

HOW TO:

CLEAN UP SPACE

Satellite Disposal with Lasers and Nets P.60

HOW TO:

CLEAN UP THE SEA

The Robotic Fix for Future Spills P.30

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Hot Products



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THE FUTURE OF ROBOTS

YOUR HELPER 'BOT HAS ARRIVED

P.38

America's First Humanoid

+ 10 More Bedside Bots

SCIENCE CONFIRMS THE OBVIOUS

P.54

Cellphones Impair Driving Skills!
Everyone Likes the Weekend!
Siblings Fight!

PLUS

58mph Sailboat Total Remote Control Solar Death Explosive Sugar

CHARLI-L, created at Virginia Tech, is the future of humanoid in America.



AUGUST 2010

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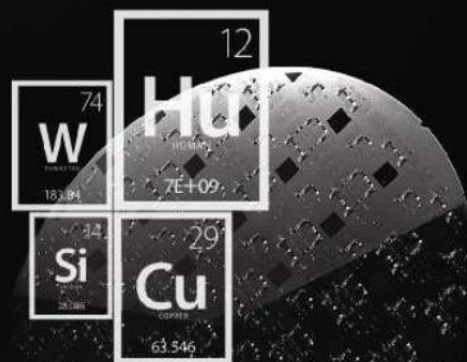
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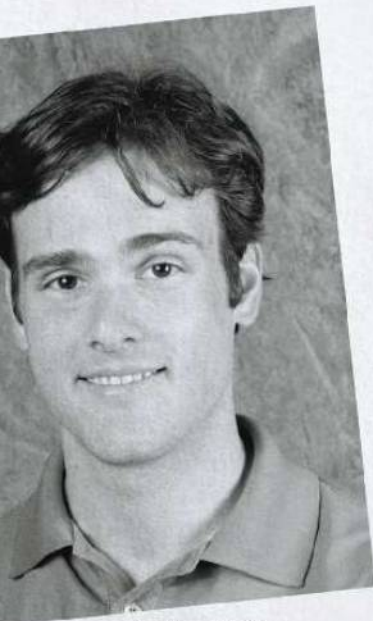
William de Ryk
"What just happened?"



Mitra Pai
"Don't do anything I wouldn't do."



Taylor Herr
"This is just the beginning."



Zach Foster
"It's been real."



Jeffrey R-5000

$$\min_{u \in U(x)} \left\{ l(x, u) + \sum_{i=1}^n \frac{\partial G^*}{\partial x_i} f_i(x, u) \right\} = 0$$



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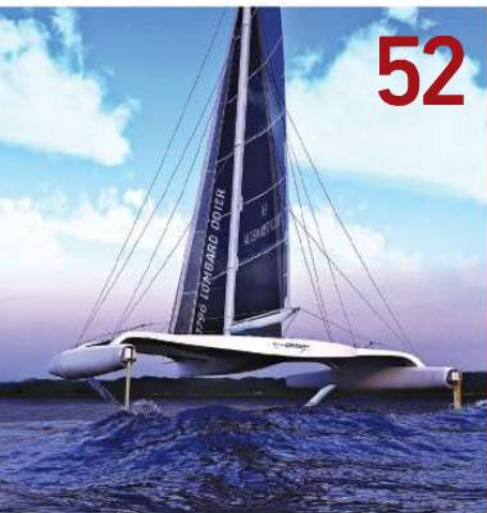
THIS MONTH'S GUIDE TO INNOVATION AND DISCOVERY



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VOLUME 277 #2

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To circle the world in a record-breaking 40 days, this boat reduces drag by taking design cues from planes. By Dawn Stover

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We've left more than 20,000 pieces of potentially spaceship-destroying junk in space. Here are five schemes for cleaning up. By David Kushner

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PopSci's staff photographer is building a home packed with eco-innovations. This month: drywall that absorbs heat on hot days and releases it for warmth on chilly nights. By John B. Carnett

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Japan and Korea throw everything they have at building humanoid robots. The U.S., land of Roombas and factory-bots, has only one. Is mimicking humans a distraction, or the future? By Jacob Ward

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Grandma's got a brand-new nurse. These android Florence Nightingales were specially engineered to care for the nation's surging elderly population. By Corey Binns



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ON THE COVER: JOHN B. CARNETT; THIS PAGE, CLOCKWISE FROM TOP LEFT: DANIEL SCHUMPERT; JOHN B. CARNETT (2); PETER BOLLINGER; KEVIN HAND; COJO

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POPSCI.COM

THE
FUTURE
NOW

Photos Forever

The Vicon Revue is a camera designed
to hang from your neck and record your
life by taking a shot at least every 30
seconds. We wear it around for a test
run at popsci.com/revue.



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QUESTIONS?

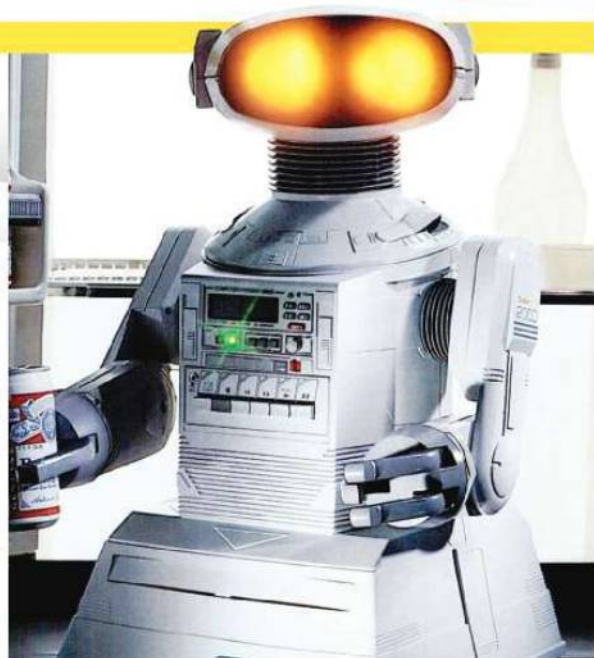
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New Old-School

We've got a guide to some of the best compact
interchangeable-lens cameras on page 25. Find out
how to easily pair them with vintage, high-quality
optics at popsci.com/oldschooloptic.

Radical R/C

After learning how to add remote
control to any project [page 74],
check out a fiery video of an
especially daring application at
popsci.com/rcfire.



Futuristic Robots . . . Then

POPULAR SCIENCE has been predicting the future—and
the future of robots—for as long as we can remember.
Tour a gallery of 'bots pulled from our illustrious
archives at popsci.com/retrospectiverobots.

CLOCKWISE FROM TOP LEFT: COURTESY NATIVE WATERCRAFT; THEREADDRESS.CO.UK; ISTOCK; POPULAR SCIENCE;
JOHN B. CARNETT; COURTESY VICON; COURTESY TOUCH BIONICS

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ANCESTRAL 'BOTS



IN OUR OFFICE, it's hard to ridicule a prediction. When one of us attempts to laugh off a fantastic-seeming forecast of the future—invisibility cloaks, jetpacks, teleportation—a colleague inevitably throws up a hand and describes a recently viewed prototype or piece of research that gives credence to the idea. It's why we love working here. Researchers in Germany, after all, bent infrared light around extremely small objects not long ago, showing that, in theory, a material could soon provide something like invisibility. An Australian inventor has

Today's bipedal robots are just barely capable of kicking a soccer ball. But don't laugh.

taken advantage of ever-lighter materials like carbon fiber to create not exactly a jetpack, but a turbine-propelled personal flying device that sure enough carries a pilot off the ground. And in the past decade, physicists have demonstrated at least the theoretical underpinnings of teleportation by transporting the attributes of atoms to other atoms. It's not *Star Trek*, but it's getting there.

In that same vein, robots are easy to mock. At the moment, as Deputy Editor Jacob Ward describes in our cover story [page 46] about Virginia Tech's CHARLI-L, bipedal robots are just barely capable

of kicking a soccer ball. Japan and Korea have poured hundreds of millions of dollars into robots that are little more than overgrown toys. The idea seems ridiculous, therefore, that someday a 'bot like CHARLI-L will be able to clear the table and give your kids a bath. Perhaps it is ridiculous. But as Colin Angle, the CEO of American maker iRobot, told us during a recent visit, the statistics show that in the coming years we'll need a way to make up the gap between the people capable of giving care and the elderly family members who need it. So laugh if you like. But because we're in the business of spotting the inventors whose prototypes turn out to be the primitive ancestors of world-changing, essential technologies, we have a feeling that someday CHARLI-L, or something like it, will no longer be a punch line.

MARK JANNOT

mark.jannot@bonniercorp.com

CHECK IT OUT



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Read this issue of POPULAR SCIENCE on Apple's new tablet!

POPULAR SCIENCE

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THE INBOX

JUNE WAS our "Inventions of the Year" issue, devoted to standout garage inventors and their creations. Winning designs included a planter that eliminates the need for irrigation and a gun sight that lets soldiers see around corners. In the same issue, Gregory Mone reported on the latest efforts to build robot therapists that can help treat the growing number of children with autism.

Robo-Therapists

"The New Face of Therapy" was a fantastic article due to its subject matter and its skillful writing. I am grandfather to a high-functioning autistic boy. He can use all the help he can get. My grandson's main limitation is with social interaction. His parents can afford only a small amount of the cost for therapy. If the robot in the article were available at \$1,000, or even \$2,000, I would buy it in a second.

Edward L. Maddox
Pelham, N.H.

I can tell you, as a 21-year-old with Asperger's syndrome, that Gregory Mone is correct. Machines, especially robots and computers, are simpler for autistic people to interact with because they are inherently uncomplicated. At the bottom level, they operate on digital (binary) signals: zero or one, on or off. Humans, on the other hand, are analog—and more difficult for someone like me to relate to.

StarSword, on popsci.com

Awards Awe

The Groasis Waterboxx is a great invention! What about a larger model made out of a flexible plastic with a slight break in the circumference so you could "wrap" it around the base of the plant? This way you could grow larger vegetation that could produce more food per gallon of water instead of wasting effort and resources keeping the plants a manageable size.

polymath87, on popsci.com

The SmartSight gun sight is the type of American innovation that made this country the great place it is today. I am amazed that there is no delay in a wireless system—that alone is quite impressive.

sciguy4050, on popsci.com

SUMMER-MOVIE SPECIAL
Real-Life Iron Man #25 Top Sci-Tech Flicks #42 Reading Minds to Make Scariest Movies #44

POPULAR SCIENCE
THE FUTURE NOW

25 Hot Products
The Mighty Morphin' Mouse #16

4TH ANNUAL INVENTIONS OF THE YEAR
Meet the Garage Tinkerers Who've Built a Better...

- GAMING DEVICE
- SNOWMOBILE
- GUITAR
- SKI GOGGLE
- HEARING AID
- GREENHOUSE
- DRUG PUMP
- GUN SIGHT
- AND MORE #39

PLUS: Rodeo Dolphins, Therapeutic Robots and Healthy Tobacco



Our May 2010 cover [top] was inspired in part by the Peugeot Epine concept [bottom].

LETTERS



POPSCI.COM

Very nice job on the ECO-Auger [a fish-friendly underwater turbine]. We at the Florida Institute of Technology have been working on a similar system over the past few years. Our first tests were in summer 2009.

SWoodfit, on popsci.com

CLARIFICATION

The Peugeot Epine concept car by Daniel Schumpert (coroflot.com/detroit429) should have been cited as a source for the vehicle featured on the May cover.

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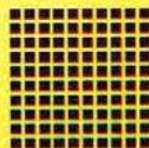
IT'S A TRAP!

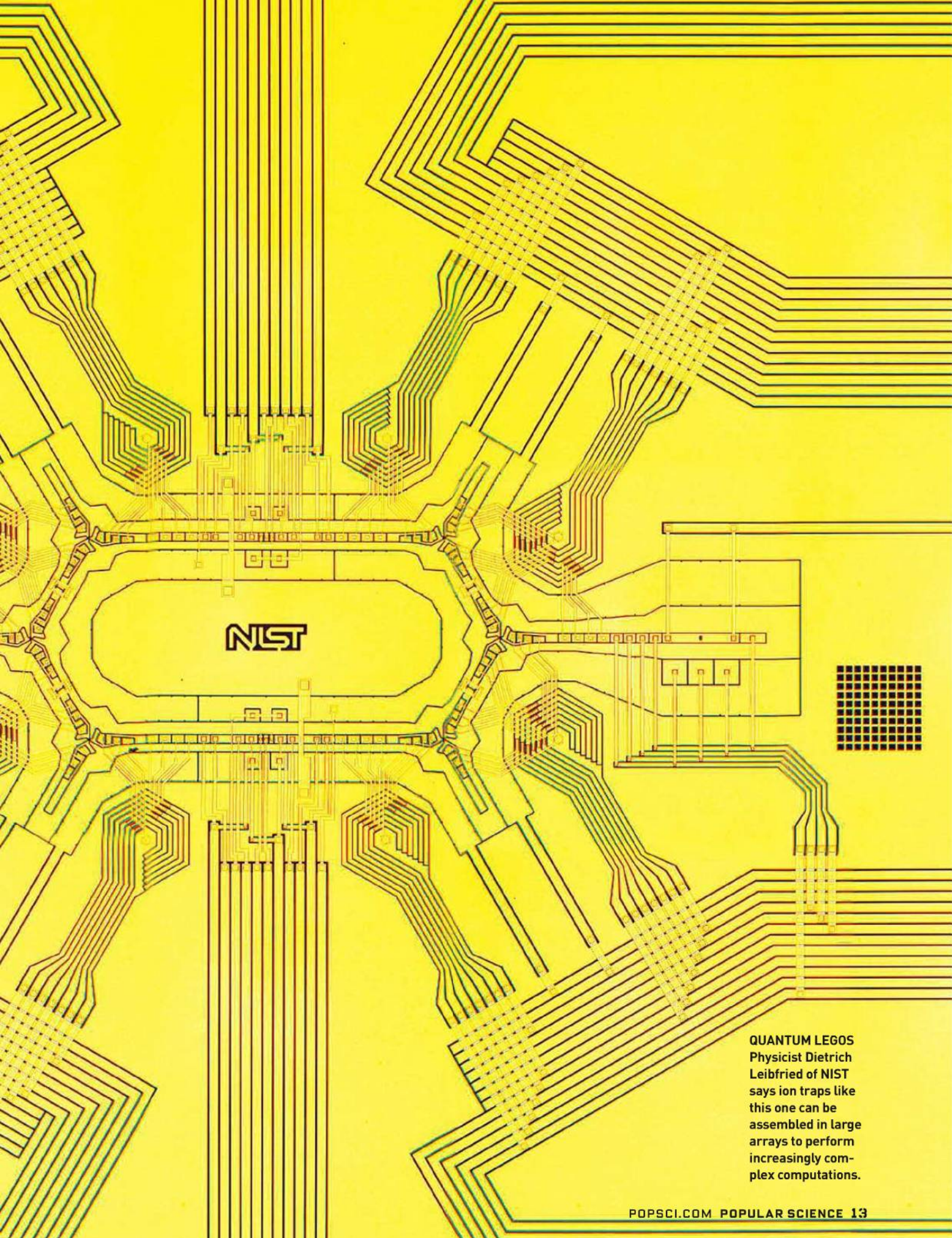
Scientists corral atoms in a major step toward quantum computing

This maze of electrodes, known as a surface-electrode ion trap, brings us closer to building quantum computers—that is, computers that could manipulate the quantum-mechanical states of atoms to process data millions of times as fast as today's most powerful supercomputers do. Whereas computers now use transistors to crunch 0s and 1s, a quantum computer could theoretically perform dozens of calculations simultaneously by zapping charged subatomic particles, called ions, with a laser. One of the first steps in building a functional quantum computer is trapping the ions in order to zap them. That's why physicists at the National Institute of Standards and Technology have created this ion trap, a web of electrodes that produces an electric field to hold the ions in place. Once in place, the ions hover just above the trap's surface. Project physicist Jason Amini says there's still much work to do. For example, he and his group would like to build a trap that can hold hundreds of ions instead of the two or three it currently manages. If they can pull it off, the traps could outperform conventional computers on certain tasks within the next five years.

BY ALESSANDRA CALDERIN

PHOTOGRAPH BY JASON AMINI





NIST

QUANTUM LEGOS
Physicist Dietrich Leibfried of NIST says ion traps like this one can be assembled in large arrays to perform increasingly complex computations.

MEGAPIXELS



SUN GIANT

The largest-ever solar-powered boat prepares for a world tour

In February, the Swiss company PlanetSolar SA unveiled *PlanetSolar*, a floating test bed for renewable energy, during a ceremony held in Kiel, Germany. The \$15-million catamaran measures 49 feet wide, 25 feet high and 102 feet long and weighs 94 tons. It is equipped with 5,380 square feet of photovoltaic solar panels, and its four motors run entirely on solar power (when it's cloudy out, energy stored in batteries powers the boat). The designers purposely eschewed fuel-powered engines to emphasize the need to conserve global resources. The company's scientific coordinator and COO, Pascal Goulpié, hopes that its size and visibility—the boat will make a world tour next year—will inspire others to pursue alternative-energy ventures throughout the next decade.

BY ALESSANDRA CALDERIN

PHOTOGRAPHS BY CHRISTIAN CHARISIUS



ALL ABOARD! The *PlanetSolar* catamaran, pictured here in its hangar in Kiel, Germany, was launched for the first time into the Baltic Sea in late March.

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WHAT'S NEW

TECH THAT PUTS THE FUTURE IN THE PALM OF YOUR HAND



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Porsche's hybrid burns rubber



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The most advanced fishing gear



25

The best little lens-changing cameras

▼ SMART SHOTS

The Revue documents lunch hour in Midtown Manhattan.



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accelerometer and infrared. When any (or several) of the sensors registers a change, the camera instantly kicks into rapid-fire mode, grabbing one frame per second until conditions settle. As you walk into a restaurant, for instance, the Revue responds to the dimmer light and air conditioning. (At rest, it takes one picture every 30 seconds.) It comes with computer software that can

create a low-res, YouTube-ready video flipbook of your day from start to finish.

While the Revue makes it easy to share your every move, it has more-practical applications, too. Researchers have used the system, based on a Microsoft Research project, as a recall aid for people with Alzheimer's or memory loss. Future versions could add more consumer-focused features such as face detection and GPS for geotagging.—CORINNE IOZZIO

POPSCI.COM

Follow our weekend with the Revue at popsci.com/revue.

WHAT'S NEW



Sounding Gel

The WOWee ONE uses vibrations to turn any flat surface into a speaker for music or calls, but with more-intense bass than similar designs. Its driver is embedded in a synthetic gel, which allows it to pulse more freely and to transfer stronger bass lines through a tabletop or window. **WOWee ONE \$80; woweeone.com**



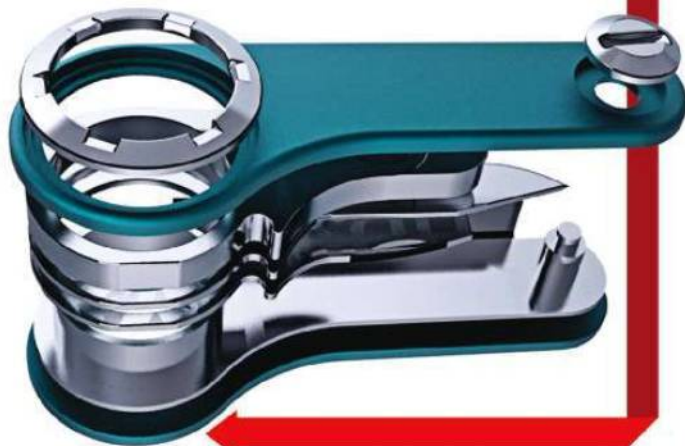
All-Round Radio

Built to withstand construction sites, this radio's aluminum cage lets it keep playing, even after a 30-foot drop, while a watertight port keeps your MP3 player safe. Plus, its five speakers deliver 360 degrees of sound. **Bosch Power Box 360S \$200; boschtools.com**



Infinity Tool

This pocketknife lets you mix and match up to 13 blades to suit any situation. The Switch comes with 18 stainless-steel attachments, from corkscrew to LED flashlight, that slide onto an inner axle held in place by two twist-off endcaps. **Quirky Switch \$80; quirky.com**



Strong Hold

The first plastic boat anchor weighs less than two pounds yet holds small craft better than metal designs do. A small blade on its shank keeps it from resting on its back, so the tip digs deep. **Cooper Anchor Price not set; cooperanchors.com**



Sound Screen

Instead of using cameras to track taps, like many large touchscreens do, this 23-inch PC uses sound. Audio emitters on the corners send sound waves that bounce around fingertips, spotting touches cameras can't, like when fingers block one another. **Lenovo IdeaCentre A700 From \$1,000; lenovo.com**



No-Rumble Pack

This subwoofer vibrates so little that you can mount it on the wall without it rattling your pictures. Rather than one large driver, it has two 6.5-inch ones that fire in opposite directions to cancel out shaking while delivering solid bass. **Bang & Olufsen BeoLab From \$2,000; bang-olufsen.com**





Full View

Now bikers can see behind them without taking their eyes off the road. Three bulletproof polycarbonate mirrors across the top of this helmet relay the rear view to a 3.3-inch adjustable mirror just above the rider's line of sight. **Reevu MSX1** \$380 (est.; import); reevu.com



Swing Blade

This power tool slices through material like a jigsaw does, but it can pivot around turns without your having to reposition it—or your grip. Instead of a straight blade, the lightweight handheld router cuts with a round pin that spins at up to 20,000 rpm. **Dremel Trio** \$100; dremel.com

THE goods

A dozen great ideas in gear

BY CORINNE IOZZIO



On Your Tail

Hiking parties can keep better track of one another with these unusually compact info-sharing GPS devices. The handhelds wirelessly share routes, so you'll all follow the same trail even if you end up getting separated. **Garmin GPSMAP 62 Series** From \$350; garmin.com



Stop Time

To avoid fatigue-related injuries from exercising too frequently, this watch schedules your time off between workouts. Its processor takes into account body type, heart rate and exercise intensity to calculate how many hours you'll need to recoup. **Suunto M5** \$210; suunto.com

Know Your Writes

A VIP's John Hancock just got harder to fake. The ink in each of these pens is laced with shreds of plant DNA, which can be scanned to verify that the scrawl came from the correct pen. **Montblanc Meisterstück with Personal Code Ink** \$15,850; montblanc.com



Seeing Double

This paperback-size Windows laptop replaces the conventional keyboard with a second, seven-inch display that can act as a full Qwerty keyboard, a shortcut menu, or a second screen for Web browsing or side-by-side e-book reading. **Toshiba Libretto W105** \$1,100; toshiba.com



GENTLEMEN, STOP YOUR ENGINES



GET IT: Porsche
2011 Cayenne S Hybrid
\$67,700; porsche.com

Clever engineering makes Porsche's hybrid genuinely efficient

Few vehicles flaunt their gas-chugging power as proudly as a Porsche Cayenne, so it's natural to be suspicious of the hybrid version. Can this racecar-like SUV really improve gas mileage and still be a Porsche?

