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POPULARMECHANICS.COM

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Radar

QW-2344u

AE-e456

Link 0

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*Based on comparison of non-luxury mid-sized sedans. SOURCE: Automotive News, 2012. †Forward Obstruction Warning system is not a substitute for safe and attentive driving. There are limitations to the range and detection of the system. Please see your owner's manual for further details. ‡Smart City Brake Support operates in certain low-speed situations. Factors including speed, road conditions and driver input can all impact stopping distance. Smart City Brake Support is not a substitute for safe and attentive driving and does not guarantee instant stopping. Please see your owner's manual for further details. **Based on EPA estimates for 2014 Mazda6 / models with 2.5L engine and automatic transmission 26 city/38 highway MPG. Actual results will vary. SOURCE: 2013 Fuel Economy Guide, April 9, 2013 (www.fueleconomy.gov). ††Starting at \$20,880 MSRP plus \$795 destination (Alaska \$840) for 2014 Mazda6 / Sport with manual transmission. 2014 Mazda6 / Grand Touring model shown, \$29,495 MSRP plus \$795 destination (Alaska \$840). MSRP excludes taxes, title and license fees. Actual dealer price will vary. See dealer for complete details.

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Sandboarder Jeremy Tutorow carves up the towering Mesquite Flat Dunes in California's Death Valley National Park.

PopularMechanics IGNITION

07/08
2013

The Range Is Hot

PopMech joins a live-fire exercise to see how—after a decade of counterinsurgency—the Marine Corps is revamping its tech and tactics to confront an old foe: the modern army. **BY JOE PAPPALARDO** 72

The Robots Are Coming ... to Mow My Lawn

Senior tech editor **Glenn Derene** chronicles his quirky experiment to surrender the care of his lawn to the automatons 80

The Case for Alien Life

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Seven Days in the Valley

Two multitasking adventurers take a packed Ford F-150 SVT Raptor into California's Death Valley to torture-test desert gear—and themselves. **BY JAMES VLAHOS** 96

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Getting a Marine to a New York photo session was too tough, so we improvised. Senior news editor Joe Pappalardo made sure the gear was authentic, and Philip Friedman nailed the shot.

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PopularMechanics

W weekend

21 Pages of DIY



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What You Said

(ABOUT OUR MAY ISSUE AND MORE)

We read all of your comments, tweets, and letters. Fan fiction is always greatly appreciated too.



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CURATED BY ALYSON SHEPPARD

Our May feature "Lessons From the Micro-manufacturing Revolution," explains how to create your own startup business. "Wow," Jesse Mencer comments via Facebook. "Perfect timing for me, since I'm currently working on building my own invention. I now know what steps I need to take next." Dan Kenyon, who owns a manufacturer-representative company in Sioux Falls, S.D., emphasizes that anyone creating a startup needs to have a marketing strategy first. "Who are your customers and how will you sell your product? Believing a product will 'sell itself' leads to all business failures," he writes. "Without the proper perspective of the marketplace, your efforts will be wasted. Even if you have the next best product to come along, you have absolutely zero chance of being successful." ● Ted Hilson of Auckland, New Zealand, is glad he can purchase PopMech overseas. "Thanks for always writing in a language the layman can understand," he writes. "I'm no scientist, but I still enjoy reading your stories." ● "Greetings from 1953!" Ethan Trooskin-Zoller of Seattle writes. (Hmm—we sense sarcasm.) "You

COMPLAINTS DEPARTMENT

Your ongoing military coverage is completely inappropriate.

