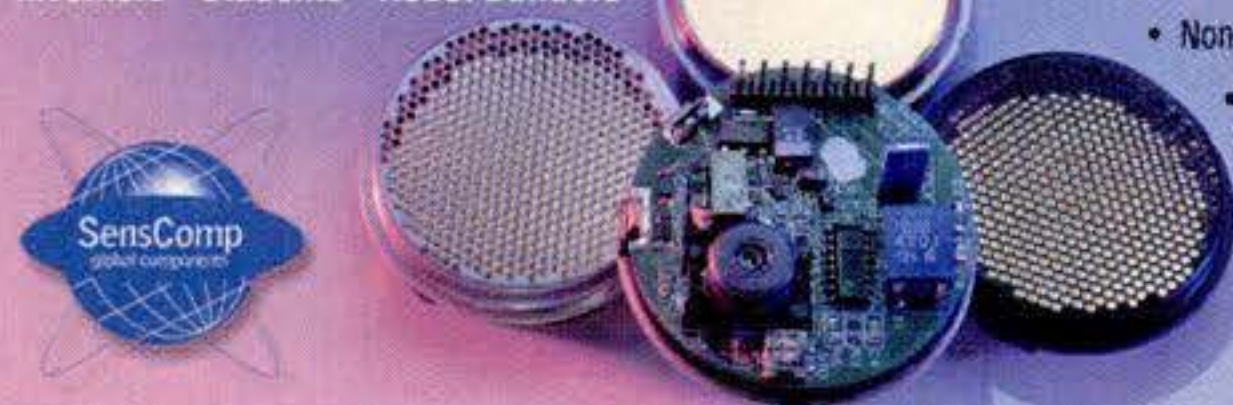
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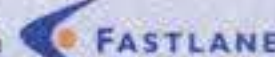
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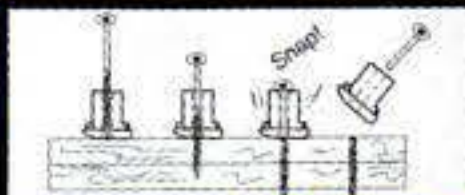


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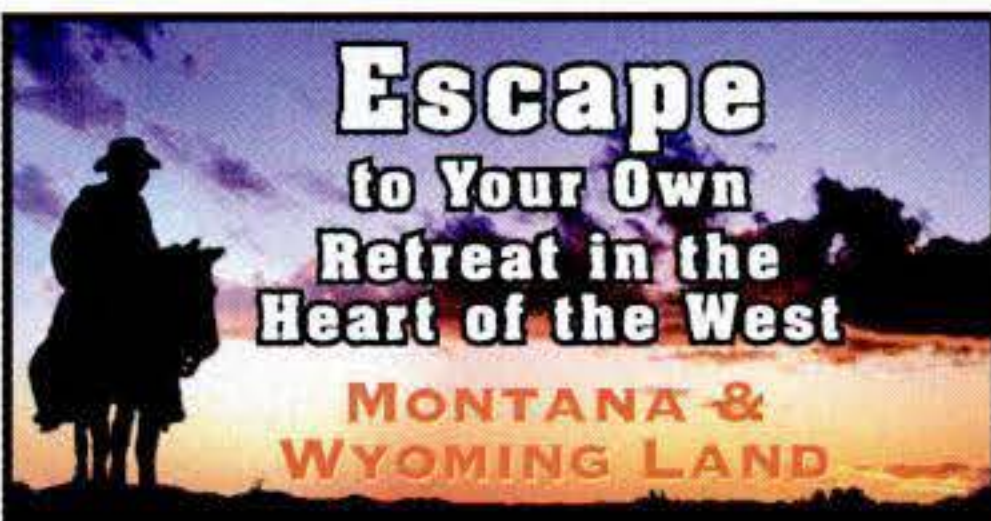
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THE FUTURE THEN

FROM THE POPULAR SCIENCE ARCHIVES

MARCH 1948

How to Crash-Proof Drivers

Think 30 miles an hour is safe? Think again

Long before seatbelts, air bags and antilock brakes, automotive safety started and ended behind the wheel. "If you hit another car head on going at the same 'safe' [30mph] speed, it would be like driving off a nine-story building," PopSci warned in a story on smart driving strategies, explaining that the only way to soften the landing was to drive defensively. One tip: "Expect the worst from the other fellow." Nearly 60 years of experience and research later, automakers are taking the onus off drivers and putting it on cars. Turn to page 44 to read about the car that won't let you crash.—ERIC MIKA

POPULAR SCIENCE

Mar. 1948 • 25c



*This Can Happen
to YOU*

PAGE 98

OTHER STORIES FROM THE
MARCH 1948 ISSUE



BUILD THIS IN FIVE STEPS

With the race to produce a commercial pocket-size radio in full swing, PopSci challenged readers to build their own handheld vacuum-tube radio. The plan called for only off-the-shelf electronic components that, thanks to improved manufacturing techniques, were becoming "so tiny that even electrons may soon feel cramped," we wrote.

THE FIRST ROCKET TRAIN

Is it possible to go supersonic at sea level? Scientists tested a "rocket locomotive" in California's desert flats to find out. Powered by 50,000 pounds of thrust, the train reached 1,019 mph, smashing land-speed records and the sound barrier.

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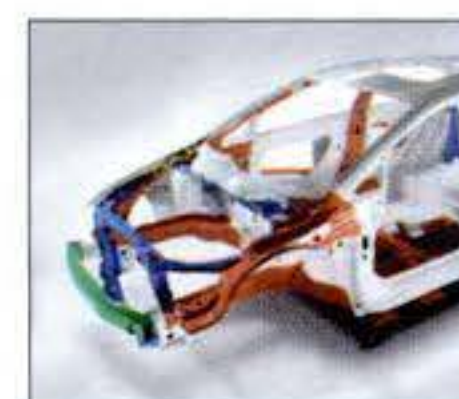
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