Thanks to several technological tweaks, yes. First, a more-efficient supercharged 3.0-liter V6 replaces the V8. The gas engine is paired with a 47-horsepower electric motor, and the two are linked with a decoupling clutch, so either one can run the vehicle independently. The motor is capable of handling the load alone at up to 37 mph. Together the pair flings the SUV from 0 to 60 mph in 6.1 seconds. Yet the hybrid gets an estimated 20 mpg city and 25 mpg highway, a 25 and 14 percent gain over the non-hybrid version. It also does tricks: At up to 97 mph, when you take your foot off the accelerator, the engine disengages from the drivetrain and shuts down. Here's how this "sailing" mode lets you briefly zoom without any power at all.—JON ALAIN GUZIK

HOW TO DRIVE GAS- FREE AT HIGH SPEEDS

LIFT OFF THE GAS PEDAL ...

when coasting at high speeds, and the gas engine powers down. A decoupling clutch disconnects the **gasoline engine** from the **electric motor** and the rest of the drivetrain, freeing the drivetrain from the drag that the powered-down engine places on it and allowing you to coast farther, fuel-free.

COAST ...

powered by unhindered momentum. In this mode, which Porsche calls "sailing," the electric motor runs in reverse, acting as a generator that harvests kinetic energy to recharge the hybrid system's **nickel-metal-hydride rear battery**.

PUNCH IT ...

to speed up again. A **computer** coordinates the transition back to gas power. The decoupling clutch reconnects the gas engine to the drivetrain within 300 milliseconds, and the electric motor provides an additional boost for highway acceleration without a perceptible lag.



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DREAM STREAM

Satellite video delivery that finally makes discs obsolete



If your video store isn't already six feet under, XStreamHD will finally put it there. The company is launching the first set-top system able to download movies that are the exact quality of Blu-ray discs: 1080p high-def, near-flawless images, and 7.1 surround sound. Subscribers can rent or buy 200 best-selling titles starting this month, with the full high-def film and TV catalogs of all major studios not far behind.

Web-based video-on-demand services, like Netflix and Amazon, compress their video to avoid hogging bandwidth, and often the result is grainy or blippy images, even if they're high-def. XStream can deliver carbon copies of studio masters because it beams them via satellite. The company broadcasts over common low-power satellites, and a 2.5-foot dish on your roof grabs the signals. Then a server box in your living room uses specialized receiver chips to weed out interference and saves up to 160 films so they're waiting for you the next time you turn on

▲ **GET IT:**
**XStreamHD
Starter Pack**
From \$400
(plus \$10/
month and
cost per title);
xstreamhd.com

the TV. By default, it keeps the most popular titles, but you can also tell it to record specific films or genres and store them on its up-to-four-terabyte drive.

The server sends content

to as many as four TVs via networked receivers such as XStream's own or a PlayStation 3. The system will eventually be able to serve up on-demand videogames as well.—TOM CONLON

MORE WAYS TO GO HIGH-DEF

If you don't want to invest in a whole new system, these services let you stream or download high-def (if compressed) video using gear you may already have, such as a Web-connected TV or set-top box.

SERVICE	HD CATALOG SIZE	VIDEO RESOLUTION	SOUND QUALITY
Amazon Video On Demand	5,000+	720p, 1080i	5.1 surround, stereo
Best Buy CinemaNow	Up to 1,000	720p, 1080p	5.1 surround, stereo
DIRECTV or DISH satellite services	Rotating selection	720p, 1080p	5.1 surround, stereo
Netflix streaming	Up to 10,000	720p	stereo
Vudu	3,000+	720p, 1080p	5.1 surround, stereo

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THE TECHIEST CATCH



The emerging sport of kayak fishing gets a boost from new gear

With approximately 40 million anglers nationwide, fishing is one of the country's most popular pastimes, and kayak fishing is arguably its hottest new trend. Compared with a motorized boat, a kayak saves gas money, fits into tight, shallow spots, and lets you sneak up quietly on that big catch. Here's how to make the most of one.—MARK ANDERS

▲ WATER WHEEL This pedal kayak's 13-pound drivetrain uses gears similar to those that transmit power to a car's wheels.

Pedal Instead of Paddle

Bicycle-like pedals replace this kayak's paddle, leaving hands free for fishing. The Propel's four-gear drivetrain turns a propeller 10 times for each crank, so you can efficiently reach 5.75 mph. It's easy to steer, too: A joystick directs a rudder, and unlike existing pedal kayaks that use unidirectional flippers, pedaling backward moves the propeller—and craft—in reverse. Lift out the drive to paddle or swap in a motor. The boat can also add a mast and sail and, in 2011, pontoons. **Native Watercraft Mariner 12.5 Propel** \$1,800; nativewatercraft.com



▲ Cast Farther

This bait-casting reel, a style often used for bass fishing, sends your line up to 30 percent farther than others. It puts less friction on the line by passing it over a smooth bar, not through a constricting eyelet, that later seesaws to neatly rewind line on the spool. **U.S. Reel SuperCaster 700X** \$80; usreel.com



◀ Find Fish

Designed to mount inside kayaks, this sonar device displays underwater objects and creatures. Its transducer sends sound waves through a kayak's plastic bottom to the depths beneath, and a dry-bag keeps the battery safe. **Humminbird 385ci Combo Kayak Fishfinder** \$500; humminbird.com

Keep Bait Alive

Kayaks don't have room for big tanks to store live bait. So bring a pliable 13-inch cooler bag, which tucks behind seats and packs a battery-operated bubbler to keep the water aerated and bait breathing. **Harmony Collapsible Live Bait Cooler** \$50; harmonygear.com

No Bites

Mosquito bites, that is! This fisherman's shirt builds in insect repellent that outlasts other bug-fighting clothing. The chemical permethrin is applied and cured onto fabric before it's stitched together, for a tighter bond and even coverage. **Simms Bug Blocker Shirt** \$90; simmsfishing.com

LITTLE BIG SHOTS

New cameras squeeze pro-style lenses onto ever-tinier bodies

Even a great camera won't take memorable shots if it's so big that you tend to leave it at home. So companies are creating models that aim for a happy medium between pocketable point-and-shoots and higher-quality SLRs. This new breed can change lenses to suit a shot,

like an SLR does, but ditches the optical viewfinder and the bulky mirror that sends it light. That means compromise: Autofocus isn't SLR-fast, there are fewer lenses, and point-and-shoots are still smaller. We tested which interchangeable-lens compacts (ILCs) hit the sweet spot.

—DON HOLLINGER



OLYMPUS E-PL1

BODY SIZE: 4.5 x 2.8 x 1.6 in.

THE FEATURES: The E-PL1 is one of the most compact cameras to use a format called Micro Four Thirds, which started the slimming ILC trend in late 2008. Its image sensor is smaller than most digital SLRs—about 7/10 the size—yet about nine times that of a point-and-shoot.

THE PICTURES: The small sensor still snaps outstandingly crisp, sharp photos. But it does generate a lot of image noise—grainy spots most apparent in low-light pics. In the end, the E-PL1 is mainly for users who put a premium on petite.

GET IT: \$600 (with lens); olympusamerica.com

SAMSUNG NX10

BODY SIZE: 4.8 x 3.4 x 1.6 in.

THE FEATURES: Samsung's first ILC uses the same size sensor as an SLR, outmeasuring the Olympus. Unfortunately, the camera is also larger, partly because it builds in an electronic viewfinder (a tiny LCD eyepiece to mimic an SLR's window) that, sadly, blurs when it moves quickly.

THE PICTURES: The larger sensor does the trick for eliminating grainy image noise. The NX10's overall image quality is on par with a similarly priced SLR. On the other hand, it's not much smaller, and its autofocus is slower.

GET IT: \$700 (with lens); samsung.com

SONY NEX-5

BODY SIZE: 4.4 x 2.4 x 1.6 in.

THE FEATURES: The Sony combines the Olympus's small body with the Samsung's sensor size and adds some tricks. It takes 1080i high-def videos (the others do 720p) and autofocuses while filming. It fires seven shots per second, and its high-dynamic-range mode catches detail in bright scenes.

THE PICTURES: The photo quality is about the same as the Samsung's, and although the autofocus speed still lags behind an SLR's, it's close. That, plus its near-pocketability and fun features, makes it an exceptional camera—and the best of the bunch.

GET IT: From \$650 (with lens); sony.com

EDITORS' PICK



David LaChapelle *for* Rolling Stone

Young people do everything online. Like order millions of magazines.

Somehow, amidst their infatuation with Facebook, YouTube, Twitter and the like, young adults are still making time for another one of their favorite pursuits: reading magazines.

Contrary to popular misperception, the phenomenal popularity of the Internet has not come at the expense of magazines. Readership is actually increasing, and adults between 18 and 34 are among the most dedicated readers. They equal or surpass their over-34 counterparts in issues read per month and time spent per issue.

What's changed isn't people's affinity for magazines but the means by which they acquire them. Last year, nearly 22 percent of all new paid subscriptions were ordered online.

And just as the Internet drives magazine subscriptions, magazines drive Web searches – with nearly double the effectiveness of the Internet itself. Some might call it ironic.

The medium that some predicted would vanquish magazines is actually helping fuel their growth. And vice versa.



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HEADLINES

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of the future

MEDICINE

FIGHTING DRUGS WITH DRUGS

A psychedelic drug gains legitimacy as a solution for addictions

Giving a heroin addict one of the most powerful psychedelic drugs seems like a bad idea. Yet that's exactly what a group of scientists will do this month. Ibogaine, they say, might be the best way to break drug addicts of their habit.

Ibogaine, a brown powder derived from the African *Tabernaemontana iboga* plant, has intrigued researchers since 1962, when Howard Lotsof, a student at New York University and an opiate addict, found that a single dose erased his drug cravings without causing any withdrawal symptoms. Unfortunately, the hallucinogen can increase the risk of cardiac arrest, and the U.S. Drug Enforcement Agency lists it as a Schedule 1 substance, a classification for drugs like ecstasy and LSD with "no known medical value" and "high potential for abuse," making it



difficult to get federal funding to run clinical trials.

Animal tests, however, have shown the drug's medicinal promise. "Rats addicted to morphine will quit for weeks after receiving ibogaine," says Stanley Glick, the director of the Center for Neuropharmacology and Neuroscience at Albany Medical College. And addicts have reported positive effects in Mexico and Europe, where ibogaine therapy is

TRIPPY MEDICINE
Ibogaine, derived from a plant root, acts on the brain's nicotine receptors to help alleviate cravings for alcohol and drugs like heroin.



legal. "Going cold turkey is horrible. There's vomiting and diarrhea and pain and a constant drug craving," says Randy Hencken, a drug user who was treated in Mexico. "After ibogaine, I didn't feel any symptoms or cravings. I've been clean for nine years. Heroin and cocaine no longer have any power over me."

Despite these successes, ibogaine lacks scientific credibility. "As great as ibogaine seems, no one knows exactly how effective it is as a treatment," says Valerie Mojieko, the director of clinical research for the Multidisciplinary Association for Psychedelic Research (MAPS), a privately funded Massachusetts-based

FOOTNOTES MAY 20 Scientists led by Craig Venter announce that they have created the first live, reproducing cell made from synthetic DNA—in essence, the first artificial life.

A SLICK FIX

Oil-eating robots could mop up ocean disasters

When the Deepwater Horizon rig began leaking oil into the Gulf of Mexico in April, the cleanup schemes were underwhelming: fire, dispersants, panty hose stuffed with human hair. But a new robotic system could corral future spills in hours so that oil never hits the shore.

Aeros (Airborne Robotic Oil Spill Recovery System) is a fleet of airplane-deployed robots that cordon off the oil and use centrifuge-like oil/water separators to collect oil for refining. Each 'bot can purify up to 3,000 gallons of water a minute. Several could clean an 11-million-gallon, Exxon Valdez-size spill in a few days.

Global Response Group, Aeros's developer, is building its first prototype robot to test on an experimental oil spill next

MARINE MESS

More than 40 million barrels of oil have been spilled in the seas since 1970—the equivalent of four Exxon Valdez-size disasters a year.

year. The company is also in talks with the Chinese government to establish the first Aeros airbase, which will deploy 'bots to protect that country's fishing waters from offshore drilling. It will cost \$800 million, a small fee compared with the billions of dollars in damage that a spill can cause.

Spills present challenges for any cleanup. "Booms don't work well with big waves," says oil expert Greg McCormack of the University of Texas. But the industry is eager for new strategies, he says, and will embrace Aeros if the prototype works. Aeros's inventor, Myron Sullivan, says it will. "It needs fine-tuning," he says, "but the technology is proven. There will be another disaster. All we can do is prepare for it."—ALESSANDRA CALDERIN

HOW IT WORKS

- 1 'BOTS AWAY!** Planes drop minivan-size water-cleaning robots and inflatable booms near the spill site.
- 2 TRAP THE SPILL** Once inflated, the U-shaped booms surround the oil. Robots use GPS to get behind a boom's flap, which directs water into the 'bot's cleaning system.
- 3 CLEAN** The robot sucks oily water into a cone that spins the liquids, sending denser water to the outside and creating a stream of oil in the center. Low pressure at one end draws oil away while the heavier—and 99 percent clean—water flows out the other side.
- 4 COLLECT THE BLACK GOLD** A bladder collects the oil, which crews pick up later to recycle. One robot can clean up to 3,000 gallons of water per minute, scrubbing the affected area in just a few days.



nonprofit. So starting this month, MAPS will enlist Clare Wilkins, the director of Pangea Biomedics, to run the first long-term study to gauge the drug's lasting effects at her clinic in Mexico (where patients already pay \$5,000 for the treatment). She will treat 20 to 30 heroin addicts and, for the next year, MAPS will subject them to psychological and drug tests to quantify ibogaine's effectiveness.

The study will also help establish how to prescribe the drug safely.

"Most psychedelics are relatively harmless," says neurologist Deborah Mash of the University of Miami, "but ibogaine has a much narrower margin for error." Mash runs an ibogaine clinic in St. Kitts and has treated more than 400 addicts without incident in the past decade. But in the early 1990s, overdoses of the drug at a clinic in the Netherlands led to several deaths, which ultimately scared off the National Institute of Drug Addiction (NIDA) from starting

its own research program in the U.S.

From the limited research, though, scientists have two theories about how ibogaine works. Some say it's purely biological—that ibogaine degrades into a compound that binds with opiate receptors in the brain to quiet cravings. Others believe that it is also psychological, with the "whole-life review" part of the hallucination providing perspective on the negative aspects of drug use, and so the subject strives to quit.

GRAHAM MURDOCH

OTHER EXPERIMENTAL FIXES

BACTERIA

Pro: Natural and lab-grown microbes eat oil.

Con: Engineered bacteria die quickly in the wild, and too much bacteria of any kind deplete oxygen that other creatures need.

SUPER-SPONGES

Pro: Carbon nanotube sponges absorb hundreds of times their weight in oil.

Con: These sponges are still in the lab, years away from large-scale deployment.



**MOST EXPERTS
THINK IBOGAIN
PRESCRIPTIONS
ARE 10 TO 15
YEARS AWAY.**

Regardless of the mechanism, proving ibogaine works is essential to winning approval and funding for clinical trials in the U.S. The sooner the better: Nearly seven million Americans abuse illicit drugs, costing the nation an estimated \$181 billion a year in health care, crime and lost productivity.

The MAPS study should begin to answer questions about ibogaine's efficacy and safety, but most experts think prescriptions are 10 to 15 years

away. Until then, desperate patients will continue to seek out treatment in unregulated places such as Mexico, and that's ideal for neither the patients nor the researchers. Rick Doblin, the founder of MAPS, hopes this study will force regulators' hands. "If we can show great results, it could increase support for ibogaine clinics and maybe get NIDA interested again—because that's who really should be doing this research."—STEVEN KOTLER

MAY 26 The U.S. Air Force's X-51A Waverider, an unmanned scramjet aircraft, bests the previous 12-second hypersonic record by more than three minutes, hitting a top speed of Mach 4.8.

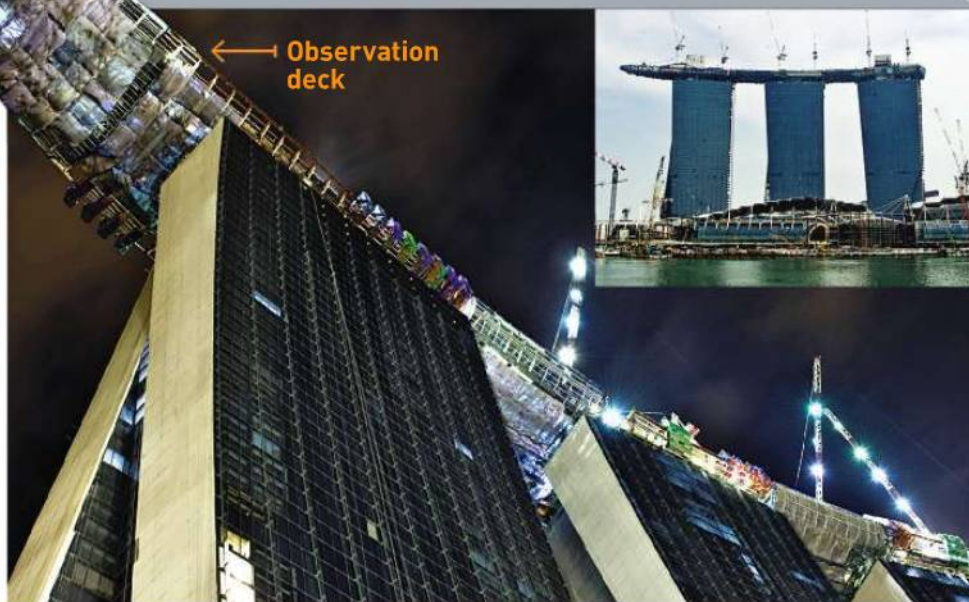
OVERACHIEVERS WE LOVE

A tricked-out fire truck, a beefier bionic hand and the largest cantilever

BIGGER

A PARK IN THE SKY

When architect Moshe Safdie was designing a hotel in Singapore, he ran out of ground space for a planned park. But there was plenty of air, so he drew up the three-acre garden connecting the 57th story of the hotel's three towers. He wasn't finished, though. Then he built the crowning piece of the Sky Park: an observation deck extending 218 feet from the hotel's roof—the world's largest cantilever. Two 937-ton steel girders run its length to support the overhang, which is as long as a Boeing 767, and dampers commonly used in skyscrapers counteract vibrations from the wind. Visitors will enjoy the structure's panoramic views of the Singapore skyline, Safdie says. "It feels like you're on a ship deck, except instead of being on water you're in the air."



BETTER

▼ BLAZE-BUSTER

This fire truck packs 3,000 gallons of water, as well as the extinguishing agent Halotron, specially designed for electrical blazes.

THE HOTTEST FIRE TRUCK

Airport fires have the added danger of occurring near plane fuel, so firefighters need to put them out fast and from a safe distance. The new Oshkosh Striker fire truck for airports features infrared cameras that target the hottest part of an inferno for faster quenching.

To attack burning fuel, it shoots flame-smothering chemicals at 760 mph—forceful enough to let crews stand 90 feet away, three times as far as with current tech. The truck goes on sale later this year. "But," says Oshkosh engineer Pete Evans, "we hope it's one they'll never have to use."



STRONGER



GET A BIONIC GRIP

Touch Bionics's new i-Limb Pulse prosthetic hand can carry an astonishing 200-pound load. The aluminum hand, on sale in the U.S. this month, features pulsing motors that, when triggered by the user's forearm, apply constant pressure to an object, rather than simply closing around it. This ability also improves each finger's dexterity for easier shoe tying and belt buckling. "People want to go back to their normal lives," says Touch Bionics co-founder Phil Newman. "This gets them one step closer."—SANDEEP RAVINDRAN

FROM TOP: COURTESY MARINA BAY SANDS/MOSHE SAFDIE (2); COURTESY TOUCH BIONICS; COURTESY OSHKOSH CORPORATION (2)

JUNE 4 SpaceX's Falcon 9 rocket launches from Cape Canaveral for the first time. The privately built rocket could someday ferry NASA's materials and astronauts into orbit.