JOHAN ROSMAN,
PERTH, AUSTRALIA

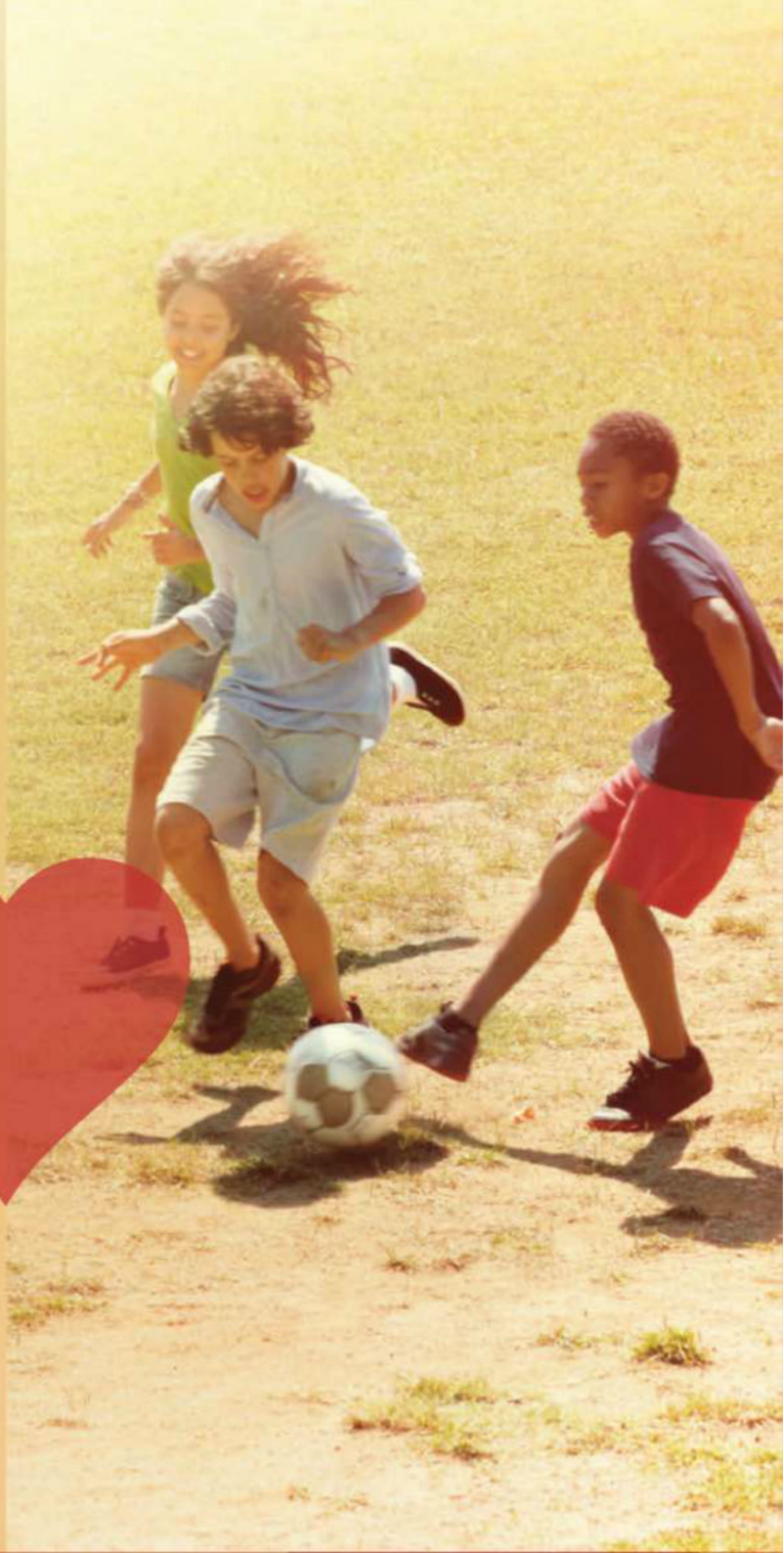


Student pilots of the 80th Flying Training Wing at Sheppard AFB, Texas, read PM in the altitude chamber at 25,000 feet during aerospace physiology training. From left: 2nd Lt. Andrew Lyons, 2nd Lt. Eli Tylski, 2nd Lt. Haden Fullam, and 2nd Lt. Tyler Welch.



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extol the virtues of the Sol Origin Multifunction Tool as great for 'both Mom (sewing and first-aid kits) and Dad (fishing hooks, knife)' [Upgrade, April]. In our family, Dad does the first aid and Mom wields the knives and fishing hooks. I sure am glad my 6-year-old daughter didn't come across this piece. You have lots of room for improvement." ● Reader Marty Lardy enjoyed our guide for building a kegerator into a video-



game arcade table (DIY Tech, May). "My mom always told me not to drink next to the entertainment system," he writes on Facebook. "But now I can!" ● Erik Fitzpatrick from Las Vegas enjoys the entire issue: "Every kid should have a subscription to PM," he writes. "You cover a myriad of topics and you do it fantastically. Keep up your extraordinary labors." ● Scott Shipman of Prineville, Ore., sends us a great tip for the difficult task of removing nails: "The best tool I have ever found for pulling nails, staples, and screws is an old horseshoe puller. Even if the heads are gone, it gets the job done." ● Joe Arroyo of San Luis Obispo, Calif., reads PM on his Nexus 7 tablet: "Something about the May issue is a little different, but I can't quite put my finger on it . . . Oh, wait, yes I can! The new interactive features are awesome!"