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TEXTING FRENZY

A research effort doubles as a shark-attack warning system

Great white sharks have been around for more than four million years, yet they remain one of the world's most mysterious animals. Scientists know that the beasts have special organs for sensing electromagnetic fields and that their jaws can snap down with 4,000 pounds of force. But migration patterns, which are critical for conservation efforts, are mostly unknown. That will change now that marine biologists in Australia can follow the whereabouts of 75 of the man-eaters using radio-transmitter tags and a network of 20 satellite-linked buoys.

It's not known how far great whites—whose worldwide numbers are estimated to be fewer than 3,500—migrate or if there's a season when they spend more time near the coast, says Rory McAuley, a senior research scientist with Western Australia's Department of Fisheries. McAuley hopes that the buoys, along with about 50 sensors on the ocean floor, will also reveal behavior. This information could help authorities better predict the monthly risk at beaches and restrict seasonal shipping routes to protect sharks from boats.

As a bonus, the work could give swimmers a heads-up when a great white is closing in. If a tagged shark swims within approximately a quarter-mile of a coastal buoy, the system sends a text to lifeguards on nearby beaches. Even swimming at top speed, it might take the dangerous fish a couple of minutes to reach shore, possibly enough time for the lifeguards to drop the phone and sunscreen and get folks out of the water.—JUSTIN McLACHLAN



WHEN ANIMALS ATTACK
Australian researchers use satellite-linked buoys [below right] and seafloor sensors [below left] to track RFID-tagged great white sharks.

OMG GR8WHT!

Most shark attacks are on surfers, probably because the silhouette of a dude paddling out on his surfboard looks just like a delicious sea lion.



FROM TOP: STEPHEN FRINK/GETTY IMAGES; COURTESY WESTERN AUSTRALIA FISHERIES DEPARTMENT (2)

AUGUST 12 The Perseids meteor shower, one of the best celestial displays of the year, peaks tonight throughout the U.S. with about 50 meteors passing an hour.

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SCUBA DRIVING

Submarine genius Graham Hawkes turns out a lightweight leisure vehicle

Graham Hawkes is known for crafting near-perfect undersea vehicles—sleek, winged subs that ferry eco-explorers to the greatest depths of the ocean. But when a brilliant

billionaire shows up and asks for something even more sophisticated, it's time to draw up a new plan.

Last summer, Richard Branson commissioned Hawkes to build a sub no heavier than 1,600 pounds, the weight limit on Branson's 105-foot catamaran. But even Hawkes's most svelte deep divers weigh at least 4,000 pounds. Trimming battery or engine weight, Hawkes realized, would hurt performance, but the thick hull required to safely contain compressed air contributes some 1,500 pounds of the bulk. That was weight that could go, Hawkes thought, so he began designing a new category of submersible: a submarine featuring open cockpits.

To dive in a roofless sub, Branson's passengers will need to

dress for the conditions. Outfitted in air-regulator masks that draw oxygen from an onboard supply, passengers can plunge to 130 feet and zip around coral reefs at a swift 4 knots for two hours. (Wetsuits are optional.) The stripped-down model weighs in at less than 1,500 pounds. "The idea was to be able to move through the water with the grace and agility of marine animals," Hawkes explains. He dubbed his invention the Deep Flight Merlin and delivered the three-seater to Branson this spring. Now he's gearing up to produce an entire line of Merlins with room for one to six passengers each. The wait time for a Merlin is four months, and they start at \$700,000—the price you pay to become one of Branson's aquatic peers.—JONATHAN KEATS

SPEED SWIMMER
Hawkes's Merlin travels twice as fast as similarly sized personal subs.

FLIGHT CONTROLS: Like in a fighter jet, pilots control the sub's depth, direction and speed with a joystick.

OPEN COCKPITS: Individual shields deflect water over passengers' heads as the vessel zips through the sea at up to 6 knots.

POWER: A lithium-phosphate battery drives a propeller that sucks in water through side vents and pushes it outward, achieving 500 pounds of thrust.

HULL: The sub is encased in lightweight carbon fiber sturdy enough to withstand collisions with rocks and debris on the seafloor.

WINGS: The ailerons, elevators and rudders control roll, pitch and yaw, just like an aircraft, all through mechanical linkages.



▲ **AHOY, MATEY** The finished sub, the Necker Nymph, on the deck of Branson's yacht

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For years you've relied on APC Back-UPS to protect your business from expensive downtime caused by power problems. Today, the reinvented Back-UPS does even more. Its highly efficient design noticeably reduces energy use, so you start saving money the minute you plug it in. Only APC Back-UPS guarantees to keep your electronics up and your energy use down!

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Power-saving outlets automatically shut off power to unused devices when your computer and peripherals are turned off or on standby. Automatic voltage regulation (AVR) adjusts the undervoltages and overvoltages without using the battery. With our patent-pending AVR bypass, the transformer kicks in only when needed and automatically deactivates when power is stable. Plus, APC's highly efficient designs reduce power consumption when power is good and extend runtimes when the lights go out. Together, these power-saving features eliminate wasteful electricity drains, saving you about \$40-50 a year. And managing today's Back-UPS couldn't be easier thanks to an integrated LCD that provides diagnostic information at your fingertips.

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The award-winning Back-UPS provides reliable power protection for a range of applications: from desktops and notebook computers to wired and wireless networks to external storage. The reinvented APC Back-UPS is the trusted insurance you need to stay up and running and reliably protected from both unpredictable power and energy waste!

Keep your electronics up and your energy use down!

Back-UPS models are available with the features and runtime capacity that best suit your application, and many models have been designed with power-saving features to reduce costs.

The High-Performance Back-UPS Pro Series

High performance Back-UPS Pro units deliver cost cutting, energy efficient features. Power-saving outlets automatically shut off power to unused devices when your computer and peripherals are turned off or on standby, eliminating costly electricity drains. (BR700G shown above)

The energy-efficient ES 750G

The ES 750G boasts innovative power-saving outlets, which automatically shut off power to controlled outlets when the computer plugged into the host outlet is deemed asleep, eliminating wasteful electricity drains.

- 10 Outlets • 450 Watts / 750 VA
- 70 Minutes Maximum Runtime
- Coax and Telephone/Network Protection



The best-value ES 550G

The ES 550G uses an ultra-efficient design that consumes less power during normal operation than any other battery backup in its class, saving you money on your electricity bill.

- 8 Outlets • 330 Watts / 550 VA
- 43 Minutes Maximum Runtime
- Telephone Protection



Enter to win one of seven Back-UPS BR 700G (a \$130 value)!

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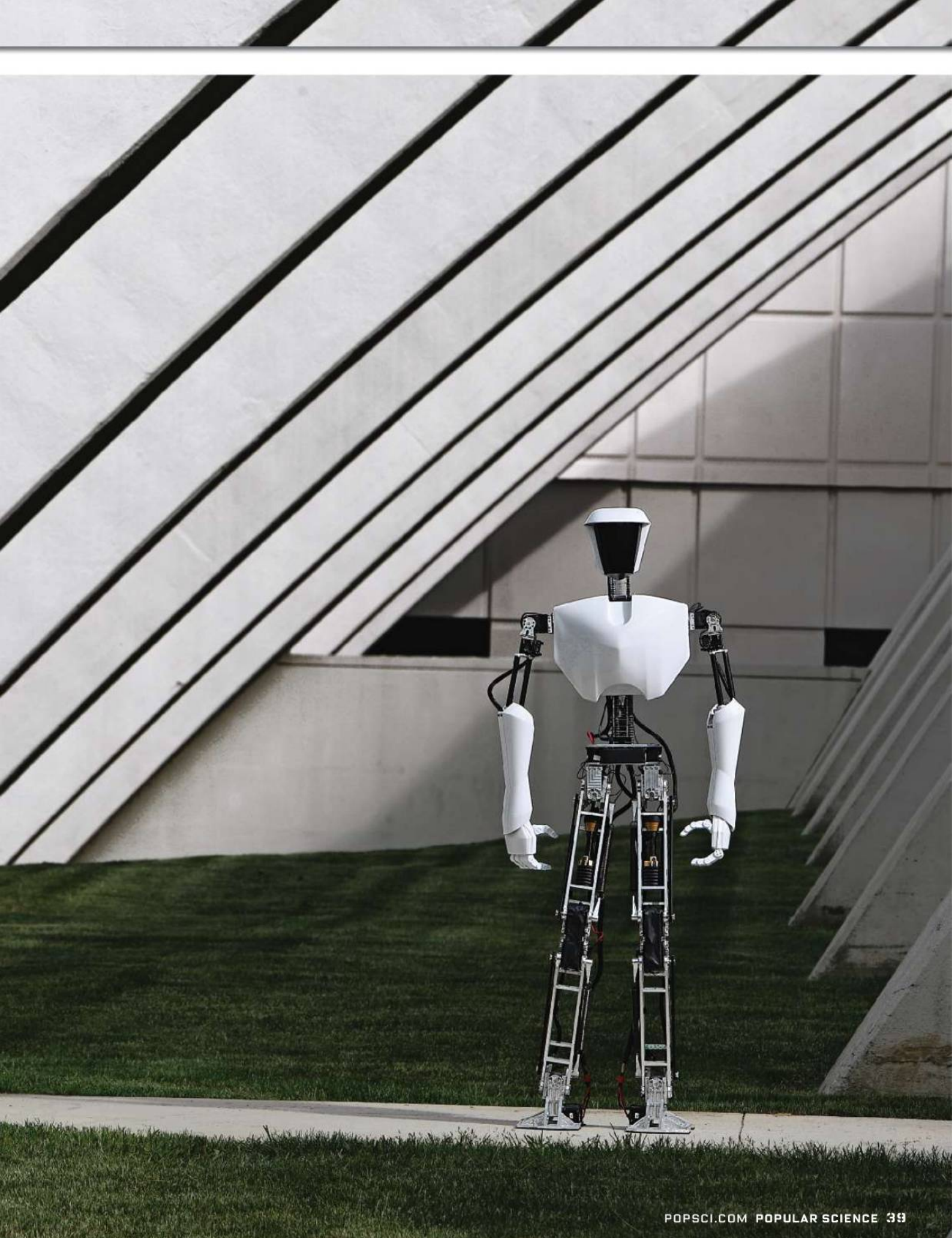
by Schneider Electric

THE LONELIEST HUMANOID IN AMERICA

Walking, self-contained, adult-size robots are commonplace in robotics labs in Japan and South Korea, but there's only one made here. Why are we falling behind? BY JACOB WARD

PHOTOGRAPHS BY
JOHN B. CARNETT

SOLO ROBOT Virginia Tech students built CHARLI-L, shown on campus, as part of a homegrown effort to compete with Japan and South Korea's best humanoids.



Let's assume that someday you will have, in your home, a humanoid robot helper. The robot, because it's shaped like you, can use your tools and move easily around your house. It folds the laundry, it helps your elderly mother up the stairs, and on Sundays it makes brunch for the family. It's capable of handling almost any household chore you can throw at it.

Now let's imagine that you're out on the lawn, kicking a ball around with your son. Your robot helper is in another part of the yard, its back to you both, fixing a drainpipe. Your son misses a kick, and the ball winds up a few feet from the robot. "Hey, robot!" you shout. "A little help?" The robot turns in place, spots the ball, walks over, and kicks it back to you. The game resumes.

Of all the tasks you would undoubtedly love to hand off to a robot assistant, fetching a soccer ball is probably low on the list. And yet in 2010, there is no humanoid robot on Earth that can consistently do something as simple as turn, spot, approach, and kick. Never mind helping Grandma to bed or starching your shirts. Broken into a daisy chain of input, calculation and action, just kicking a ball is incredibly hard. It's so difficult, in fact, that engineers from all over the world have embraced it as the modern era's standardized test of humanoid-robot sophistication, and they converge each June at an event called RoboCup to try it. This year, only one adult-size, self-contained, humanoid robot in this country can even attempt it.

Its name is CHARLI-L (the "L" stands for "Lightweight" and the rest for "Cognitive Humanoid Autonomous Robot with Learning Intelligence"). Created at Virginia Tech, it's America's first true humanoid, in that it requires no remote power source or computer, it stands roughly five feet tall and has arms and legs, and it walks—left, right, left, right—like a human.

As such, CHARLI-L belongs to an exclusive international club of humanoid robots, each of them designed to hasten the day when robots play a central role in all of our lives. Japan and South Korea dominate this club, together outspending the U.S. in civilian robotics many times over. Japan's Asimo, a humanoid first built in 1986 by the Honda Corporation and now in its 12th generation, and Korea's Hubo, built to compete with Asimo in 2004 by Jun-Ho Oh of the Korea Advanced Institute of Science and Technology (KAIST), are the pride of their nations. Honda is said to have put \$300 million and more than 100 worker-years into the first Asimo. Dennis Hong, an

TEST CASE

A humanoid like CHARLI-L, says Dennis Hong, whose students created it, "combines all the disciplines of robotics: dynamics, controls, power, all of it."

ADDITIONAL REPORTING FROM JAPAN
AND KOREA BY BRIAN ASHCRAFT





"I think a full-size humanoid is the Holy Grail of robotics," Hong says. "It's a system of systems."

associate professor of mechanical engineering at VT, laughs at the idea. "That guy," he says, pointing at CHARLI-L, "was 12 undergrad and grad students in a year and a half, with seed money of \$20,000."

Dennis Hong is the founder of VT's Robotics and Mechanisms Laboratory and the leader of the student team that built CHARLI-L. We're seated at a workbench inside the University of Pennsylvania's robotics lab, run by Hong's friend and collaborator Daniel Lee. Hong's students are here to show CHARLI-L to Lee's students, to prepare for RoboCup 2010, held in June in Singapore, and to discuss upcoming partnerships. Hong (winner of a 2009 POPULAR SCIENCE Brilliant 10 award) and his students have produced chemically driven, amoeba-like robots; a spider-like 'bot called STRiDER, whose swinging walk is modeled on the human gait; and a system by which blind adults can make guided yet independent decisions as the drivers of their own cars. Lee's students build complex software to govern robot behavior and human-robot interaction. These are some of the most accomplished robotics engineers in the field. But as I watch the students fiddle with CHARLI-L, it begins to dawn on me how much work stands between CHARLI-L and the RoboCup trophy, to say nothing of how much work it will take to reach a future full of robot helpers.

The sheer scale of the challenge is the point, Hong says. "I think a full-size humanoid is the Holy Grail of robotics," he explains. "It's a system of systems. It combines all the disciplines of robotics, from artificial intelligence to autonomous behavior to dynamics to controls to mechanical design—everything!"

At the moment, however, VT junior Taylor Pesek, Ph.D. student Jeakweon Han and master's student Seungmoon Song are just trying to get CHARLI-L to stand upright. "Uh-oh," Han says, catching the robot as it lolls forward, knees buckling. "Stop putting in commands," Pesek says. "I'm not," Song responds. Pesek turns the power off and on and, with a bit of wrestling, the robot stands at quiet attention.

If standing still is so difficult, how hard is kicking a ball? The rules of RoboCup, in which six teams will compete for the title of "Best Humanoid" in the Adult Size Humanoid division, require that the robot be facing away from the ball when the event begins, so the machine has to turn around and find it. "It's a high-end academic exercise dressed up as an entertainment event," Hong says. Break the goals—kicking balls at a target, basic dribbling, and trying to slowly block the very slow shots from other robots—into individual processes, and the to-do list grows very long. To eventually build the brunch-making 'bot of the future, Hong must first win RoboCup. And that's hard. "Just getting it to turn around in place is ridiculous," says master's student and CHARLI-L team member Robert Nguyen. Is it also pointless?

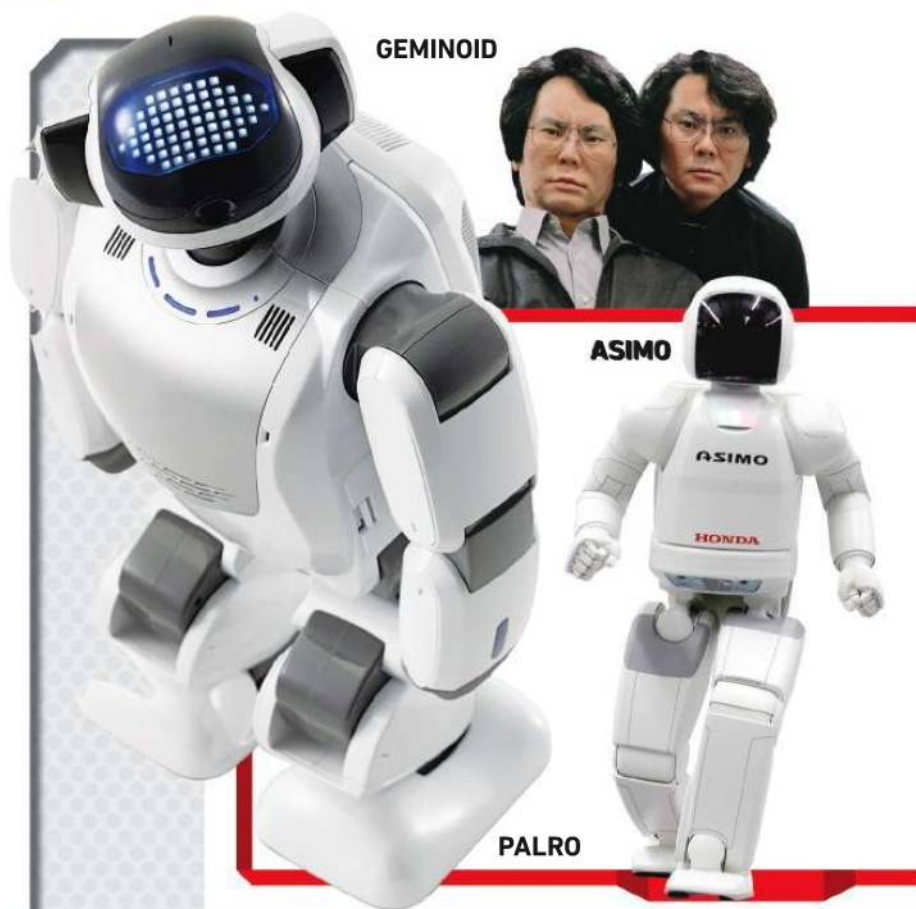
AMERICA'S HUMANOID DILEMMA

Nearly everyone would want a dutiful, reliable robot helper, so why is there only one such humanoid made in this country? And why is it the work of a small team of unpaid students? To get at the answer, consider the machines in your life. Your dishwasher, your car, your DVR all serve a practical, well-defined purpose. Today's humanoids, meanwhile, serve almost no practical function. "They represent incredible research and technology that's then backed into an application" says Colin Angle, the CEO of iRobot, which makes domestic cleaning robots and military models. Roboticians working on humanoids, he says, "are doing amazing, exciting work, but it's just not going to drive the robot industry—unless it's for entertainment purposes."

Asimo, the most sophisticated Japanese humanoid, is famous for its balance and adaptability. It can even run, in an awkward, distinctively robotic way. But if it encounters a closed door, the show's over, because the calculations necessary to reach out, grasp the knob, turn it, and walk forward, pushing the door ahead of itself, are still too complicated. (The fragility doesn't end there. "Our products can survive a two-story fall," Angle says. "See what happens with an Asimo.") Japan has embraced Asimo, however, as a broad, long-term investment in a wide range of scientific challenges, from materials science to artificial intelligence. It's not a robo-butler. It's a stake in the ground, a totem of Japan's belief that our future will be full of helpful, sentient, Japanese-made machines.

That kind of open-ended vision doesn't work here, where our funding environment rewards near-term products, not totems. As a result, the U.S., though it is filled with robotics projects, lags behind Japan and South Korea in the development of humanoids. In 2006, sponsored by the National Science Foundation and others, the nonprofit World Technology Evaluation Center (WTEC) published a report entitled "International Assessment of Research and Development in Robotics," comparing America's activities with the rest of the world's. The report concluded that while this country leads the world in military and medical robotics, it is quickly losing that advantage and falls short when it comes to robot mobility and humanoid robotics. Although "robotics is a very active field, worldwide," the authors wrote, "Japan, Korea and the European Community invest significantly larger funds in robotics research and development for the private sector than the U.S."

"Money is flowing to universities and research centers," says University of Southern California engineering professor George Bekey, who led the WTEC team on a research trip through Korea and Japan in 2004 and 2005. "Korean funding for robotics is about \$80 million a year. In contrast, U.S. funding for civilian robotics from the National



MADE IN JAPAN

ASIMO

Japan's leading humanoid is rumored to have cost \$300 million and 100 worker-years.

PALRO

One of dozens of autonomous Japanese 'bots to hit the market every year.