WHAT YOU SAID

What We're Up To

(POPMECH NEWS & EVENTS & STAFFERS ON THE SCENE)

Great work, *design team*! In May PopMech received two gold medals from the Society of Publication Designers: one for the November

2012 issue of our iPad app (for Best General-Interest App) and another for our June 2012 feature "Fixing the World's Most

Complicated Plane," which won for Best Design Feature in a Tablet. PM also received four other nominations.



THE SOCIETY OF
PUBLICATION DESIGNERS
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POPULAR MECHANICS



"We did it! Now can someone please put us back to scale?"

WE'RE REALLY BUSY IN JULY/AUGUST

- **July 27-28:** Maker Faire Detroit
- **Aug. 11-12:** Perseids Meteor Shower
- **Aug. 12:** Launch of Lunar Atmosphere and Dust Environment Explorer (LADEE) to orbit the moon, Wallops Flight Facility, Va.



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RAZOR
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PRESSURE
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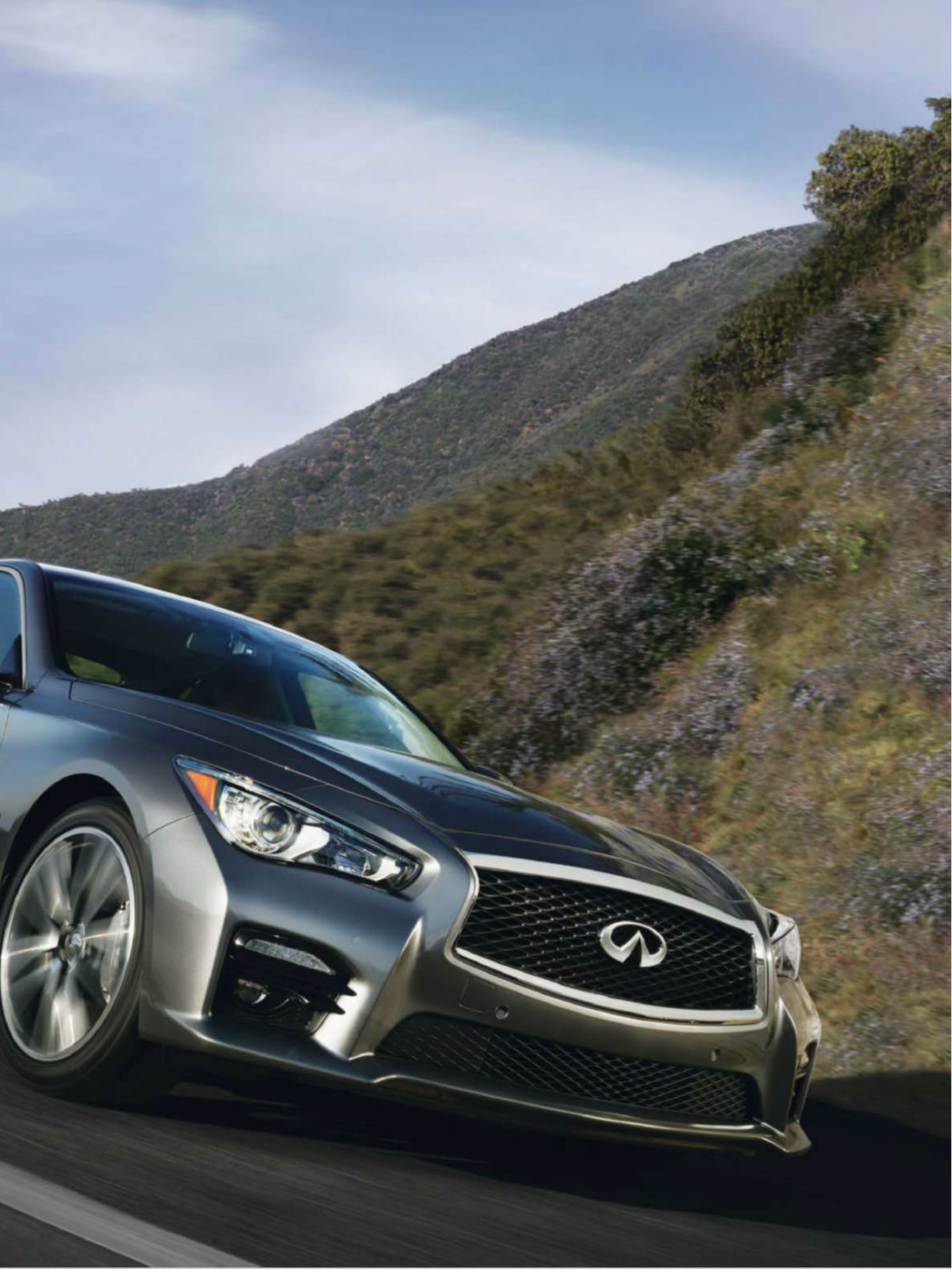