GEMINOID

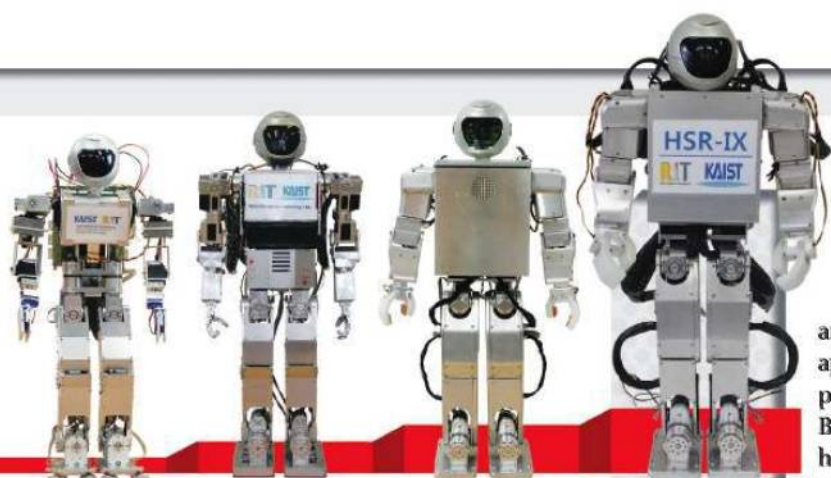
The robot, at left in the photo above, is a jarring experiment in human-robot interaction.

Science Foundation is about \$10 million a year."

Military spending on American robotics is robust, but our war-robot platforms are getting us no closer to a humanoid. Those platforms are purpose-built for bomb defusal and aerial surveillance, and so don't provide broader opportunities. "Korea and Japan have national strategic initiatives in robotics," the WTEC group wrote. "In the U.S., Darpa programs"—the chief source of military funding for high-level robots—"are highly applied and short-term oriented, while its support for basic research in robotics has been drastically reduced."

Viewed through the eyes of a Darpa program officer, it's easy to see why humanoids have been largely ignored. The logic of researchers like Hong is that to be truly useful, domestic robots must be human-shaped, because such technologies as stairs and refrigerator doors and bottle openers are designed for human use. But when funding agencies read that argument in a grant proposal, it only goes so far, because research hasn't established a consistent model for automated forms of walking, or opening iceboxes, or cracking beers. Designing humanoids, in other words, puts the cart before the horse.

"It has to do with U.S. pragmatism," says Carnegie Mellon University professor James Kuffner, who develops machine-learning software and heads the university's Humanoid Interaction Team. Like many leading American roboticists who do research



MADE IN KOREA

HSR SERIES

South Korea's HanSaRam (HSR) series, built by the Robot Intelligence Technology lab in Daejeon, has been updated every year since 2000.

HUBO

Jun-Ho Oh's answer to Asimo, and Korea's greatest humanoid.

ALBERT HUBO

The autonomy and bipedal movement of Hubo, with an expressive face by Hanson Robotics.

MAHRU

Another Korean humanoid, the male of a pair, built as a "network humanoid."

capable of assembling tiny, intricate machines on a factory floor. Robotic components evolve separately and for highly specialized tasks.

Take grasping, for example. The interception and manipulation of objects by an automated appendage is perhaps the most commonly researched problem in robotics. ("It's approachable," Hong says.) Barrett Technology, in Cambridge, Massachusetts, has developed the WAM arm (short for Whole-Arm Manipulation) and the BarrettHand—lightweight, high-torque robotic limbs capable of complex motions and manipulations. Deka Research and Development Corp., led by inventor Dean Kamen, created the Luke Arm, which is also capable of extremely sophisticated movement, as an advanced human prosthesis. And Willow Garage, a company founded by open-source-software pioneer Scott Hassan, has created PR2, a two-armed robot atop a wheeled base. PR2 is particularly useful for investigating the manipulation of objects while it's in motion, an even more advanced problem—a team at the University of California at Berkeley recently used PR2 to devise a sophisticated and much-celebrated towel-folding algorithm.

Several U.S. teams are focused on bipedal walking, generally considered among the most difficult of all humanoid-robotics challenges and the one most closely linked to human applications, in that building bipedal robots helps researchers to develop a better prosthetic leg and foot because it forces them to reverse-engineer human movement. Marc Raibert, considered the father of leg robotics, founded the Leg Laboratory at Carnegie Mellon in 1980 and then moved it to the Massachusetts Institute of Technology in 1987 before going on to launch Boston Dynamics in 1992. The company's four-legged BigDog and two-legged Petman are capable of walking across unstable terrain—perfect for carrying supplies alongside a soldier on patrol—and can regain their balance dynamically even after being suddenly and violently shoved off course. Yobotics, founded by four alumni of MIT's Leg Lab, created M2, a bipedal robot that can walk in place and balance on one leg. And the University of Michigan's Human Biomechanics and Control Laboratory, headed by professor of mechanical engineering Art Kuo, is developing an "elastic locomotion" model that can help explain how we humans walk without seriously exerting ourselves.

Each of these systems feels like its own piece of an all-in-one American-made robot of the future. But without a governing authority piecing them together, or a centralized funding agency directing their convergence, each team, and their individual pieces of technology, will never form a cohesive whole.

ROBOT, PLEASE TELL ME WHY

What is the practical purpose of creating humanoids? Asking roboticists this question is like asking

The U.S. lags far behind Japan and South Korea in humanoids.

in Asia, Kuffner worked for several years in Japan as part of a robotics fellowship at the University of Tokyo and is in the midst of a year's sabbatical at Google. "We think, 'If we have a problem, let's design the simplest, cheapest solution,'" he says.

Lee explains it in similar terms. "If you write a proposal here for a robot that plays music, you'll have a very hard time finding funding. What's the practical purpose?" he says. "Yet if a robot improvised a jazz performance, it might teach you all sorts of things about artificial intelligence and even human intelligence. There's more openness to that kind of investigation in Asia and Europe. Here the focus is on a well-defined problem."

As a result, what might otherwise someday form a full-fledged humanoid is in well-defined pieces all over the country. American researchers, focused on solving practical problems, are developing robotic prosthetics that are the functional equivalent of human limbs, robotic eyes that can detect cancer, and highly articulated robot arms

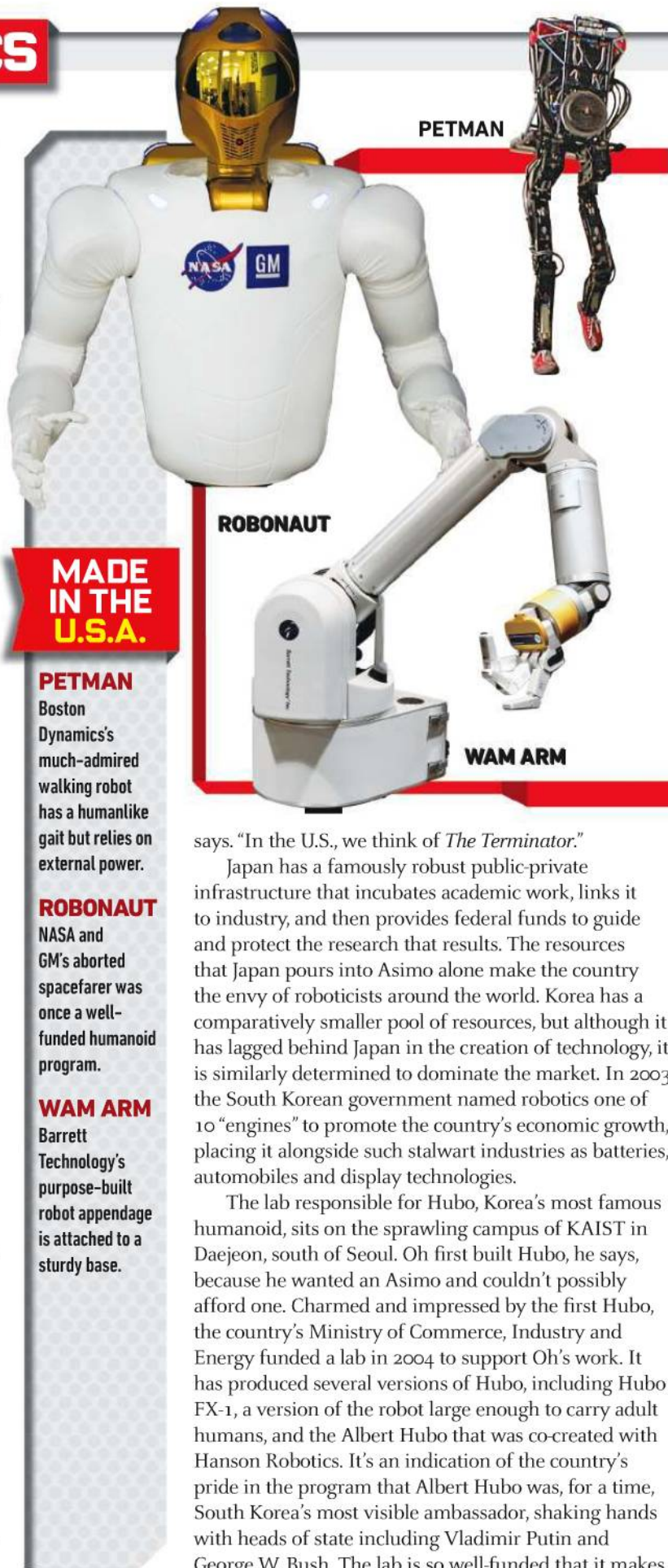
THE FUTURE OF ROBOTICS

philosophers why they pursue the meaning of life. The logic is circular (we're building robots in humanoid form so that humans will better accept the robots we're building in human form), the message has to do with faith (when we're on the far side of this problem, we won't know how we got along before), and the broader purposes all involve distant rewards (artificially intelligent, problem-solving robot companions) that the researchers seem to consider unquestionably valuable but that are difficult to conceive of in the here and now.

David Hanson, the founder and chief technology officer of Hanson Robotics, collaborated with Jung-Ho Oh, the creator of Korea's Hubo, to produce a version of the robot with the face of Albert Einstein, made of simulated flesh and expression-generating actuators. Hanson is now developing a humanoid, called Zeno, that he hopes to market both as a household companion and as a research platform. His summary of the need for humanoids is representative of many people I spoke with. "Making humanlike robots," he says, "allows us to understand ourselves better." He believes that it creates a clearly defined research path; not just advancements in the various parts of a humanoid—improved prostheses, grasping, finally pinning down the mechanics of human balance—but the pursuit of robotic consciousness. "Cognition is the greatest challenge in all of robotics," he says. "If on the way we're designing humanoids, we have a handy benchmark for seeing where we are in the process."

In Japan and Korea, researchers—and, more significantly, funding sources—embrace this logic. Their commitment to developing humanoid robots means that Asimo and Hubo incorporate their respective countries' best work in everything from mechanical functions to intangibles like artificial intelligence. These functions are integrated into every successive generation of humanoid, rather than remaining in the lab of a specific team. By 2004, Asimo had already incorporated facial recognition, speech recognition, the subtleties of interpreting gestures and posture, and digital mapping of its environment. With Asimo, Hanson says, "Toyota and Honda have solved manual-dexterity tasks that used to be unsolvable. It's just that they show them off in silly ways. They get him to play trumpet or the violin. But with that dexterity, imagine what you can assemble in a factory! These are massive breakthroughs."

Most American engineers who have encountered Japanese and Korean engineers offer up armchair psychology about a pro-technology bias in those societies that creates enthusiasm for humanoids. Kuffner points out that in Japan, Shinto beliefs posit that inanimate objects have a benevolent spirit. "And Japanese boys who grew up in the '50s and '60s read comic books about Astro Boy and other characters with robot assistants and sidekicks—all friendly, kind," he



**MADE
IN THE
U.S.A.**

PETMAN

Boston Dynamics's much-admired walking robot has a humanlike gait but relies on external power.

ROBONAUT

NASA and GM's aborted spacefarer was once a well-funded humanoid program.

WAM ARM

Barrett Technology's purpose-built robot appendage is attached to a sturdy base.

says. "In the U.S., we think of *The Terminator*."

Japan has a famously robust public-private infrastructure that incubates academic work, links it to industry, and then provides federal funds to guide and protect the research that results. The resources that Japan pours into Asimo alone make the country the envy of roboticists around the world. Korea has a comparatively smaller pool of resources, but although it has lagged behind Japan in the creation of technology, it is similarly determined to dominate the market. In 2003 the South Korean government named robotics one of 10 "engines" to promote the country's economic growth, placing it alongside such stalwart industries as batteries, automobiles and display technologies.

The lab responsible for Hubo, Korea's most famous humanoid, sits on the sprawling campus of KAIST in Daejeon, south of Seoul. Oh first built Hubo, he says, because he wanted an Asimo and couldn't possibly afford one. Charmed and impressed by the first Hubo, the country's Ministry of Commerce, Industry and Energy funded a lab in 2004 to support Oh's work. It has produced several versions of Hubo, including Hubo FX-1, a version of the robot large enough to carry adult humans, and the Albert Hubo that was co-created with Hanson Robotics. It's an indication of the country's pride in the program that Albert Hubo was, for a time, South Korea's most visible ambassador, shaking hands with heads of state including Vladimir Putin and George W. Bush. The lab is so well-funded that it makes



HUMAN TOUCH The lightweight design of CHARLI-L makes it possible that a future version could climb stairs, deliver objects, and hold hands.



The logic of researchers like Hong is that to be truly useful, domestic robots must be shaped like humans.

its own parts on-site, instead of having to explain requirements to a manufacturer. An adjacent room stores countless nuts and bolts and a seemingly endless spool of wires. "We produce everything in the lab," Oh says. "It's much faster."

Two hours away, in Ansan, the Korean Institute of Industrial Technology maintains its own lab, the Division of Applied Robot Technology. And these government-funded programs exist alongside robust robotics programs at companies like Samsung, LG and Hyundai and smaller, dedicated ventures like Yujin and Microrobot. Fifty Korean kindergartens use educational robots for daily lessons, and pilot programs have been distributing domestic robots to Korean households since 2005. "They see robotics the way we saw the Apollo program," Lee says. "The government has decided 'We're going to put resources into this, we're going to throw our best and brightest at this, and we're going to transform our lives.'"

HOW TO FIGHT A ROBOT WAR

The fact that Dennis Hong and his students were able to build CHARLI-L in such a short amount of time, on a donated budget, using donated parts, is a sign that America's best and brightest are eager to create humanoids. But CHARLI-L—light enough to lift with one hand and fitted with just enough actuators to make it through RoboCup—cannot challenge Japanese and Korean supremacy in humanoid robotics on its own. Byoungsoo Kim is the founder and CEO of the Seoul-based company Robotis, which produces off-the-shelf parts for use in robotics systems, including CHARLI-L. Virginia Tech is a prized partner, as Hong's students regularly put Robotis components into their inventions. Kim believes that an open-source community working on a standardized platform could transform American robotics the way open-source development has transformed computing. Without that community, he says, "the robot itself is nothing. The software is what's important."

Several American companies are vying to be that platform. Willow Garage's PR2 robot, in use at Stanford University and U.C. Berkeley, is built around the same distribution model: The company builds the hardware, then sells or rents it to academic institutions that can then write and test algorithms for motion. And for the past three years, Paul Oh of Drexel University along with Lee and Hong have been developing their own open-source platform around Hubo.

Shortly after the WTEC report was issued, Drexel, in collaboration with Virginia Tech, UPenn, Bryn Mawr College and Colby College, won a National Science Foundation

(CONTINUED ON PAGE 84)

RISE OF THE HELPFUL MACHINES

The world's most sophisticated robots don't assemble trucks or cruise around Mars. They're designed to support our surging population of elderly and disabled citizens. Meet 10 of the most promising senior-friendly 'bots

BY COREY BINNS

PHOTOGRAPHS BY JOHN B. CARNETT

RIBA A FORKLIFT FOR HUMANS

BIRTHPLACE: Institute of Physical and Chemical Research, Japan

OCCUPATION: Helps patients who are too weak to walk, sit, or stand on their own
WHY WE NEED IT: The number of Americans over age 65 will reach 71 million by 2030. RIBA (Robot for Interactive Body Assistance) is the only robot with arms designed to carry those people around.

HOW IT WORKS: A powerful motor, plus 454 sensors

embedded in RIBA's arms, helps the robot lift and move people weighing up to 135 pounds. (Inventor Toshiharu Mukai and his colleagues aim to increase its strength next year when they test it in nursing homes in Japan.) For a comfortable ride, squishy skin made of urethane foam covers RIBA's metallic frame. The robotic orderly can also recognize faces and voices and responds to commands such as, "RIBA, please help me off the couch."

ON THE JOB BY: Next year

PERMMA

THE ONLY WHEELCHAIR WITH ROBOTIC ARMS

BIRTHPLACE: University of Pittsburgh

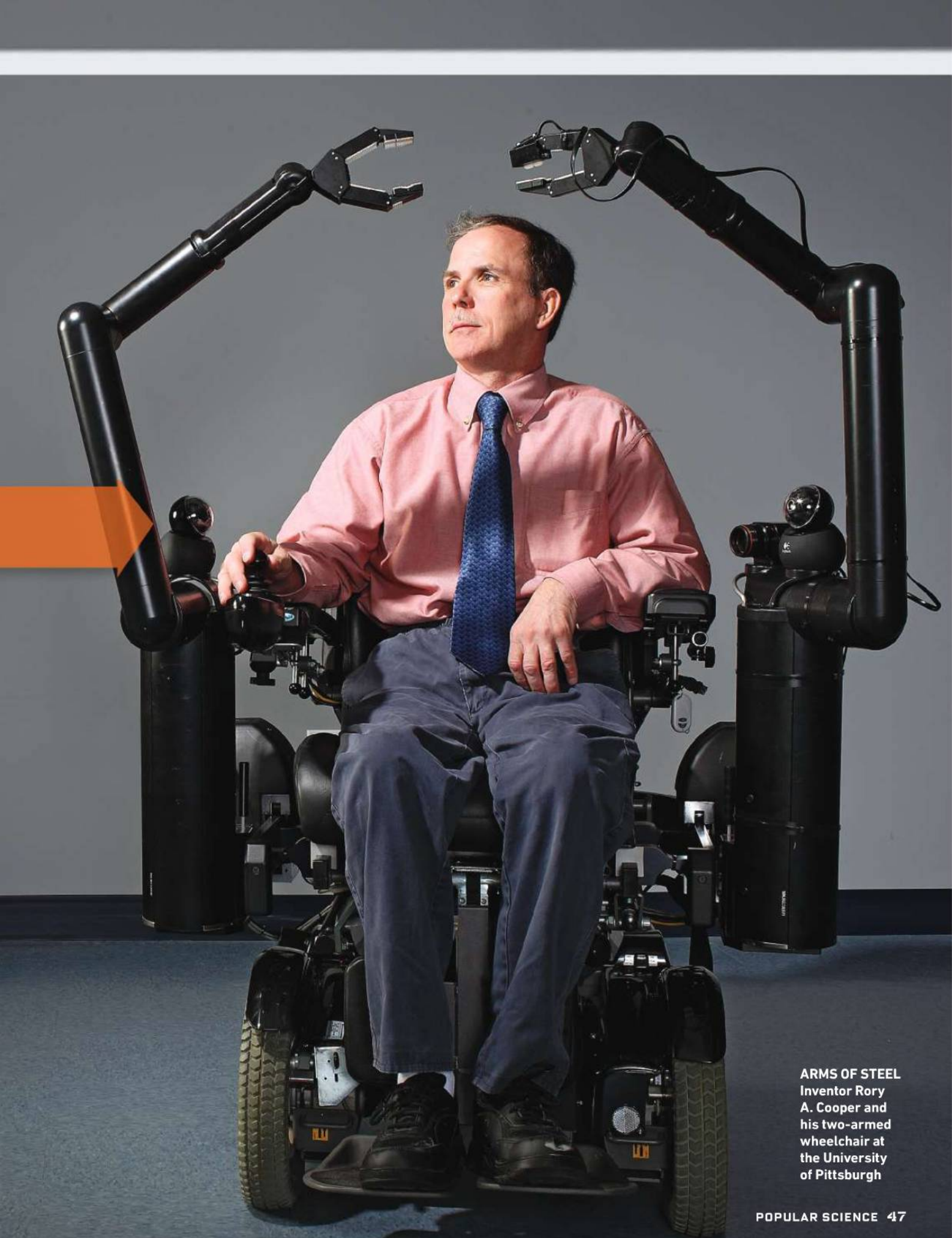
OCCUPATION: Nurse: transports and feeds patients with spinal-cord injuries

WHY WE NEED IT: Today 4.3 million Americans rely on wheelchairs, yet few of those chairs are ideal for people with debilitating physical impairments, such as those of a quadriplegic.

HOW IT WORKS: After Rory A. Cooper was partially paralyzed during a bicycle accident, he learned firsthand the limitations of conventional wheelchairs. Although he still had the use of his arms, many other paralyzed people he met did not. So he set out to build them a better chair. His Personal Mobility and Manipulation Appliance (PerMMA) features two robotic arms programmed to help users easily perform everyday tasks like cooking, dressing and shopping. Users can control the robotic arms from a touchpad, microphone or joystick, depending on their abilities. For now, each arm can support six pounds, but Cooper is designing a new arm strong enough to hold 150 pounds, pull a turkey out of the oven, or pick up a pot of spaghetti off the stove, he says.