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David Agrell and his wife, **Olivia**! They
welcomed daughter, **Elodie**, into the
world in May. (And thanks, **David**, for
completing your editing duties before
going on paternity leave.)**PopMech****MICHAEL KUNTZ**

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Email popularmechanics@hearst.com.**How do LCD
screens work?****Eli N., 13,
Minneapolis-
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to control the flow of light between two pieces of polarized
glass. Add current and the liquid crystal aligns, blocks the
light, and creates a black bar. Color displays apply the same
concept to thousands of tiny dots, known as pixels, each
with a red, green, and blue subpixel. Adding voltage filters
a white backlight into a colored dot. Combine enough pixels
together, and voilà, an image. —**STEVE ROUSSEAU**

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Tech

WATCH

- NEWS
- TRENDS
- BREAKTHROUGHS

Edited by
RACHEL Z. ARNDT

1

WING SAIL

The AC72's sail is more akin to an aircraft wing than to a traditional fabric sail. The crew can adjust the fixed wing by trimming its multiple flaps individually.

SENSORS

Structural sensors monitor the loads on the rigging and daggerboards, others track boat and wind speed, and units on the wing help the crew make sure they're not overloading it.

FOILS

As boats increase speed, L-shaped carbon-fiber foils that extend from the bottom of the hulls generate lift and keep the boat "flying" above the water.

THE
COURSE
MAP AND
TURNS

MARINE TECHNOLOGY

Speed Racer

The fastest sailboats in the world arrive in San Francisco Bay this July, where they'll battle to qualify for this year's America's Cup race. Aboard the AC72, Oracle Team USA will face the winner among the three teams competing in dozens of preliminary races this summer. The boats are larger than ever, at 72 feet, and feature multiple hulls to decrease weight and drag. The AC72 can hit more than 47 mph thanks to carbon-fiber hulls and a rigid plastic wing sail. For the first time spectators will actually be able to see the race: It's happening just off the California coast. — *TIM NEWCOMB*

Oracle's grinder, Brad Webb, walks us through some key points on the course.

Golden Gate Bridge



1

Start

"Taking off toward the first mark, the key to the transition from sailing 90 degrees to the wind to sailing downwind is keeping on the foils and going as fast as possible."

2

First Turn

"The second key is deciding when we jibe. The first leg is a little over a minute, so there is not a lot of time to make decisions."

3

Maneuvering

"Going at such a high speed, we pay dearly for any error. The speed drop is more dramatic, so potential losses are much higher."

4

Bottom of the Bay

"It is actually a gate, so you have to go between the marks, and you can make a left or a right. That is the next big decision point."

5

Top of the Bay

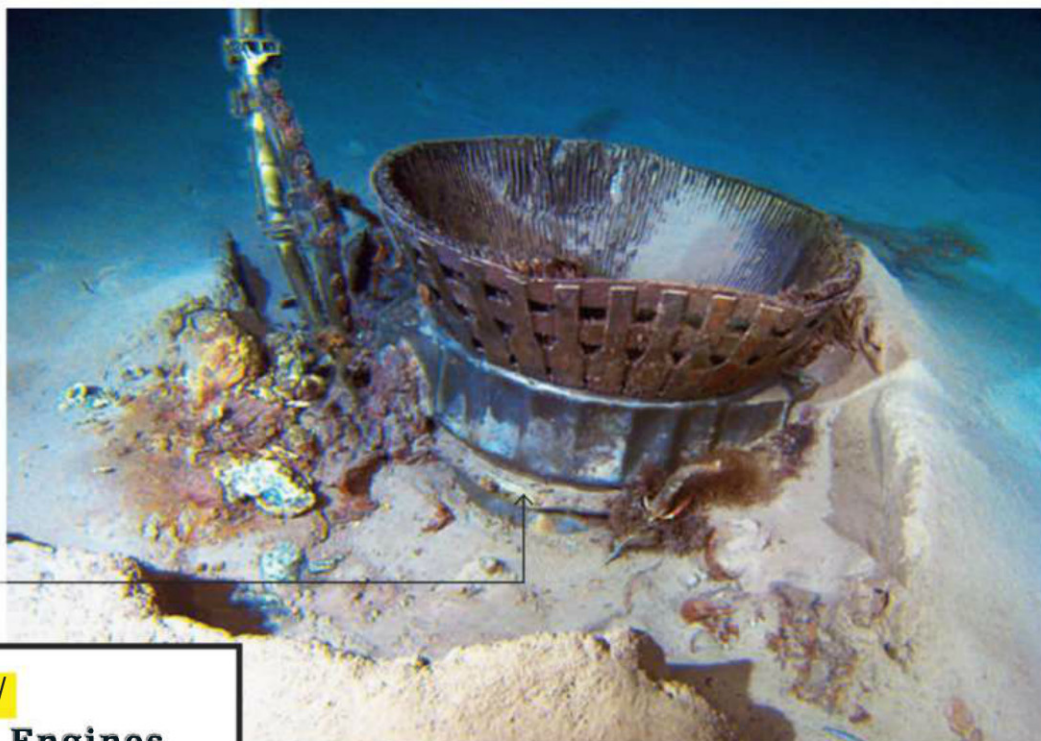
"At the top is the second gate, so if you're ahead you get the pick of which side to pass the gate."

6

Shore Course

"Sailing inshore, restricted by the elements and boundaries, makes the racecourse that much trickier. It's like we're racing on a moving carpet that is not uniformly moving."

TECH WATCH

**NEWS BRIEF /****Apollo 11 Engines Pulled From the Ocean**

For the first time since they helped propel moon-bound astronauts off Earth in 1969, the Apollo 11 engines are again above-ground. A team funded by Amazon.com CEO Jeff Bezos raised the battered, corroded turbines, thrust chambers, and heat exchangers from the bottom of the Atlantic Ocean off Cape Canaveral, 14,000 feet below the water's surface. The parts made up a Saturn V rocket's five F-1 engines, each of which was capable of producing 32 million horsepower by burning 6000 pounds of kerosene and liquid oxygen per second. The team used remotely operated subs tethered to salvage ships via fiber-optic and electrical cables to pull the engines from the seafloor. The goal is to restore them to their pre-seawater-soaked state. — ALEX HUTCHINSON

#WishGranted



The 2013 RAV4 with available Blind Spot Monitor.*

Wish Granted.



TOYOTA

Let's
Go
Places

Prototype shown with options. *Do not rely exclusively on the Blind Spot Monitor. Always look over your shoulder and use your turn signal. There are several limitations to the function, detection, range and clarity of the monitor. For a complete list of limitations and directions regarding use of the monitor, please see the Owner's Manual. ©2013 Toyota Motor Sales, U.S.A., Inc.

MOTOR ADVANCES

Cheaper Fuel Injection for Small Engines

In search of a cleaner motorcycle, Lihang Nong went straight to the source of pollution: the fuel-injection engine. Most small engines still rely on dirty, inefficient carburetors. Nong, a recent graduate of the University of Michigan, developed the PicoSpray to take the place of a carburetor. The all-in-one electronic-fuel-injection (EFI) system should cost only \$20. Potential uses range from motorcycles to lawnmowers. — MICHAEL AUSTIN



INTAKE

The size of the intake and how it bolts on to the engine will vary between applications. Nong says the first PicoSpray model will work on single-cylinder engines with displacements from 90 to 300 cc.

ENGINE CONTROL UNIT

The built-in Engine Control Unit (ECU) includes sensors for air temperature, manifold absolute pressure, and throttle position. For something simple, such as a portable generator, the system requires fuel and power connections alone, but it can accept outside inputs.

PUMP

A positive-displacement pump replaces the fuel pump, pressure regulator, and injector of a traditional EFI. The pump squirts high-pressure fuel into the intake on demand in precisely metered amounts.

NEWS BRIEF / The Wandering Meat Loaf Battery

Drifting along the shores of the Pacific Ocean between central California and Alaska are "wandering meat loaves," creatures that may improve battery manufacturing. That animal, the gumboot chiton, is a marine snail whose regenerating teeth could hold the secret to next-generation batteries. The snail feeds on algae in rocks using more than 70 rows of 0.5-mm-long teeth. When the outer rows of teeth wear down, the chiton replaces them by forming magnetite along scaffolding made of complex sugars, creating teeth that are both exceptionally hard and magnetic. David Kisailus, a chemical and environmental engineering professor at the University of California, Riverside, wants to adapt that process to synthesize unnatural materials such as lithium iron phosphate, which is used as a cathode in lithium-ion batteries. "By doing this, we can control materials' optical or electronic properties," Kisailus says.