ON THE JOB BY: 2020





ARMS OF STEEL
Inventor Rory
A. Cooper and
his two-armed
wheelchair at
the University
of Pittsburgh



KOMPAÏ

A PLAINSPOKEN PERSONAL ASSISTANT FOR GRANDMA

BIRTHPLACE: Robosoft, France

OCCUPATION: Personal assistant: reminds seniors to take their meds and calls for help if needed

WHY WE NEED IT: It's a simple 'bot for the tech-challenged

HOW IT WORKS: Kompaï's chief feature is its senior-friendly interface and congenial personality. Tell the Web-enabled robot you're not feeling well, and it thoughtfully asks, "Where does it hurt?" and then e-mails your symptoms to your doctor. Kompaï can record a grocery list, set up videoconferences with doctors, and call 911. Around the house, it avoids stairways and knows when it's time to roll itself to its charging dock. Although it operates primarily by voice control, the robot also has a touchscreen with simple icons. Arms are optional. Robosoft CEO Vincent Dupourqué is marketing an open-source version, called RobuBox-Kompaï, to developers, who can design their own software for the 'bot.

ON THE JOB BY: Next year

HERB

THE FASTEST, MOST CAPABLE ROBO-SERVANT

BIRTHPLACE: Intel Labs in Pittsburgh and Carnegie Mellon University

OCCUPATION: Butler

WHY WE NEED IT: Who doesn't need reliable, competent help with household chores? "HERB is the most technologically advanced personal robot in existence," says Intel senior researcher Siddhartha Srinivasa.

HOW IT WORKS: Scientists at Intel and Carnegie Mellon built HERB (Home Exploring Robot Butler) on a nimble Segway base, so it can maneuver around kitchen cabinets and balance a tray of martinis without spilling a drop. It's smart, too. Image-recognition software lets the robot distinguish between objects, so when you ask for a soda it won't bring you juice. HERB can also imitate humans, learning to pick up objects the way its owners would. The team is refining software that will make the 'bot less prone to collisions in cluttered spaces and building another arm so that it can empty the dishwasher and fold laundry, even the dreaded fitted sheets.

ON THE JOB BY: 2025

TAMER

A ROBOTIC "TOUCH THERAPIST" SOOTHES ANXIETY

BIRTHPLACE: University of British Columbia

OCCUPATION: Child therapist

WHY WE NEED IT: An estimated 13 percent of kids aged 9 to 17 experience some kind of an anxiety disorder.

HOW IT WORKS: This furry, touch-sensitive robo-bunny helps children with stress and anxiety disorders "tame their worry dragons," says inventor Karon MacLean of the University of British Columbia. Sensors worn on the patient's body measure signs of stress such as increased heart rate and sweaty fingertips. The Tamer wiggles to help patients

recognize these changes—a critical step in controlling their anxiety. Pressure sensors and accelerometers inside the robot also let it respond to touch. For instance, Tamer stiffens its ears when jabbed but then softens them and begins to purr as the patient gently pets it. "No one else is using touchable, emotionally expressive robots in anxiety therapy," says MacLean, who began testing the robot this summer with kids who have anxiety disorders. She ultimately hopes to build an at-home version for around-the-clock comfort.

ON THE JOB BY: 2014



FROM TOP: ROBOSOFT; MARTIN DEE/UBC PUBLIC AFFAIRS; PRECEDING PAGES: INSET: RIKEN/TRI COLLABORATION CENTER FOR HUMAN-INTERACTIVE ROBOT RESEARCH



MIND YOUR MANNERS
The robotic butler HERB helps engineer Michael Vandeweghe with his chair.

CYCLOPS

A LEGALLY BLIND ROBOTIC GUINEA PIG FOR TESTING ARTIFICIAL EYES

BIRTHPLACE: California Institute of Technology

OCCUPATION: Simulates the visual experience of a blind person outfitted with a retinal implant

WHY WE NEED IT: Most vision implants are still too crude to test on humans.

HOW IT WORKS: Cyclops, a \$20,000, four-wheeled rover, is the world's first stand-in for the visually impaired, allowing researchers

to test and refine image-processing software for prosthetic eyes on a robot instead of a person. Mounted to Cyclops's head is a remote-controlled camera that can pivot to capture the same view as a patient with that particular prosthesis would. If the robot can't tell the difference between a stairwell and a fireplace, researchers will know they need to refine their algorithms.

ON THE JOB BY: This year



RISER A FULLY IMMERSIVE REHAB ROBOT

BIRTHPLACE: University of British Columbia

OCCUPATION: Rehabilitator

WHY WE NEED IT: Today's physical-therapy equipment for balance requires stroke victims to have enough strength to stand on their own, but that puts them at risk of more falls and injuries.

HOW IT WORKS: The RISER (Robot for Interactive Sensory Engagement and Rehabilitation) is the only rehab system that can simulate a wide range of unstable situations while fully supporting a patient's body weight to help him regain his sense of balance after a stroke. Supported by a back brace, a patient stands on a Wii-board-like platform that can move in six directions. Virtual-reality goggles work in sync with the platform to guide users through different simulated activities, such as riding up an escalator or windsurfing. Patients can gradually attempt more-challenging balancing acts to speed up their recovery.

The platform is also a powerful research tool in the quest to better understand the neurobiology of balance. When a patient stands on the platform and experiences a recording of his previous ride, electrodes attached to his scalp give scientists insight into how different brain regions are responding to the experience.

ON THE JOB BY: 2015



The RISER

RAVEN 2

A ROBO-SURGEON THAT DOES THE WORK OF TWO DOCTORS

BIRTHPLACE: University of Washington and University of California at Santa Cruz

OCCUPATION: Remotely operated surgeon

WHY WE NEED IT: Wounded soldiers, disaster victims and people who live in rural areas are rarely within reach of top-notch surgeons and medical centers. As inventor Jacob Rosen puts it, "There's a doctor who's done the surgery once in his lifetime standing next to you, or an expert halfway around the world. Who do you choose?"

HOW IT WORKS: The Raven surgical system is the first to allow two surgeons to remotely operate together on a patient. One surgeon could sit at a console in, say, Los Angeles, watching on a computer screen as the robotic arm she's manipulating with a joystick deftly slices into a patient lying on an operating table in North Dakota. Meanwhile, another surgeon at a console in New York wields the second set of robot arms. Rosen, a computer engineer at the University of California at Santa Cruz, designed software that allows surgeons to seamlessly operate the four arms without colliding them.

ON THE JOB BY: 2013



CARDIOARM THE SLINKIEST SURGICAL TOOL

BIRTHPLACE: Cardiorobotics and Carnegie Mellon University

OCCUPATION: Surgical assistant: conducts minimally invasive heart surgery

WHY WE NEED IT: Heart surgery means slicing the chest, breaking the sternum, and splaying the ribs; recovery can take months.

HOW IT WORKS: Carnegie Mellon University engineer Howie Choset's snake-shaped surgeon is only a centimeter long and weighs less than three ounces, yet it's packed with motors and joints that give it 102 degrees of freedom, letting it deftly wrap itself around organs and worm through intestines, bronchial tubes and

other pathways used during endoscopic surgery. Its unprecedented flexibility, along with a tiny camera head, makes it easy to steer remotely using a joystick. "Make a quarter-inch turn one way, move an inch, make a quarter-inch turn another way, and boom!—you're behind the heart," says Choset, the co-founder of Cardiorobotics, Inc. In February the robot performed a diagnostic procedure on a patient who otherwise would have required a surgeon to split her breastbone, which would have tacked months onto recovery.

ON THE JOB BY: 2012



FROM TOP: JOHN B. CARNETT (2); ALAN GOUGH/UNIVERSITY OF BRITISH COLUMBIA/
INSTITUTE FOR COMPUTING, INFORMATION AND COGNITIVE SYSTEMS



DR. ROBOT0 This remotely operated surgeon at the University of California at Santa Cruz features four arms.

TAIZO

THE RICHARD SIMMONS OF ROBOTS

BIRTHPLACE: National Institute of Advanced Industrial Science and Technology, Japan

OCCUPATION: Workout instructor

WHY WE NEED IT: Exercise can help senior citizens live longer, healthier lives, but their growing ranks will soon outnumber qualified fitness instructors.

HOW IT WORKS: This two-foot-tall robot looks more like a miniature snowman than a personal trainer, but its 26 joints make it almost as flexible as a yogi. Taizo helps lead simple movement classes in Japan, mostly from a chair for the convenience of

its seated students. Among its repertoire of 30 exercises, Taizo can stretch its arms wide and bend down to touch its toes. And although the robot is in great shape, it's not tireless—after two straight hours of exercise, its batteries need recharging. Special motors allow the little guy to perform slow, methodical motions that are easy to imitate and help followers avoid muscle strain. Next month, developer General Robotix begins selling the robot's \$10,000 frame to scientists for research.

ON THE JOB BY: Next year



CONCEPTS & PROTOTYPES

A FLYING BOAT

To circumnavigate the world in a record-breaking 40 days, *l'Hydroptère Maxi* takes inspiration from the Wright brothers

BY DAWN STOVER ILLUSTRATIONS BY DANIEL SCHUMPERT

THE TEAM BEHIND the world's fastest sailboat—*l'Hydroptère*, a 78-foot trimaran that sailed at a record-breaking 50-plus knots (nearly 58 mph) for more than a nautical mile last year—is designing a new model to break another big racing record. With *l'Hydroptère Maxi*, a crew of 10 hopes to sail around the world in less than 48 days and eight hours, beating the current fastest time as set by the French crew of *Groupama* last March.

The *Maxi*'s skipper, Alain Thébault, who has been creating high-speed sailboats for 25 years, has assembled a team that includes advisers from the Swiss Federal Institute of Technology and aeronautical engineers. Like *l'Hydroptère*, whose name comes from the Greek words for water and wing, *l'Hydroptère Maxi* will be part boat and part plane. At slower speeds, it will glide through the water like a conventional trimaran, floating on a center hull flanked by two stabilizing hulls. But at faster speeds, submerged finlike hydrofoils

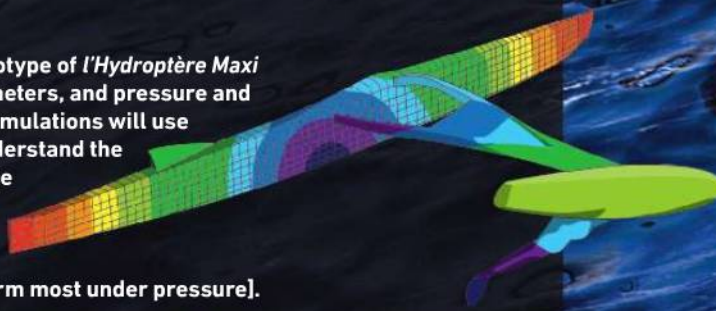
attached to the bottom of the side hulls act like airplane wings, forcing water over the curved top surface of the foils to lift the hull up to 33 feet above the water. With no drag acting on the hulls, the boat essentially flies across the ocean.

Breaking the record, not to mention keeping the crew safe, rests on the perfect design of the foils and hulls. If the wings snap in rough weather or the hulls suddenly smack into the water, the boat could take a nosedive. "Flying in waves can be dangerous," says lead designer Jean-Mathieu Bourgeon. Another big challenge is making the boat as light as possible without sacrificing too much strength, to maximize speed and safety in both floating and flying modes.

Thébault and his group will spend the next year designing *l'Hydroptère Maxi*, including testing scale models of the foils in computer simulators. If all goes as planned, the crew could set sail as early as 2013, possibly starting in Europe and heading south through the Atlantic Ocean to circle Antarctica.

STRESS TESTING

Researchers will outfit a prototype of *l'Hydroptère Maxi* with strain gauges, accelerometers, and pressure and rotation sensors. Computer simulations will use the data to help designers understand the behavior of the boat as a whole and push the design to its physical limits. This example shows stress distribution [red indicates areas that deform most under pressure].



CENTERBOARD

When the wind speed is low—less than 15 knots—the crew deploys a centerboard [not shown] and raises the foils out of the water, switching the boat from flying to floating mode.

CREW CONTROLS

Using real-time measurements from stress sensors, GPS and an inertial unit, which measures factors such as roll, pitch and speed, the crew can adjust the boat accordingly for the most efficient sailing.



THE SPECS

L'HYDROPTÈRE MAXI

LENGTH: 100 feet

MAST HEIGHT: 130 feet

SPAN: 90 feet

WEIGHT: 20 tons

CREW SIZE: 10

TOP SPEED: 50 knots

VIDEO IMAGING

The team will use video cameras to film sail behavior, crossbeam deformation, and how far the foils are immersed in water under various conditions. Computer models are then refined to predict how the boat will behave under even more extreme conditions.

CROSSBEAMS

Crossbeams made from lightweight carbon and titanium connect the central hull to two side hulls. Blueprints for hydrofoil trimarans date back to the 1950s, but not until the advent of composite materials could engineers build strong enough crossbeams to support boats as large as the *Maxi*.

FOILS

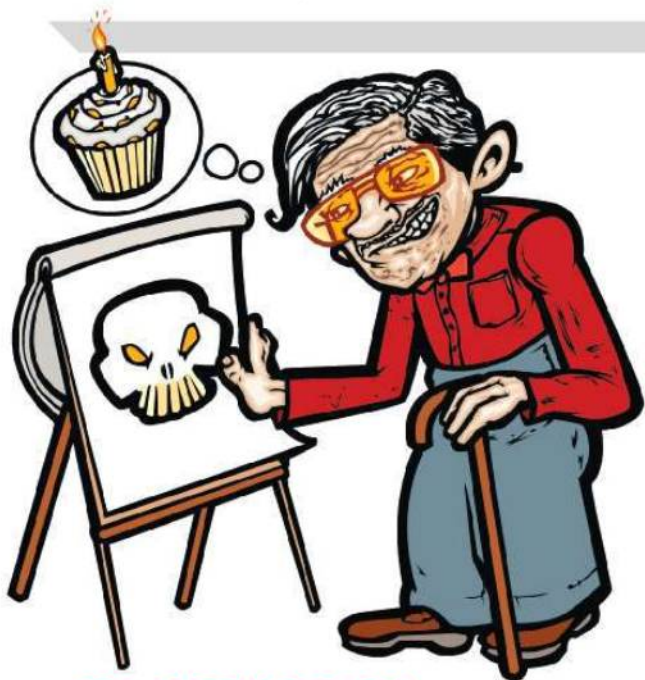
Unlike the foils on most multihull racing boats, which reduce drag but do not raise the boat completely out of the water, *Maxi*'s underwater wings lift it up to 33 feet above the ocean's surface.

RUDDER ELEVATORS

Maxi has two rear tail units for better balance when elevated on its foils.

Science Confirms the Obvious

It might seem silly to investigate whether people are happier on the weekend, but behind such truisms are revelations about our brains, our behavior and our environment



BY JASON DALEY
ILLUSTRATIONS BY COJO

Blowing Up Mountains Is Bad for the Environment

THE STUDY: "Mountaintop Mining Consequences," *Science*, January 2010

THE FINDINGS: One of the most popular mining techniques in Appalachia has been cutting down the trees on top of mountains and blasting the peaks off to get to the buried coal. It doesn't take a doctorate to see that mountaintop mining (MTM) is bad for the environment, but until Margaret Palmer of the University of Maryland and her colleagues collected the data, no one knew just how bad it was. Their analysis shows that the technique has led to downstream flooding and toxic levels of selenium in West Virginia streams, that the blast dust can cause respiratory problems, and that reclaiming the mined areas by planting grass doesn't appear to work.

WHY BOTHER? Last summer, the Obama administration inked a plan that adds more regulation but allows the practice to keep expanding. Palmer hopes her paper gives policymakers a clear rundown of the potential consequences. "MTM permits should not be granted unless new methods can be subjected to rigorous peer review and shown to remedy these problems," she writes. "Regulators should no longer ignore rigorous science."

Old People Prefer Happy Memories

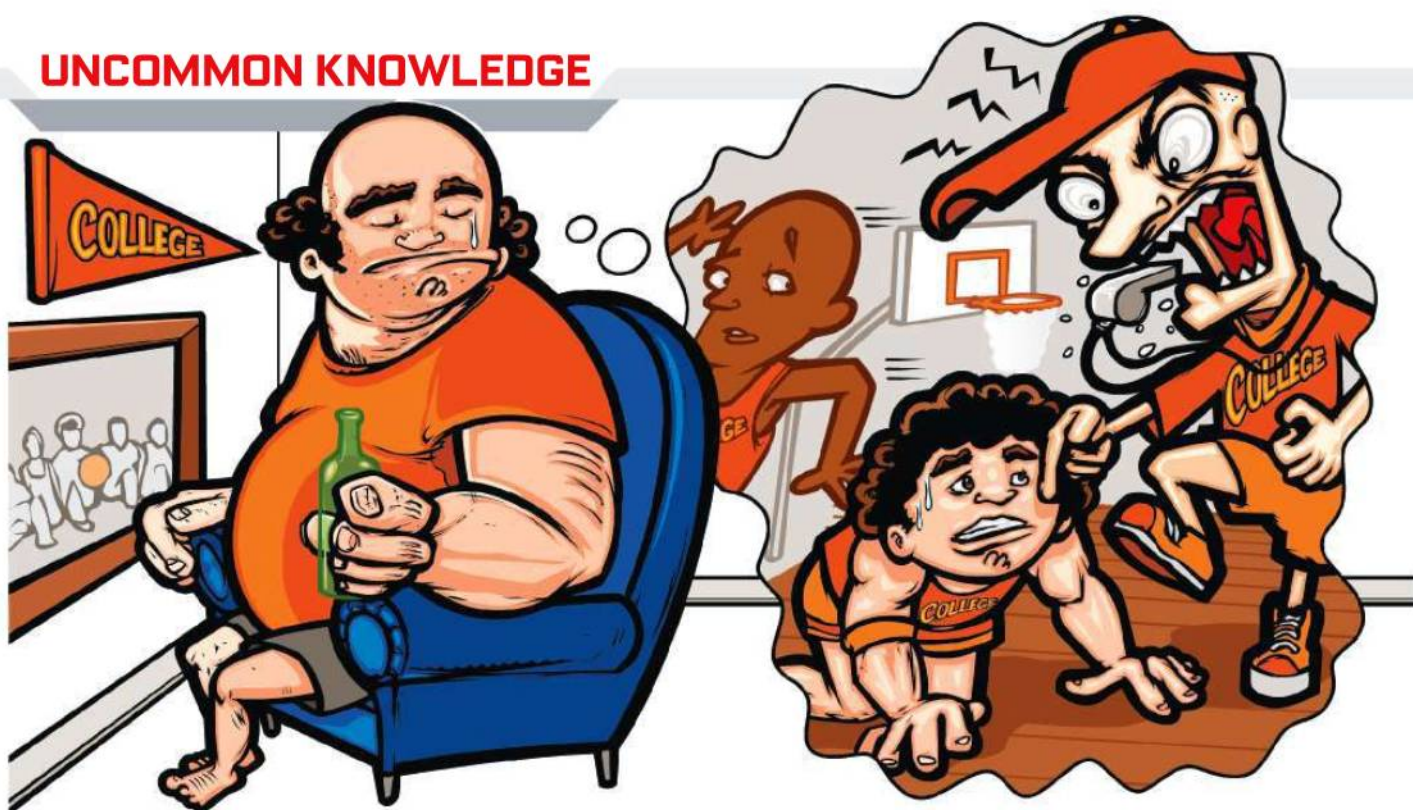
THE STUDY: "There Are Age-Related Changes in Neural Connectivity during the Encoding of Positive, but Not Negative, Information," *Cortex*, May 2009

THE FINDINGS: An international team of psychologists put a group of people aged 19 through 31 and a group aged 61 through 80 into a functional MRI and showed participants positive, neutral and negative photographs. It turned out that the brains of younger and older people responded similarly when they saw gunshot wounds, but for the older people, their ventromedial prefrontal cortex and amygdala, which are involved in emotion, and the hippocampus, which governs memory, all responded when they saw positive images like kittens, indicating the formation of a stronger memory. (The younger brains showed no such effect.) The researchers think this may explain

the "positivity effect," the idea that as people age, positive memories tend to get stronger while bad memories fade more quickly.

WHY BOTHER? We're not sure exactly why older folks look on the bright side, but before this study we weren't even sure if there was a biological basis for the phenomenon. The next step is to establish whether the positivity effect is simply a part of aging or whether, as older adults feel time slipping away, they are more likely to emphasize the positive. This could help determine if there are differences in the memory encoding between elderly people with depression and those with a cheerier disposition.





A Mean Gym Teacher Can Turn You Off Sports

THE STUDY: "Remembering Instructors: Play, Pain and Pedagogy," *Qualitative Research in Sport and Exercise*, November 2009

THE FINDINGS: The sadistic gym teacher who belittles students for their sissy push-ups is a sitcom cliché, and it's reasonable to think that someone who hated gym class in middle school might not be a gym rat in later life. William Strean of the University of Alberta nonetheless interviewed 24 subjects to see how influential their gym teachers had been on their later attitudes toward exercise. He found a strong

correlation between people who were turned off to physical activity and bad personal experiences with aggressive gym teachers.

WHY BOTHER? By some estimates, as many as 70 percent of children drop out of team sports, many because of negative events like being hit, called names, or pressured to play while injured. Strean's research was intended to determine what aspects of physical activity

kids consider positive and negative. As it happens, instructors play a large part. "Although it may seem obvious that negative experiences may turn people off future physical-activity opportunities, it is apparently not always so evident to teachers and coaches that they have such an impact," Strean says. "It's important that educators realize that a few of their words can build someone's spirit or crush it like a bug."