— MICHAEL ROSELLI

TECH WATCH

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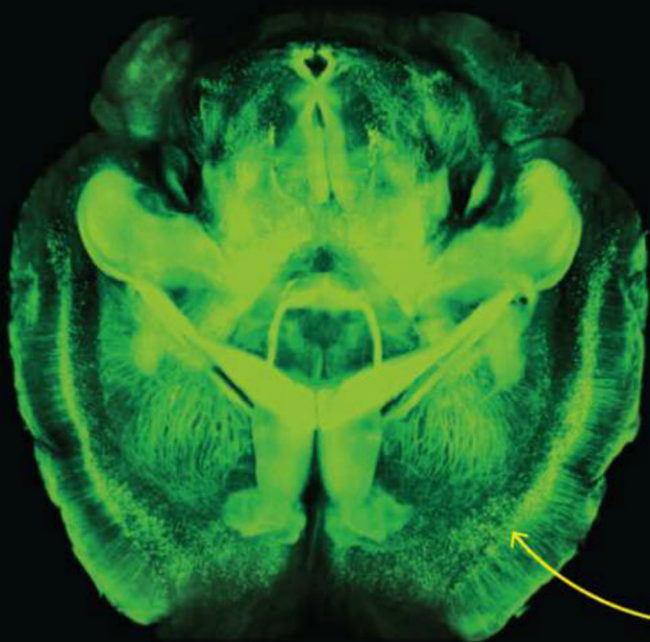


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Shining a Light on the Brain

How does a 3-pound bundle of cells give you a memory and consciousness? What was once the realm of philosophers is now being researched by scientists.

BY SARAH FECHT



To get light through the brain to reveal neural connections, scientists replaced the light-blocking fat cells.

At Stanford researchers have developed a technique to make the brain see-through, allowing them to trace individual neurons, and their sometimes far-flung connections, from end to end. They've succeeded in doing so with **an entire mouse brain** and portions of human brains.

Meanwhile, the federal government in 2014 is investing \$100 million in Brain Research through Advancing Innovative Neurotechnologies (BRAIN). The BRAIN scientists want to chart the simultaneous functions and activity of the brain's 100 billion neurons and its 100 trillion synapses at an unprecedented resolution. Understanding the brain's circuitry could lead to better treatments for dementia and other neurological ailments, as well as developing mind-controlled prostheses and computers that "think" like humans. The National Science Foundation, the National Institutes of Health, and DARPA will contribute to the project, expected to cost millions more over the next few years.

TECH WATCH

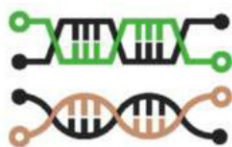
Meanwhile, in Your Brain

What scientists already know about the human brain.



BRAIN HIGHWAYS

When brain signals need to travel long distances, they take the highway. Researchers at Indiana University and the University Medical Center Utrecht in the Netherlands have uncovered high-capacity pathways that form the backbone of the neural network, facilitating communication between far-off brain regions.



GENE MAPPING

The variance in how different areas of the brain express the same genes may play a role in shaping the brain's architecture. Icelandic Heart Association researchers discovered a gene that's overactive in the brains of people with Alzheimer's, disrupting the activity of many other genes.



DEEP-BRAIN STIMULATION

Some diseases interrupt the electrical signals neurons use to communicate. In deep brain stimulation, implanted electrodes deliver weak impulses to the brain, changing how neurons fire. The technique, a Parkinson's disease treatment since 2002, may also be effective against depression and bipolar disorder.



MIND-CONTROLLED PROSTHESES

Electrode implants allow patients paralyzed from the neck down to operate thought-controlled robotic arms to independently drink coffee, eat chocolate, and reach out to a loved one. Better understanding of the motor cortex's circuitry may unlock new prosthesis abilities.

Robots Saving Lives

Healthcare-Associated Infections:

AFFLICTED

1.7
MILLION

KILLED

98,987

Even as robots become more common in operating rooms, one aspect of hospital life is sorely lacking in high-tech tools: sanitization. That's changing at Johns Hopkins Hospital, where some rooms are cleaned not just by a person wielding an old-fashioned mop and bleach but by the Bioquell cleaning robot. The Bioquell system releases a mist of hydrogen-peroxide vapor that covers all surfaces in a hospital room, killing ultrapersistent microorganisms. After spraying, another bot breaks down peroxide residue into water and oxygen. In a test with 6350 patients, drug-resistant infections were reduced by 64 percent in the robotically cleaned rooms. — A.H.



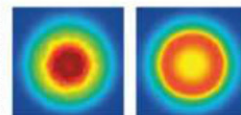
TESTING THE BEES

How Do Bees Find Flowers?

→ To find out whether bees really do use electric fields to find food, the researchers created artificial flowers: Some were positively charged and contained a bee-pleasing, sugary drink, and the others had no charge and a bitter drink. The bees quickly learned to find the sweet rewards of the positively charged flowers—with 81 percent accuracy. But when the researchers turned off the electricity, the bees were totally clueless.

How Do Bees Choose Flowers?

→ To find out if bees can use not only the presence of a charge but also differently shaped electrical fields to forage, researchers gave sweet flowers a negative charge in the center and a positive voltage at the edges (below, left), and bitter flowers a uniform voltage (below, right). Bees were able to sense the voltage patterns with 70 percent accuracy to stay away from the bitter flowers and opt for the sweet ones.



FLORA AND FAUNA

Plant-Insect Communication

Bees use a flower's color, shape, and scent to find the best nectar. But they also use electricity, say scientists at the University of Bristol in England. Flowers naturally have a negative electric charge. Bees, which have a positive charge, may be able to feel the flower's electrical force when the static bristles their body hairs. The researchers' experiments reveal that when a bee lands on a flower, it temporarily alters the flower's charge, a change that lasts even after the bee departs. By sensing that voltage change, a bee might be able to detect whether another pollinator has just visited a flower and plundered its nectar. — S.F.

TECH WATCH



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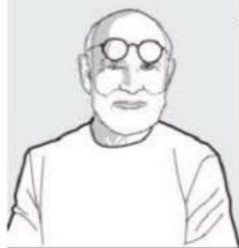


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60-SECOND GENIUS

Oliver Sacks, neurologist and author

Q How do hallucinations affect society?

A: Hallucinations have played some part in the culture and in individuals with regard to beliefs and folklore—I mean with regard to the whole spectrum of beliefs, from little green men to the Almighty. The most common hallucinations are lilliputian, which usually don't cause fear but rather delight and amusement. One wonders whether they might be the explanation for little people and fairies and sprites and leprechauns.

Can hallucinations be useful?

Something which is clearly helpful and not consciously adopted are hallucinations of bereavement. They've been seen as a built-in measure that occurs to at least a third of people who have lost a husband or wife, a child or parent.

Now that you've tackled hallucinations, what will you focus on next?

In a word, consciousness. The history of our thoughts on memory is enormously interesting. In that way I'm sort of a history and story buff—which is why I like natural history and evolution. It's all about how things come to be. In a sense I think there is only one theory in biology, and that's evolution. In particular, evolution by selection in a large population—whether natural selection in a species or neural Darwinism in the immune system or nerve cells. The immune system is not programmed; it develops through experience, and it evolves. — AS TOLD TO RACHEL Z. ARNDT

TECH WATCH



A week before Oliver Sacks turns 80 this July, his latest book, *Hallucinations*, comes out in paperback. In it, he explores the eponymous neurological phenomena by telling stories of people who hallucinate voices, images, beings, and smells.



PRIVATE SPACE TRAVEL

Getting to 800 mph in 16 Seconds

Virgin Galactic's SpaceShipTwo took its first rocket-powered flight in late April over Mojave, Calif., a milestone toward its use as a reusable spacecraft. SpaceShipTwo dropped from its carrier aircraft at 47,000 feet, then

ignited its engine. In 16 seconds test pilots Mark Stucky and Mike Alsbury accelerated to Mach 1.2 (about 800 mph at that altitude) and climbed to 55,000 feet. Virgin plans to test the craft at higher altitudes throughout 2013 and hopes to reach space before the year's end. "For the first time, we were able to prove the key components of the system, fully integrated in flight," says Sir Richard Branson, founder of Virgin Galactic. "We saw history in the making." He says commercial flights could start in 2014.

— JOE PAPPALARDO

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Upgrade

- GEAR
- TOOLS
- GADGETS

Edited by
JENNINGS BROWN

2

We tried out the latest running shoes to see if the new technology is game-changing or just attention-grabbing.

BEST IN SHOE

RUNNING TECH

Innovative design and high-tech materials have put a new spring in the step of the oldest form of exercise. Soles with polymer blades bounce back. Elastic bands make you feel like you're running barefoot. An entire upper is woven from a single strand of microengineered yarn. The results of years of research, these and other advances have put an edgy breed of shoe in the running. — TIM NEWCOMB



ADIDAS SPRINGBLADE (\$180)

YEARS IN THE MAKING: Six

TECH SPEC: 16 polymer blades of different lengths and varying degrees of stiffness are designed to respond to the direction and amount of pressure imparted by the foot.

HOW IT WORKS:

The blades absorb energy when the shoe meets the ground, then unleash that energy on the rebound. Steve Vincent, Adidas VP and global head of innovation, touts the shoe's high energy return. "It is explosive with every step," he says.

FEEL: Explosive? Nah. But the spring-loaded sole definitely put a *boing* in our gait.

HANG-UP: How will the blades stand up to the rigors of concrete and uneven terrain over time?

UPGRADE



NIKE FLYKNIT (\$130)

YEARS IN THE MAKING: Four

TECH SPEC: Instead of using a variety of traditional fabrics to weave together dense layers in shoe uppers, Nike invented a yarn for its Flyknit system to cloak the foot in one layer.