People Are Happier on the Weekend

THE STUDY: "Weekends, Work, and Well-Being: Psychological Need Satisfactions and Day of the Week Effects on Mood, Vitality, and Physical Symptoms," *Journal of Social and Clinical Psychology*, January 2010

THE FINDINGS: Heaven knows everyone hates Mondays, but there has been very little scientific data to explain why. That's why, for 21 days, 74 people near Rochester, New York, filled out questionnaires three times a day that asked about their mood and physical well-being. As expected, people felt better from Friday night until Sunday afternoon and felt worse while at work.

WHY BOTHER? Author Richard M. Ryan hypothesizes that we enjoy the weekend more

because it satisfies self-determination theory: We feel best when we are autonomous (no boss around), competent (barbecuing is easier than wrangling with a computer database) and related (hanging out with your family beats eating lunch with a co-worker). The study emphasizes the importance of free time in increasing feelings of well-being. Figuring out how to structure work so that people feel more capable and satisfied during the week is one of the next steps of Ryan's research.



Most People Drive Poorly while Talking on the Phone

THE STUDY: "Supertaskers: Profiles in Extraordinary Multi-tasking Ability," *Psychonomic Bulletin & Review*, in press

THE FINDINGS: Common sense—and plenty of dented bumpers—tells us that driving and cellphones don't mix. Jason M. Watson and David L. Strayer of the University of Utah had heard that this applies more to some people than others, but previous studies had failed to distinguish between the two groups. That's why Watson and Strayer observed 200 volunteers in a driving simulator who were tasked with simultaneously memorizing word sequences and doing math problems while following a lead vehicle. As you'd expect, 97.5 percent of people failed at least one task miserably. But a surprising 2.5 percent appeared to be "supertaskers," people who can do two tasks at once as competently as they perform a single task.

WHY BOTHER? Identifying and studying the rare supertaskers among us helps scientists better understand how the brain works. "We didn't expect anyone to be able to juggle these two goals at once," Watson explains. "A lot of cognitive theory says [supertaskers] shouldn't exist." But since they do, Watson hopes to learn more about the biological basis of their rare gift. He also believes that finding these people could help in fast-tracking them into jobs that involve multitasking, such as flying fighter jets.

Siblings Who Fight Don't Get Along

THE STUDY: "Who Said You Could Wear My Sweater?" Adolescent Siblings' Conflicts and Associations with Relationship Quality," *Child Development*, March/April 2010

THE FINDINGS: Fighting in the backseat seems natural enough, but it turns out that sibling conflict can have a truly negative effect on relationships. Nicole Campione-Barr of the University of Missouri and Judith G. Smetana of the University of Rochester interviewed 115 pairs of siblings between the ages of 8 and 20, assessing their relationship quality and conflict ratio. While what the study calls "equality and fairness" conflicts—spats over things like who operates the TV remote—didn't seem to be a big deal, personal-space conflicts, like hanging around when big sis has her friends over, indicate a lack of trust and communication between siblings and negatively affected the quality of siblings' relationships.

WHY BOTHER? Campione-Barr hopes that looking at these sibling conflicts will illuminate whether they play a role in depression, anxiety and self-esteem.



Young People Want Big Money, Big Vacations

THE STUDY: "Generational Differences in Work Values: Leisure and Extrinsic Values Increasing, Social and Intrinsic Values Decreasing," *Journal of Management*, March 2010

THE FINDINGS: Companies are trying to change their management style to satisfy Generation Y by offering such perks as on-site laundry and five weeks of vacation right off the bat. The problem is, there's very little information on what Gen Y—defined in this study as people born after 1981—are actually looking for. Jean Twenge of San Diego State University and her collaborators examined the Monitoring the Future survey, which has been given to high-school seniors since 1976. They determined the work values of baby boomers, Gen Xers and Gen Y. The result? Gen Y, also known as "GenMe," is less

work-oriented and places a higher value on leisure time than their predecessors, but they still covet the fat paycheck. Kids these days. "The combination of not wanting to work hard but still wanting more money and status verifies the sense of entitlement many have identified among GenMe," Twenge writes.

WHY BOTHER? With 75 million boomers on the verge of retirement, it's Gen Y that will be stoking the GDP over the next few decades. Motivating this group of workers will be key to the economic health of the country.





Environmentalists Can Be Smug Jerks

THE STUDY: "Do Green Products Make Us Better People?" *Psychological Science*, March 2010

THE FINDINGS: Sure, getting organic bok choy and phosphate-free toilet-bowl cleaner can make you feel good about yourself, but how good? And does buying green translate into more redeeming behavior overall? Nina Mazar and Chen-Bo Zhong of the University of Toronto conducted three experiments on 305 subjects to find out. It turns out that just being exposed to green products—seeing a TV commercial or walking by an organic store—creates a "halo effect" that makes people more charitable and trusting. But actually buying green products was like getting a license for hypocrisy: After a purchase, the green consumers were more likely to lie and steal.

WHY BOTHER? Mazar points out that more and more consumers are buying green and socially responsible products, which gives them "moral capital" (a.k.a. a superiority complex). But, she says, she wants to learn how to get beyond the smug factor: "How do we educate kids to get to the stage of being more thoughtful about using resources without thinking 'I'm so great'? This is ultimately the goal of our research."

Self-Control Makes Students More Manageable

THE STUDY: "Intervention to Strengthen Emotional Self-Regulation in Children with Emerging Mental Health Problems: Proximal Impact on School Behavior," *Journal of Abnormal Child Psychology*, July 2010

THE FINDINGS: An inability to regulate emotions in childhood—throwing temper tantrums or acting up in class—often forecasts

serious psychological problems like depression later in life. That's why, as part of the Rochester Resilience Project, a school-based mentorship program, a research group from the University of Rochester and the University of Miami decided to teach 226 kids ranging from kindergartners to third-graders new methods for improving emotional regulation. During 14 weekly lessons, mentors taught the children self-control skills, including breathing techniques

to control emotions and self-monitoring of emotions to help the kids stop and think before making that fart noise. The intervention reduced disciplinary actions against the participants, such as being sent to the principal's office, by 46 percent, and it helped improve girls' social skills, such as making friends. (Boys' social skills remained unchanged.)

WHY BOTHER? Only about one in eight children with behavioral disorders ever receives treatment. In-school programs like the Rochester Resilience Project are some of the best strategies to reach these kids, and they can reduce the types of bad classroom behavior that can disrupt learning for other students.

Hard-Drinking Adrenaline Freaks Are Prone to Injury

THE STUDY: "Extreme College Drinking and Alcohol-Related Injury Risk," *Alcoholism: Clinical and Experimental Research*, September 2009

THE FINDINGS: Research has already shown generations of antacid-crunching deans that the more often college students get drunk, the more likely they are to hurt themselves. Using data from the College Health Intervention Projects, a survey of 12,900 students that screens for problem drinking and other health data, Marlon Mundt of the University of Wisconsin pinned it down: The chance of male college students having an alcohol-related injury jumps by 19 percent for each day a month they guzzle eight or more drinks. Among women, it increases by 10 percent for each day they consume five or more drinks. Additionally, students with high "sensation-seeking" scores—adrenaline junkies—were more likely to get injured while drunk, whereas sober thrill-seekers rarely visited the ER.

WHY BOTHER? Six hundred thousand college students a year sustain injuries while drinking, and 1,700 die. Knowing how much drinking increases injury rates can help colleges and hospitals design alcohol-awareness campaigns.



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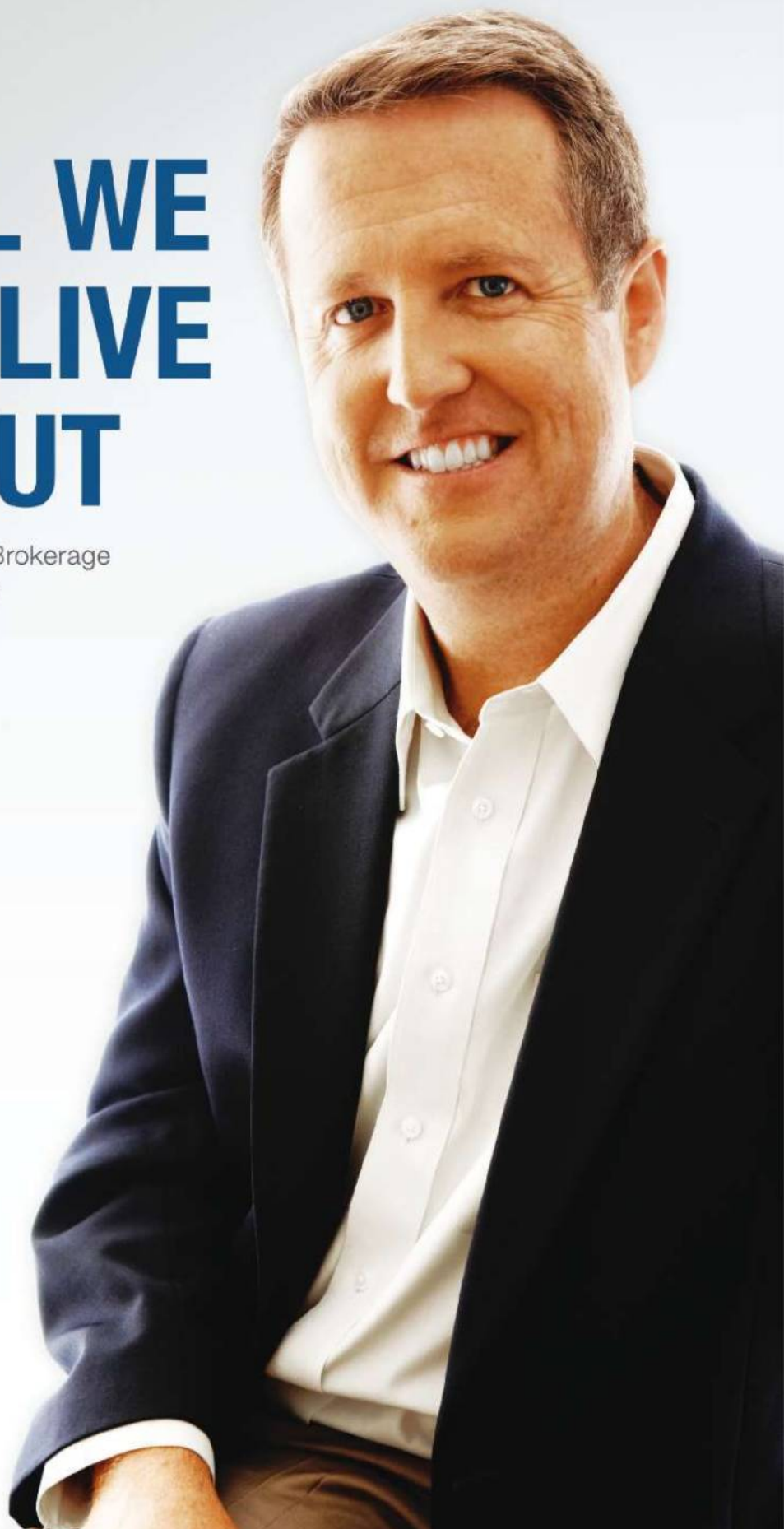
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CLUTTERED

In orbit, debris as small as a metal screw can cripple a vehicle or kill an astronaut. Here are five ideas for cleaning up the growing band of trash circling Earth

BY DAVID KUSHNER ILLUSTRATIONS BY KEVIN HAND

ONE FRIDAY last November, the six astronauts onboard the International Space Station received an urgent warning from mission control: Watch out for space junk. A piece of orbital debris, possibly a chunk of satellite, was hurtling toward the station. A direct hit could break through the hull. The crew prepped for escape.

The fragment ended up missing them by about 3.7 miles. Near-collisions between debris and spacecraft are on the rise, as we continue to put trash in orbit faster than it can fall back out—a phenomenon known as the Kessler Syndrome, in which each collision between pieces of space debris creates even more debris. It's a chain reaction that will make the problem much worse.

In October, just one week before the ISS scare, NASA delayed a return trip from the ISS of a Japanese craft when a shard of Russian satellite was spotted near the space station. In February 2009, two satellites smashed into each other 500 miles over Siberia. And in 2007, China littered low-Earth orbit with the fragments of a satellite that it had deliberately shot down. The debris population in low-Earth orbit now totals more than 20,000 items larger than four inches, from pieces of rockets to old screwdrivers.

In 1976, when NASA scientists first identified the debris risk, they predicted that space collisions would happen once a century. Four occurred over the next four decades. Today the agency predicts four collisions every 20 years. Former NASA scientist Don Kessler, who discovered the debris amplification process with former Norad senior analyst John Gabbard, foresees a catastrophic collision once every 20 years.

Even NASA recognizes that its existing rule—objects must have the capability to push

STATS

500,000: Estimated number of man-made pieces larger than 0.4 inch floating in low-Earth orbit
24,480 mph: Speed those pieces are traveling
0.04 inch: Smallest size at which a piece of debris could kill an astronaut

themselves (or be pushed) out of orbit within 30 years of launch—isn't enough anymore. Earlier this year, it published a paper showing that it could make low-Earth orbit safe by removing five objects per year.

To collect ideas on how to achieve this, last year NASA and Darpa, the Department of Defense's research arm, gathered hundreds of engineers and scientists for the first-ever International Conference on Orbital Debris Removal, in Chantilly, Virginia. Nearly all the solutions discussed there rely on finding some way to deorbit the debris so it burns up in the atmosphere. The conference also revealed that international cooperation is the greatest hurdle. There is, for example, no official consensus on what constitutes space debris—one country's seemingly dead satellite might just be hibernating for future use. Governments are

concerned that debris-removal systems could have military uses. And not every country is providing details about what they have in orbit.

To punctuate the need for international cooperation, Brian Wepden of the Secure World Foundation noted at the Orbital Debris Conference, "60 percent of the orbital-debris population is owned by Russia and China." He scanned the room. "Is anyone from China or Russia at this conference?" One brave person in the back raised his hand.

Whatever the challenges here on Earth, something must be done up there. With some luck, one of the following five solutions could clean up our orbital junkyard.

LASERS

HOW IT WORKS: In a ground-based configuration, a detection system could be made up of radar or lidar to locate a piece of stray debris. Then a laser fires a series of pulses at the object, altering its orbit and knocking it into the atmosphere, where it descends and is incinerated. Space-based systems require a shorter range and lower laser power.

PROS: A laser system is effective on objects smaller than four inches in size, because they are less apt to create more debris during the removal process. A laser-equipped satellite would wait in orbit for a target to pass by and then zap it. "The duck-hunter paradigm is becoming an option," says Richard Fork, a principal investigator for the Laser Science and Engineering Laboratory at the University of Alabama at Huntsville. "You sit and wait for debris to come past you. Then you can hit it with enough impulse to deorbit it."

CONS: Because the ground-based lasers would need to be powerful, the systems are alarming to countries that see in them the potential for anti-satellite military technology.

PLAUSIBILITY: It's technically possible but still very controversial for political reasons.



SPACE



TRASH PICKERS
Sunlight reflects off a piece of space junk [A], alerting the deorbiting satellite to its presence. The satellite tracks the debris with one laser [B] until the trash is in range, and then another laser [C] nudges the debris out of orbit so it burns up in the atmosphere.

SOLAR SAILS

HOW IT WORKS: The sun's radiation exerts force on the ultrathin fabric of solar sails, much like wind propels a sailboat. These sails can clean up orbit by slowing debris enough that it deorbits. For example, an expandable 97-square-foot sail can be launched as a secondary payload on even a small 110-pound satellite, and an onboard system or ground control triggers its deployment. Conductive coils embedded in the sail control its angle, so it can maneuver a satellite out of orbit; sail and satellite disintegrate together in the atmosphere.

PROS: The material is cheap and portable.

CONS: The sail's expansion and the spacecraft's altitude need to be carefully calculated beforehand.

PLAUSIBILITY: The technology has existed for decades, from a sail-equipped craft in the mid-1970s intended to ride along with Halley's Comet (the craft never flew, and the project was scrapped) to large solar arrays currently affixed to the *Messenger* spacecraft, which are helping steer it to Mercury. Most recently, the Japan Aerospace Exploration Agency launched a solar-sail-propelled "space yacht" called *Ikaros* in May. But the solar sails precisely controllable enough to remove debris are still years away.



COME SAIL AWAY Solar sails, pushed by solar radiation, drag objects into the atmosphere.

TETHERS AND NETS

HOW IT WORKS: Aerospace company Tethers Unlimited proposes a system called Rustler (for Round Up Space Trash Low Earth-orbit Remediation). Once launched into low-Earth orbit, the satellite releases an electrodynamic tether, a 1.5-mile-long cable that conducts electricity. The conductivity allows the tether to wrap around any piece of debris that it encounters, which it then drags into the atmosphere, where the object either falls into the ocean or burns up on reentry. The net secures even small objects tumbling around in space, a challenge for other systems.

PROS: Tethers and nets don't require propellant, saving cost by relying on solar power and electrodynamic thrust, and can piggyback on almost any low-Earth-orbit launch.

CONS: It requires tricky maneuvering, because potentially miles of material twisting around in space could just create more junk.

PLAUSIBILITY: Tether-based solutions have been tested by NASA, including a 1996 experiment with a 12.5-mile cable in space. The Rustler system was tested on a zero-G flight last September and could launch on a real mission within five years.



SPACE TUG A tether could work like a giant electrified lasso, pulling objects out of orbit.

An illustration showing a rocket launching a large cylindrical tank into space. The tank is positioned to spray a cloud of frozen mist towards a dense field of space debris, including various satellite components and smaller objects. The scene is set against the backdrop of Earth's blue and white atmosphere and the blackness of space.

CLOUD COVER Tanks of liquid gas would emit mist that slows down objects passing through enough that the debris would fall from orbit.

SPACE MIST

HOW IT WORKS: One of the more novel solutions, first proposed by researchers at NASA's Ames Research Center in 1990 and recently resurrected, is to use frozen mist to drag an object out of orbit. A rocket launches a tank filled with liquid gas, such as carbon dioxide, and thrusters position the tank near the path of the target object. Thousands of miles from the debris, the tank sprays a cloud of frozen mist. The droplets slow down and deorbit anything they encounter. According to the idea's originator, aerospace engineer George Sarver of Ames, a spaceship emitting a

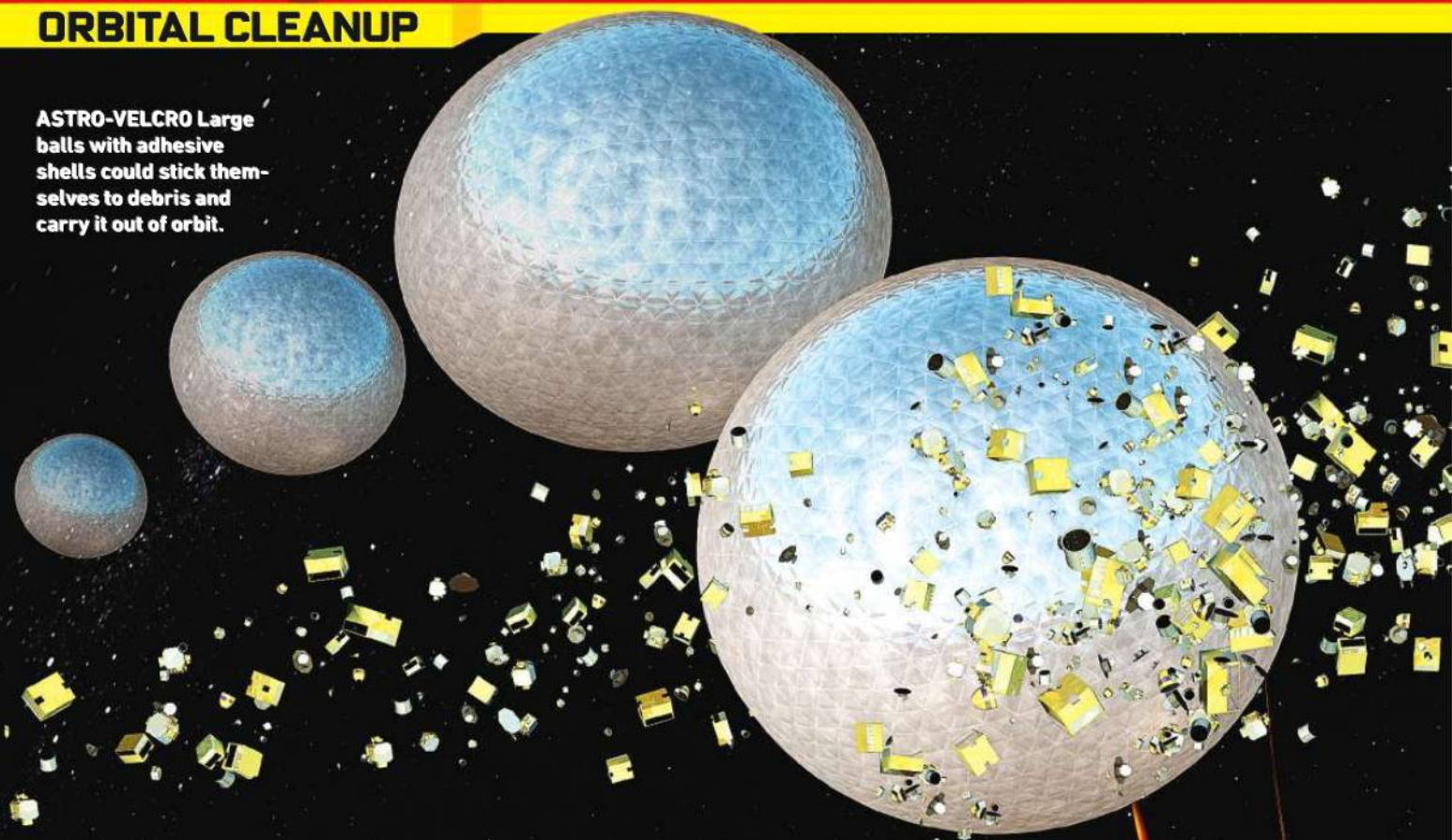
220-pound, 62-foot-diameter cloud of frozen mist could deorbit dense objects such as steel nuts. Larger clouds could stop less-dense items like insulation.

PROS: Once the mist dissipates, nothing remains in orbit. The tank falls back into the atmosphere, which means less clutter that could otherwise create more debris.

CONS: It requires precise aim, because each tank sprays its shot just once.

PLAUSIBILITY: "We could probably test it in orbit within 18 months if NASA funded it," says Creon Levit, the chief scientist for programs at Ames.

ASTRO-VELCRO Large balls with adhesive shells could stick themselves to debris and carry it out of orbit.



ROBOTS AND ADHESIVES

HOW IT WORKS: One idea to capture tumbling debris employs orbiting spacecraft that would use robotic arms to grab and release debris, essentially tossing it out of orbit so it burns up in the atmosphere. Sean Shepherd, a curriculum coordinator at Eastern New Mexico University, proposes a more novel idea, called Adhesive Synthetic Trash Recovery Orbital Spheres, or Astros—essentially a collection of sticky balls. The balls consist of a layer of metallic foam (such as silicon carbide) and an outer shell of adhesive (such as aerogels or resins). They attach themselves

to debris and then dive into the atmosphere, where both are incinerated.

PROS: Spacecraft that carry and position the robotics are easier to control than tethers or sails and can remove multiple pieces of debris. Adhesives are cheap.

CONS: The adhesive balls can't be compressed, so packing them into a rocket for launch will be difficult.

PLAUSIBILITY: Hanspeter Schaub, the associate chair of graduate studies in the Aerospace Engineering Sciences department at the University of Colorado, says the orbiting robot concept could be tested in space within five years.





Lamborghini LP560-4



Ferrari F430

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Audi R8 V10



Mercedes-Benz SLR McLaren



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THE GREEN DREAM

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STAGE #8

POWER WALLS

Sheetrock that cools or heats a house by changing when the temperature does

THE CONCRETE structural walls and cement floors in my newly built green home function as natural air conditioners, passively absorbing heat and slowly releasing it as the temperature in the house drops each evening. As a result, the bones of my home go a long way toward keeping it cool through the summer. Now I've discovered wall panels that do the same thing, and I'm installing 300 square

JOHN B. CARNETT,
PopSci's staff photographer, is using the latest green technology to build his dream home. Visit popsci.com/greendream for John's blog.

feet of them in rooms with the most sun exposure to reduce air-conditioning costs and energy use.

Drywall covers the structural beams of a house to create a smooth, insulated and fireproof surface. Typically, it consists of gypsum mineral sandwiched between two sheets of paper or fiberglass. Drywall manufacturer National Gypsum is developing a new product, ThermalCore, that looks similar, but embedded

inside are wax-filled capsules, called Micronal. When the surrounding temperature hits 73°F, the wax liquefies and absorbs thermal energy, cooling the room in the same way an ice cube cools water when it melts. As the temperature drops, the wax solidifies again and gradually releases heat back into the room.

The Green Dream is one of several test cases to determine how different amounts of wax

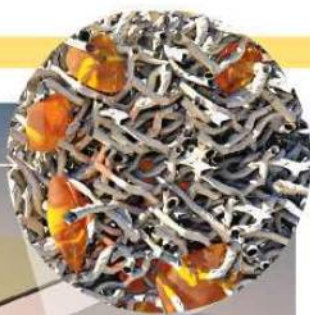
ILLUSTRATIONS: PETER BOLLINGER;
FACING PAGE, FROM TOP: J. MERIC/AP PHOTO, AP PHOTO

HOW IT WORKS

DAY:

Microscopic capsules filled with paraffin wax and embedded inside ThermalCore wallboard change from solid to liquid when the surrounding temperature reaches 73°. As the wax melts, it absorbs heat and cools the room in the same way melting ice cools water.

Wax-filled capsules store heat

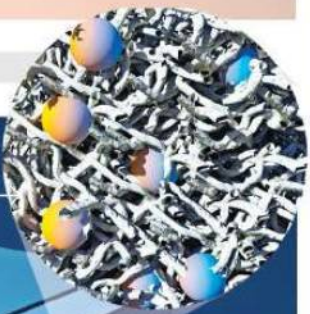


ThermalCore wall panel

NIGHT:

At night, when the temperature drops below 73°, the wax hardens. This reaction releases heat back into the room.

Wax-filled capsules release heat



ThermalCore wall panel

in the gypsum will behave in different climates and seasons. The goal is to be able to tailor the panels to their environment, so homes in Florida, where humidity is more persistent, might have drywall with more wax capsules than homes in colder New York, for example.

For now, there's no guarantee that National Gypsum will ever make ThermalCore commercially available. Much depends on

demand, so my hope is that I'm not the only homeowner who thinks it's a good idea.—JOHN B. CARNETT

THE SPECS

HOUSE: 3,500-square-foot, four-bedroom contemporary

LOCATION: Greenwich, N.Y.

PROJECT: Installing 300 square feet of phase-change drywall

TIME TO INSTALL: One day

ECO-ADVANTAGE: Reduces energy needs for heating and cooling

HOMEWRECKER

BEWARE DRYWALL THAT CAN FILL YOUR HOME WITH SULFURIC ACID

Not all drywall is as environmentally friendly as John's. In fact, some is downright toxic. In May a report from the largest investigation in the history of the U.S. Consumer Product Safety Commission cited 10 Chinese manufacturers as sources of sulfur-laden drywall found in thousands of homes constructed in the U.S. between 2005 and 2009, when a post-Hurricane Katrina building boom created a run on drywall and forced builders to seek out new suppliers. Investigators say hot and humid conditions can cause the tainted building product to release sulfur compounds that smell of rotten eggs and react with moisture in the air to create sulfuric acid, a primary ingredient in acid rain. Released in a home, sulfuric acid can corrode and blacken metal, ruining electrical wiring, air-conditioning coils, fire alarms, TVs and stereos. It can also exacerbate asthma

and cause bloody noses, headaches and wheezing.

In many cases, the damage has been so severe that victims have abandoned their homes or been forced to finance expensive gut renovations. To date, the CPSC has received more than 3,300 complaints nationwide. If you suspect there's tainted drywall in your home, copper test strips that turn black after two weeks can indicate sulfur contamination, but CPSC spokesman Alexander Filip recommends that you enlist professional help to rule out other sources of sulfur, including well water, sewer gas or even jarred pickles. A professional diagnosis can also help homeowners secure mortgage forbearance and relief funds available through state agencies.

For a list of implicated manufacturers and resources, call the CPSC at 800-638-2772 or go to cpsc.gov/info/drywall.—NICOLE DYER

BEFORE EXPOSURE TO SULFUR



AFTER EXPOSURE TO SULFUR



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HOW 2.0

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



72

The explosive power of sugar



74

Add radio control to any project you build



76

Decide if it's time to buy a 3-D TV

YOU BUILT WHAT?!

BACKYARD BOMBER

Weighing nearly 100 pounds, a giant model plane takes to the skies

Four years ago, engineer Tony Nijhuis was visiting an aviation museum in Duxford, England, when he spotted his next project: the iconic World War II-era Boeing B-29 Superfortress. Nijhuis has been building electric models since he was a boy, but he had been thinking about doing something bigger. Much bigger. The result is a replica that—with a 20-foot wingspan, period decals, and loudspeakers that blare sounds of the real engine—boasts nearly everything but the bombs.

Nijhuis decided to go with a variant of the B-29, the B-50,

because of its aerodynamic design and because it was more novel. The real bomber had four engines, so he hunted down four of the biggest electric motors he could find. He created 2-D sketches of the body, wings and tail using AutoCAD and commissioned a laser-cutting company to handle the more than 300 custom segments he needed.

To make the plastic nose and gun canopies, Nijhuis first had to hand-carve wooden molds of each one. For the retractable landing gear, he hooked an off-the-shelf pneumatic system up to pressurized air tanks

made from plastic Coke bottles. He also skinned the balsa-wood-ribbed fuselage with laminate wood composite and fiberglass.

Aside from some shredded tires, test flights have been a success. Nijhuis believes that it's the largest and heaviest electric flying model in the world, and thanks to the added sound effects [see next page], he says, "it is certainly one of the loudest."

—GREGORY MONE

(CONTINUED ON NEXT PAGE)

THE
H2WHO
CREDO:

DIY CAN BE DANGEROUS.

We review all our projects before publishing them, but ultimately your safety is your responsibility. Always wear protective gear, take proper safety precautions, and follow all laws and regulations.

BIG FLYER The craft can get up to about 50 mph in the air.

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HOW 2.0 YOU BUILT WHAT?!

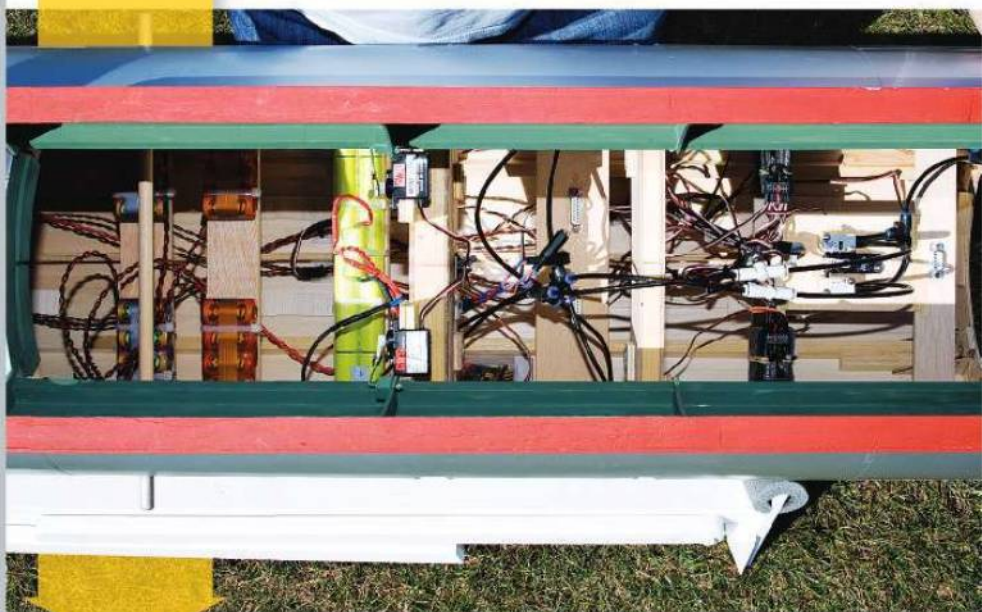
(CONTINUED FROM PRECEDING PAGE)

HOW IT WORKS

TIME: 2 YEARS
COST: \$9,000

▼ POWER

Nijhuis estimated that the model would weigh 95 pounds. A rough calculation determined that he would need 40 watts of power per pound to take off, so he figured four 3.5-kilowatt electric motors would do the trick. He designed a balsa-wood-and-plywood-based nacelle, or housing, for each of the motors, the nickel-hydrate batteries, and the speed controllers that would crank them up or wind them down. Each nacelle is totally independent of the others, so if one fails, the others aren't compromised, and Nijhuis can still land his baby safely.



► PORTABILITY

Nijhuis designed the structure to separate into eight pieces. The wings and tail fins are secured by aluminum and carbon-fiber rods, respectively, and the fuselage bolts together. He moved the bolts in line with the longerons—the parts that act as a structural spine, running perpendicular to the ribs—so it would connect properly.

EIGHT EASY PIECES The bolts had to be repositioned so that the skin around the fuselage wouldn't crack when the plane's parts were snapped together during assembly. For more details, go to tonynijhuisdesigns.co.uk.



▲ SOUND

The builder wanted the craft to sound authentic, too. So he had a sound designer find a recording of a plane with the same engines as the B-50, and add the sound files to a memory chip. He installed four speakers on the underside of the wings, added amps, and hooked them all up to the speed controllers. The speakers blare the sounds loudest when the motors are working their hardest. Instead of an electric whir, it sounds like the real thing.

JONATHAN WORTH

U.S. GOV'T GOLD

U.S. GOLD COINS AUTHORIZED FOR IMMEDIATE RELEASE

The United States Rare Coin and Bullion Reserve Vault Facility today announces the final release of U.S. Gov't Issued Gold Coins previously held in The West Point Depository/U.S. Mint. For a limited time, U.S. citizens will have the opportunity to purchase these \$5 Gov't Issued Gold Coins for the incredible "at-cost" price of only \$141.00 per coin. An amazing price because these U.S. Gov't Issued Gold Coins are completely free of dealer markup. That's correct, our cost. This may be your final opportunity to buy U.S. Gov't Issued Gold Coins "at-cost." The Gold market, which recently skyrocketed past \$1,200/oz., is predicted by experts to have the explosive upside potential of reaching up to \$5,000/oz. in the future. **Due to extremely high Gold demand, availability of these special at-cost Gold Coins may vary based on current vault inventory.** The United States Rare Coin and Bullion Reserve will release these U.S. Gov't Issued Gold Coins "at-cost" on a first-come, first-serve basis. Orders that are not immediately received or reserved with the order center could be subject to cancellation and your checks returned uncashed. Good luck. We hope that everyone will have a chance to purchase this special U.S. Gov't Issued Gold "at-cost." Order your Gold immediately to avoid disappointment. Special arrangements can be made for Gold purchases over \$50,000.



U.S. Gov't Issued American Eagle Gold Coins

Coin enlarged to show detail.



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A NOT-SO-SWEET SURPRISE

Sugar seems harmless, but in powder form it can be a deadly explosive

It's all sweetness and light until the sugar hits the fan. In 2008 the sweetener killed 14 people in Georgia—not from diabetes or heart disease, but in a violent explosion. Absence of regulation, ineffective enforcement, and lack of preparation for the potential danger led to the Imperial Sugar factory disaster, one of the worst industrial accidents of our time.

Any substance that burns at all can be made to burn bigger and faster by increasing its surface area, thus increasing its access to oxygen. Fine powders can have very large surface areas, making materials such as flour and sugar, which barely burn when in bulk form, explosive enough to demolish a factory.

THE SETUP The author used a candle, a plastic bottle and fine confectioners' sugar. Regular granulated sugar did not work, but a turkey baster could substitute for the squeeze bottle.



Never light flammable dust in a closed container: It really is explosive. Lit out in the open, the resulting fireball can singe or set on fire anything flammable in the area.

To demonstrate the awesome power of confectioners' sugar, I blew a stream of it over a candle flame, creating a two-foot-long burst of fire. If the powder is instead dispersed in an enclosed space before ignition, it all burns in a fraction of a second. With nowhere for the pressure to go, it will cause a thundering explosion.

Few people truly appreciate this hazard. Fortunately, a renewed political interest in effec-

tive safety regulations has led to new enforcement and educational campaigns that should help keep powder-plagued workers safer.

But there's still a ways to go. A few years ago, I watched my neighbor auger his beans up into my spare grain bins. The air was thick with dust—and he was smoking a pipe. We didn't die that day, but seeing him with that glowing pipe in his mouth was one of the scariest experiences of my life.—THEODORE GRAY



ON THE LEVEL Blowing too low made the candle flame go out; too high, and the sugar didn't catch. But when done just right, the room filled with heat, light and the pleasant smell of burned sugar.

MIKE WALKER

IT'S ALL UNDER CONTROL

How to add remote control to any project, no matter how large

You may associate remote control with the urge to jump little R/C cars through walls of fire in your backyard, but that's just the beginning of what you can do with the technology. Once you've mastered the basic concepts, the same parts and techniques used in toys can be used to control machines big and small, practical and absurd.

The basic R/C setup consists of a transmitter, a receiver, and several actuators on the receiving end—either servos (electric motors that rotate to a specified position or speed) or relays (which turn electrical components on and off). Commands from the transmitter about position, speed of rotation, or simply “on” and “off” are sent to the onboard receiver, which decodes them into a signal that can be interpreted by the connected servos and switches.

Although most of the parts of a hobby R/C system can be used in something larger, big machines like a lawn tractor or an excavator often require more torque than a hobby servo can provide. Those machines call for a high-powered super servo. Commercial models

exist in the \$500 price range, but you can make your own version for \$75 or less [see “Build a Super Servo,” facing page]. In fact, I just did. Some friends and I built gas-powered bumper cars several years ago, but at the insistence of our internal organs, we had had to set them aside. Now, using the DIY super servo for the steering and a hobby servo to control the throttle, the carts have a new life in R/C form. They're just as much fun as our original bumper cars, with none of the spinal trauma. And I can do flaming-obstacle jumps on a much bigger scale than ever before.—VIN MARSHALL



This Dukes of Hazzard-style stunt may look like child's play, but it was performed by people highly trained in fire safety. Do not attempt to replicate anything like this without strictly following the proper precautions.

INTO THE FIRE

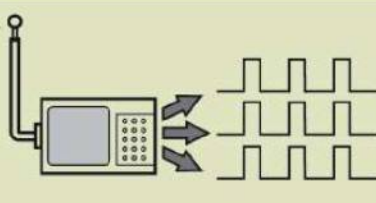
A receiver on the R/C bumper car translates encoded pulse-width modulation signals from the handheld transmitter into commands that enable the connected servos and relays to control the car.



HOW R/C WORKS



1 Pulse-width modulation signals indicating servo position or whether the relay switch is on or off are transmitted via radio signal to the receiver.



2 The receiver onboard your R/C project receives the radio signals and translates them into an appropriate set of commands for each servo channel.



3 Signals from the receiver tell the servos and relay switches what to do. Potentiometers use position feedback to ensure that the servos are close to the position requested.



POPSCI.COM

For video of the R/C bumper-car stunt, go to popsci.com/rcfire.

BUILD A SUPER SERVO

Hobby servos are great, but sometimes you need more power. You can make a DIY super servo using the windshield-wiper motor from a car. Here's how:

1. Get a wiper motor. Try *MonsterGuts.com*, which sells a 12-volt DC motor for only \$16.
2. Attach some means of feedback to measure the position of the motor's shaft. I used a Futaba s3003 hobby servo (\$11; *TowerHobbies.com*) rewired to act as a potentiometer, but a 5K potentiometer

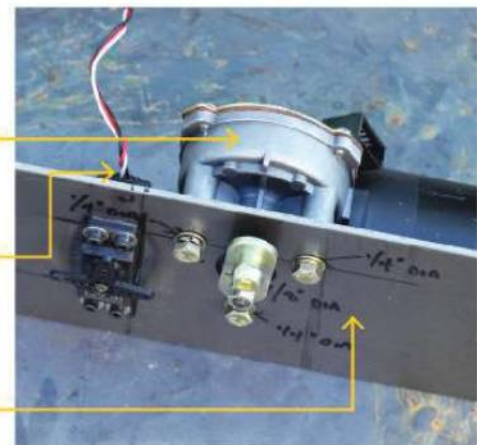
from RadioShack would work equally well.

3. Connect the motor, the feedback potentiometer and the R/C pulse-width modulation signal to an appropriate motor-controller board. The Pololu Jrk 21v3 (\$50; *pololu.com*) is a good choice.
4. Some basic calibration should give you a DIY super servo capable of around 15 pound-feet of torque, enough to control just about any midsize machine. If even that isn't enough, you can build your servo with a larger gear motor and motor controller.

Wiper motor

Potentiometer

Custom mounting bracket



HOW 2.0 ASK A GEEK

SHOULD I BUY A 3-D TV YET?

Unless you absolutely must be the first person on your block to have one, I'd suggest waiting awhile. The few 3-D TV models available now aren't cheap—the Samsung UN55C7000, for example, costs \$3,300. Plus, you'll have to lay out more cash for a new Blu-ray player, since the one you have is probably incompatible with the new 3-D Blu-ray format. Prices may drop over the coming year, but even that won't be enough if there isn't anything to watch; at press time, no 3-D Blu-ray discs were available for purchase (although some Samsung TV packages come with a copy of *Monsters vs. Aliens*), and the only 3-D broadcast content is an ESPN channel and a handful of other 3-D channels on satellite-TV systems.

That will change with time, though. Several movie studios have announced plans for 3-D Blu-ray



RICHARD BAGULEY writes for *Televisioninfo.com*, which produces in-depth, scientific reviews of televisions.

releases, such as *Coraline*, later this year and early next year. And, always eager for more viewers, the TV networks have more 3-D channels and events like college basketball tournaments in the works for next year. To accommodate that new content, many TVs coming out soon, such as the Sony HX800, will be "3-D Ready": They will display three-dimensional images, but you can buy the glasses separately later. So if you're in the market for a new TV anyway, buying one of those models is a good way to future-proof your living room.

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- Residential Landscapers
- iPod Users
- Machine Operators
- Night Club Workers
- Musicians

The symptoms of Tinnitus are real. I had what 1 out of 6 Americans get: the symptoms associated with Tinnitus (*ti-nahy-tuh s*) from loud noises that worsen as you age, and in many cases lead to hearing loss.



Silence is now music to my ears.

I tried everything from hearing aid sound generators to ginkgo biloba, zinc and magnesium mineral doses to bio feedback. Some of these things helped reduce the ringing, but nothing worked short of expensive, risky surgery. Not until I discovered the active all-natural ingredients of my new homeopathic product Quietus, did my prolonged ear ringing finally silence.

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Bernard
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HOW 2.0 TECH SUPPORT

PROJECT OF THE MONTH

A DIY SUPER SOAKER

College student J  r  my Lavoie has made water guns for years, but his latest is his masterpiece. Made with an ABS pipe frame, three pressure chambers and a custom-made nozzle, the gun has a range of 50 feet and can draw water from a pool or lake, so it has endless ammunition. For details, search for "JLspacemarine" at sscentral.org.



WEB SITE OF THE MONTH

THREADSY.COM

Keeping an eye on e-mail, chat sessions and social-networking sites usually means having to navigate among multiple browser tabs. Threadsy saves hassle by displaying all that information in one customizable window, without sacrificing any of the applications' regular functions.

HAVE AN IDEA FOR A 5-MINUTE PROJECT?

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5 MINUTE PROJECT

A DISPOSABLE-CUP TRIPOD*

Because steadiness is a virtue

- 1 Find a bolt that fits in your camera's tripod hole (most are a quarter-inch).
- 2 Poke a hole in the bottom of a cup, feed the bolt through it, and glue the bolt in place.
- 3 Screw the camera onto the bolt. Weight down the cup to stabilize it if necessary.



FROM TOP: COURTESY J  R  MY LAVOIE; SATOSHI (3)
*originally posted by Aaron Lindow on instructables.com

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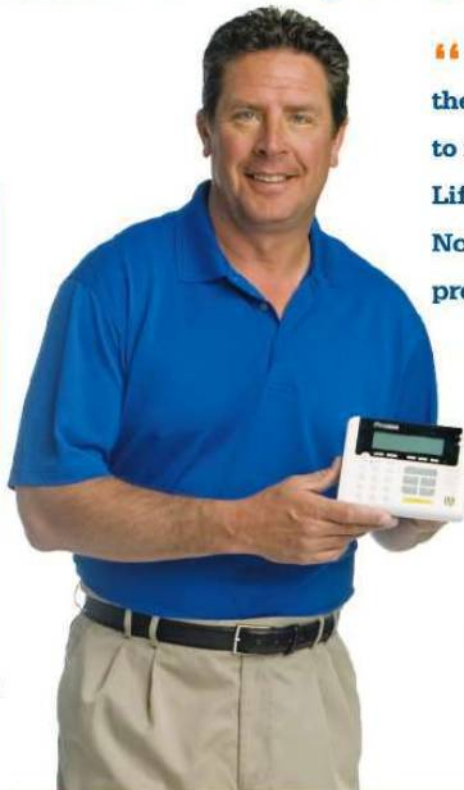
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—Dan Marino



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*Based on pricing for comparable equipment from ADT and Broacview as of 4/14/2010.

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†Offer valid on Home Kit purchase only. Free monitoring begins at date of purchase, first month only. Free fire monitoring contingent upon continuous service of professional security monitoring. Other restrictions apply. Call or see website for details. Offer not valid on prior purchases. Limit one offer per customer.

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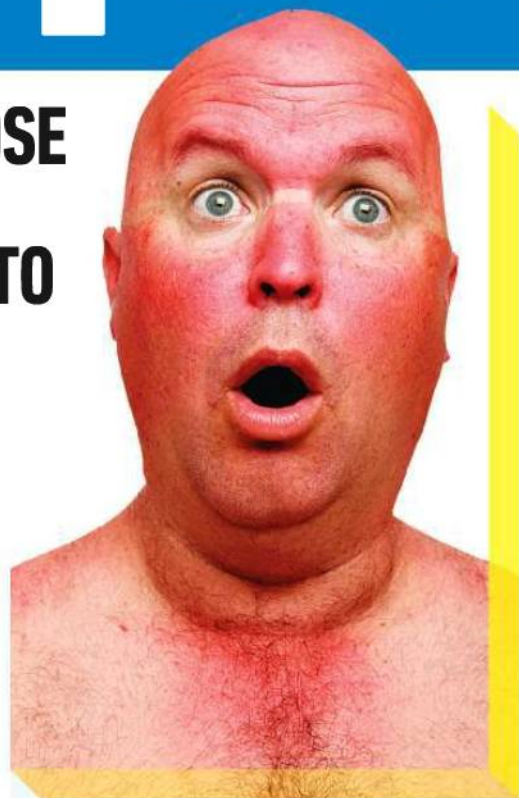
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Q HOW CLOSE COULD A PERSON GET TO THE SUN AND SURVIVE?

Calvin Hughes, via e-mail

A Of all the bodies in our solar system, the sun is probably the one we want to give the widest berth. It gushes radiation, and even though its surface is the coolest part of the star, it burns at about 9,940°F, hot enough to incinerate just about any material. As such, there are no plans to send a manned mission in its direction anytime soon (Mars is much more interesting, anyway), but it can't hurt to figure out at what distance a person would want to turn back. You can get surprisingly close. The sun is about 93 million miles away from Earth, and if we think of that distance as a football field, a person starting at one end zone could get about 95 yards before burning up.

That said, an astronaut so close to the sun is way, way out of position. "The technology in our current space suits really isn't designed to withstand deep space," says Ralph McNutt, an engineer working on the heat shielding for NASA's *Messenger*, a new robotic Mercury probe. The standard space suit will



keep an astronaut relatively comfortable at external temperatures reaching up to 248°. Heat coming off the sun dissipates over distance, but a person drifting in space would begin encountering that kind of heat (the five-yard line) some three million miles from the sun. "It would then be a matter of time before the astronaut died," McNutt says. Above 248°, the suit would transform into a close-fitting sauna—the temperature would climb above 125° and the person would become dehydrated and pass out, eventually dying of heatstroke.

Riding in the space shuttle, though, someone could get much closer to our star. The ship's reinforced carbon-carbon heat shield is designed to withstand temperatures of up to 4,700° to ensure that the spacecraft and its

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passengers can survive the friction heat generated when it reenters the atmosphere from orbit. If the shield wrapped the entire shuttle, McNutt says, astronauts could fly to within 1.3 million miles of the sun (roughly the two-yard line). But the integrity of the shield degrades rapidly above 4,700°, and the cockpit would begin to cook. "I would advise turning away from the sun well before that point," McNutt says. Much hotter than that, the shields would fail altogether, and the vehicle would combust in less than a minute.

Of course, just getting that close to the sun would be quite an accomplishment, says NASA radiation-health officer Eddie Semones. The constant exposure to cosmic radiation during the voyage would most likely prove fatal before the astronauts crossed the 50-yard line.—ALESSANDRA CALDERIN

If evolution had taken a different turn, could dragons have existed?

Austen Gleave, via e-mail

It would have taken quite a few turns for natural selection to have produced dragons, but if you're willing to stretch a bit, most classic dragon characteristics do exist in other species. They just don't come packaged in one animal.

First up on the dragon checklist: flying. Dragon wings are usually depicted in one of two ways—a third pair of limbs connected to the backbone, or webbed forearms. Jack Conrad, a paleontologist and reptile expert at the American Museum of Natural History in New York, thinks the latter is more plausible. "It seems that six appendages are very unlikely in vertebrates," he says. "The only thing close to having six limbs are these frogs in the western part of the U.S. that get this bad parasite and end up generating extra limbs. Even then, the new limbs are identical to the hind limbs, and the frogs don't do well. It seems that

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anytime nature tries to generate a vertebrate hexapod, it dies. That seems to be the main limitation."

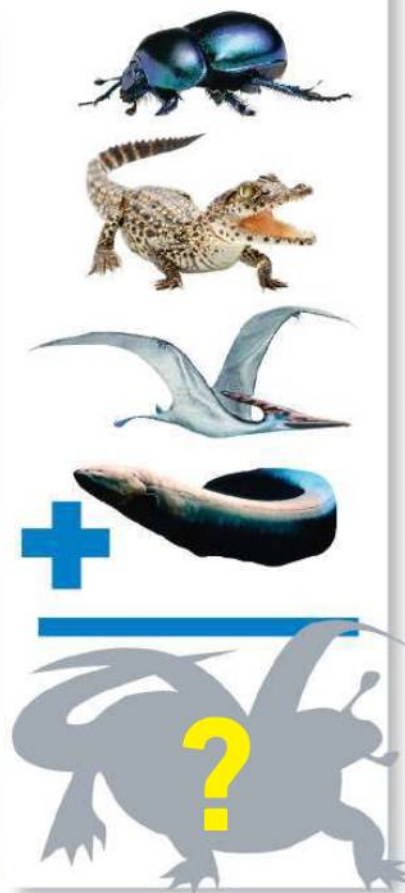
In Conrad's opinion, the leathery wings of a pterosaur are the best possible flight mechanism for a giant lizard. "Quetzalcoatlus had a 30-foot wingspan," he says. "That would do the trick." Big, strong wings are necessary to compensate for the weight of a dragon's skin, which, of course, would need to withstand bow-and-arrow attacks. "Let's throw a little alligator in there for armor," Conrad says. An alligator's skin, he explains, is made partly of bony plates. When European settlers first encountered the reptiles, the skin proved to be tough enough to turn away a musket ball, plenty strong for a dragon.

OK, so we've got a very large alligator with the wings of a

pterosaur that can repel musket fire. Now it just needs to breathe flames. This is where no parallel exists—there are no known animals that can spit fire or even a flammable liquid. But there are some beetles that can shoot caustic chemicals from their abdomen that can burn people's skin, so it's not *totally* out of the question that some animal at some point in time could make a flammable liquid. Cobras can spit venom with great accuracy at objects six feet away; the dragon could borrow that ability to propel the flammable liquid. As for lighting it? "Well, maybe, if you had some specialized organ like an electric eel's tail dangling in the mouth, that could spark that liquid and allow the creature to breathe fire," Conrad says. "Of course, this is all very theoretical."—BJORN CAREY

GROUP EFFORT

Dragons don't exist (as far as we know), but some of their individual characteristics can be found throughout the animal kingdom.



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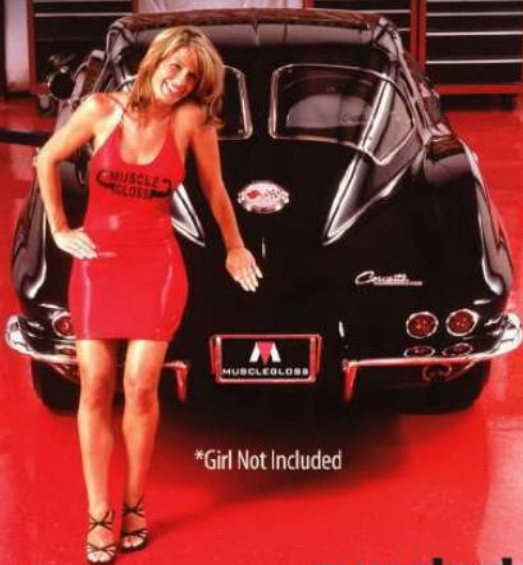
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THE FUTURE OF ROBOTICS

(CONTINUED FROM PAGE 45)

THE LONELIEST HUMANOID IN AMERICA

grant known as PIRE (Partnerships for International Research and Education). Drexel's Oh, UPenn's Lee and VT's Hong are all second-generation Korean-Americans, and Oh is first cousins with Jun-Ho Oh, the creator of Hubo. "International collaborations require trust," says Paul Oh. "Hubo is [Jun-Ho Oh's] brainchild, and he won't entrust it to just anyone. Being family makes those concerns immaterial." Oh positioned Hubo, a South Korean-made robot, to the NSF as a research platform that would train American students in multinational cooperation, and the team is now developing three versions of Hubo for academic purposes: a Virtual, Mini and Online Hubo.

Virtual Hubo will be an online robot simulator, something that students without the necessary funds to purchase or build their own robot can download. The software enables basic onscreen robotics experiments.

If, however, an academic program wanted to experiment with outside forces on the robot—how it's affected by picking up a weight, for instance—it needs a tangible prototype. The full-size Hubo is too expensive, "so we created Mini-Hubo," Hong says. "We wanted a sub-\$8,000 robot that has the same kinematics and proportions as the real Hubo, just smaller." The idea is that Mini-Hubo is an open-source hardware platform. Virginia Tech, which was responsible for this part of the project, prepared blueprints, CAD drawings, and fabrication and assembly manuals, and the documents are now available free online to anyone. As a test of the system,

(CONTINUED ON PAGE 86)



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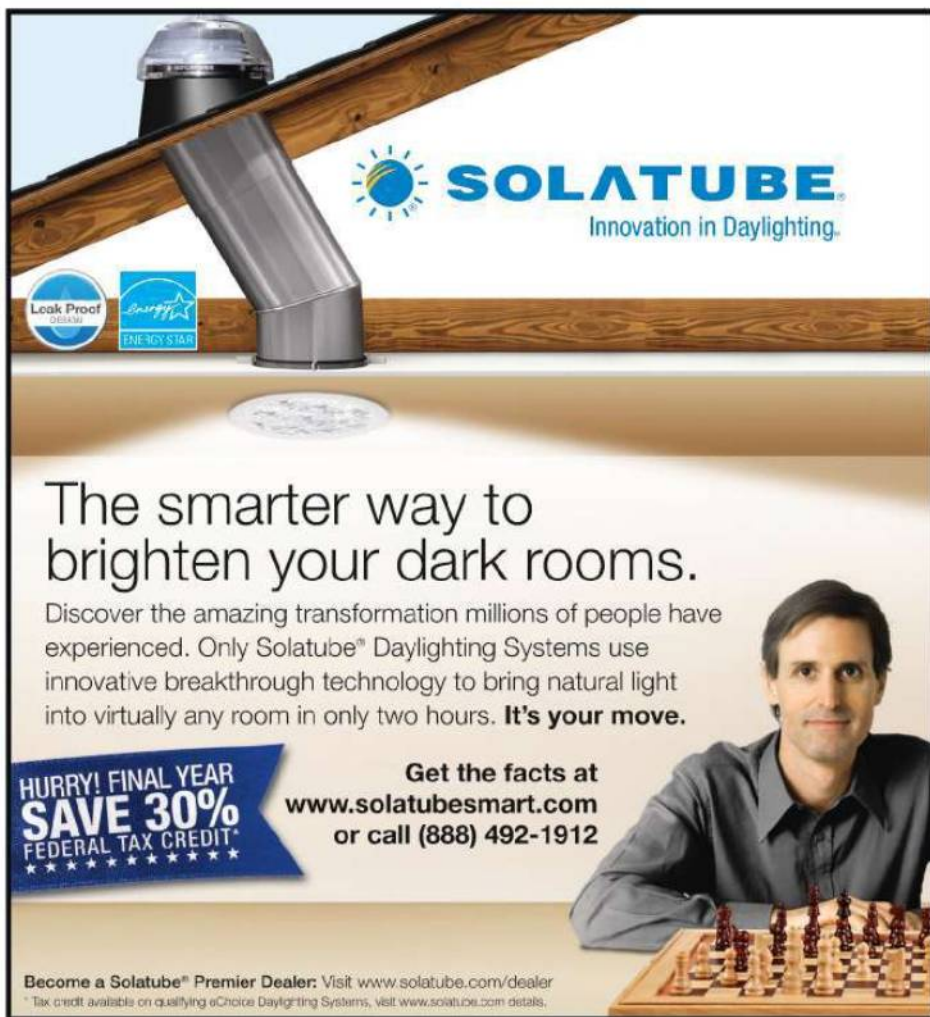
Drexel students were asked to build a Mini-Hubo from the instructions. The robot accepts algorithms that let it do things like avoid obstacles and manipulate objects. "And it worked," Hong says proudly. Orders have already arrived from two universities for pre-built Mini-Hubos.

Finally, Drexel will, as the last phase of the five-year grant, host the full-size Hubo in Oh's lab. The robot, Online Hubo, will be surrounded by webcams. Other universities will be able to send algorithms to it and monitor the results remotely. "It's like a time-share," Hong explains. "And the best part is that Online Hubo, Mini-Hubo and Virtual Hubo all share the same [software]. It will be a full set of tools to conduct humanoid research."

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The path forward from CHARLI-L to an all-in-one humanoid is not clear. But then, the field of humanoid robotics moves rapidly. In 2000, Kuffner remembers, "people were saying, 'I wonder how long until we'll figure out stable walking in robots.' The prediction was that it would take 10 years. It happened in two and a half."

Keep in mind that the roboticists who work on humanoids are not dreamers by nature. They tend to be practical people. When I ask Hanson how one defends the concept of developing self-aware humanoids in a grant proposal, his language tightens, and his logic suddenly seems less circular and the rewards not as distant. The practical benefits are, he believes, endless. "Automation is the future of an efficient" (CONTINUED ON PAGE 88)



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(CONTINUED FROM PAGE 86)

THE LONELIEST HUMANOID IN AMERICA

society," he says. "It results in more-affordable goods, more-efficient transportation and improved quality of life. It can increase what a civilization like ours can achieve with limited resources. Intelligent automation is our best hope for solving our big problems."

On the long list of big problems facing the United States, there is one for which humanoid robots could present a very real solution. The baby-boomer generation will soon form the single biggest spike in retired and elderly Americans in history. In rural and suburban homes reachable only by car, that's going to be a far-flung and very fragile population. As a result, the ratio of available caregivers to needy patients is expected to change from 4:1 to barely 1:1 in the next 20 years. Perhaps that's the practical task for which

humanoid robots are best suited. iRobot, for instance, perhaps the most widely known robot manufacturer in the country, has spun off a new division to meet the trend. (Angle is adamant that bipedal robots are not part of the company's plan, however. He believes his existing tank-tread platform is the best option for climbing stairs, navigating obstacles, and someday carrying a human.)

There's a great deal of difficult and painstaking work to be done before we'll have anything close to an automated home health aide. And in the end, of course, it's hard to avoid rolling one's eyes over the notion of pouring time and effort into a bipedal humanoid robot that is barely able to kick a ball. But consider that this year an American-made humanoid may, for the first time,

accomplish the task of walking forward and interacting with other objects without falling over. Until recently that task was considered practically impossible.

It's the open-ended spirit of this research that's important. That open-ended work, that near-religious zealotry, is what could someday put a robot helper in homes where they're desperately needed. Put aside the idea of a robot that cleans out your gutters so you can spend a Saturday in the yard with your son. Imagine now that your son has children of his own, has taken you in, and works a ten-hour shift. Who will have the time to administer your medication? To schedule your next doctor's appointment? To help you to the bathroom? Who will you rely on? Perhaps—if Hong and his peers can convince our country that their work could someday remedy a national crisis—you'll rely on CHARLI.

Jacob Ward is the deputy editor of POPULAR SCIENCE.



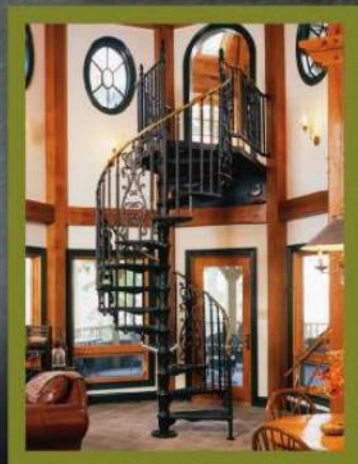
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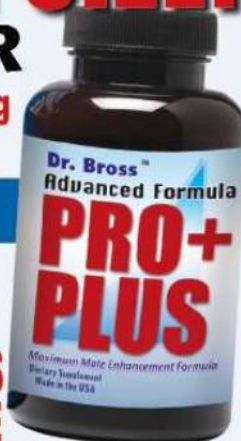


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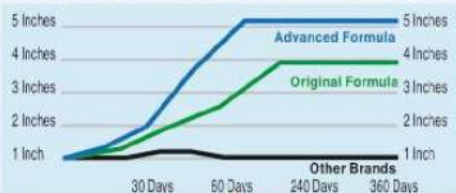
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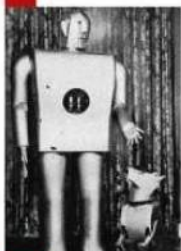
Chains of Command

In 1983, engineers struggled to design useful robots that were anything more than expensive toys. Heath Co. inventors envisioned a future in which their one-armed HERO 1 [right] could handle household chores. Although it could zip around and pick up film canisters, HERO 1 required too many commands to do much else—it was an educational tool, not Rosie from *The Jetsons*. Engineers from Androbot, meanwhile, hoped their joking and singing robot, B.O.B. (for Brains on Board) would eventually be like a family member, but B.O.B. couldn't even sing "Happy Birthday" without a string of commands, let alone navigate a flight of stairs. More than two decades later, although computation has improved, scientists are still striving to advance battery and actuator technology to create practical robot helpers. To read about the Korean, Japanese and American humanoids that come the closest, turn to page 46.—DENISE NGO

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More Automatons Over the Years



1949

MAY 1933 Got Milk-Bots?

For the World's Fair in Chicago, the design firm Messmore & Damon unveiled a mechanical cow that used hidden mechanisms to moo, wink, and give milk.

AUGUST 1949 Robotainment

The seven-foot-tall, voice-controlled and light-responsive Elektro [left] thrilled audiences by mimicking 26 humanlike gestures, including smoking cigarettes.

MAY 1962 Battle Beetle

The U.S. Air Force's tanklike Beetle was the first in a planned family of robots made to operate in irradiated regions to keep operators shielded from nuclear fallout.

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