HOW IT WORKS: The fabric cuts weight: The Flyknit Racer is 19 percent lighter than Nike's previous high-tech offering. "It acts like a second skin for the foot," Nike CEO and designer Mark Parker says.

FEEL: As comfortable as a sock but with the cushioning and support of a shoe.

HANG-UP: We had some trouble figuring out the right size, because the fabric—which is intended to mold to the foot—is so stretchy.

PUMA MOBIUM (\$110)

YEARS IN THE MAKING: Two

TECH SPEC: 16 pods linked by a high-tension band. Each pod moves in multiple directions.

HOW IT WORKS: "The combination of pods with the elastic band allows for expansion and contraction,"

says Christian Harig, Puma head of research and insights. Mobiums encourage the natural motion that has become popular with the barefoot-running trend but provide stability and protection that toe shoes don't.

FEEL: Barely there—in a good way. The support level was right for running but wouldn't cut it for heavy cross-training.

HANG-UP: Will that elastic band hold up, especially with repeated use in harsh weather?



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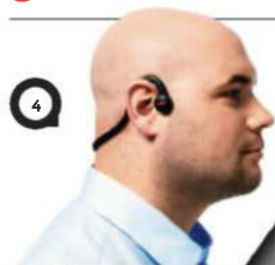
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DEAD ON ANNIHILATOR (\$50)

1 Nothing compares to the sheer bliss of taking a sledgehammer to a bare wall. But by packing a nail puller, tile ripper, chisel, and hammer, the Annihilator is a more versatile, finely tuned instrument of destruction and thus suited to smaller, more detailed demo work. And the bottle opener helps you celebrate after a job well done. — JENNINGS BROWN

DEVOTEC FUEL (\$15)

2 Devotec's Fuel Micro Charger gives you the juice you need when your phone is running on fumes. The clever mini jerrican package supplies 20 to 30 minutes of talk time. — RYAN O'CONNOR

PANASONIC CORDLESS RECIPROCATING SAW (\$200)

3 No need to haul alternate battery packs for this reciprocating saw—just grab whatever is handy. Use a 14.4-volt pack for quick demo work, or switch to an 18-volt for jobs that require more power

and longer run time. — DAVID AGRELL

AFTERSHOKZ SPORTZ M2 (\$70)

4 While most headphones' selling point is their ability to block out ambient noise, AfterShokz's calling card is letting in background noise. The speakers rest on your cheekbones instead of plugging into your ears, which, surprisingly, works: You can listen to music *and* what's going on around you. The tech can make running or cycling safer, but the sound quality is just so-so, and everyone around you is going to know you're rocking out to Beyoncé. — ALYSON SHEPPARD

OUYA CONSOLE (\$100)

5 The next great gaming console came out of the second-most-successful Kickstarter campaign ever. Early versions of the device drew criticism for being slow, among other gripes. But the bugs have been banished in this iteration. The compact and powerful Android-based gadget encourages open development and cheap gaming. — R.O.

UPGRADE

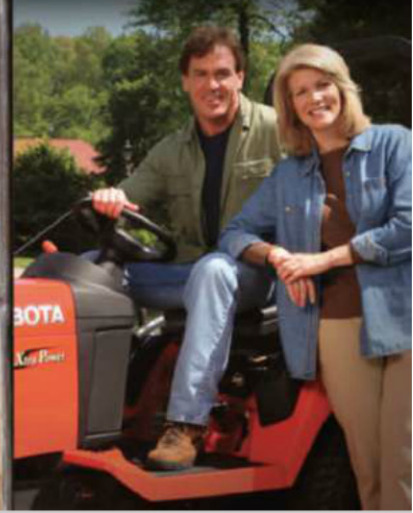
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SOLOSHOT (\$480)

1 No need for a cameraman. Sit any camera atop the base, strap on the armband, and you're ready to capture selfies from up to 2000 feet away. The device has flaws (setup takes about 20 minutes, and tracking is imperfect), but when you don't have a friend to record your gnarly moves, the Soloshot is a worthy stand-in. — *RACHEL Z. ARNDT*

PLANTRONICS BACKBEAT GO (\$80)

2 Gesticulate wildly, if you want: This wireless Bluetooth headset frees you from the electronic-cord leash while still providing quality audio for your music and calls. The BackBeat Go provides up to 4.5 hours of listening and talk time, and flat wires that prevent tangling and aggravation. — *JAIME NETZER*

BASIS B1 BAND (\$200)

3 Basis is a multisensor health and activity tracker that integrates into the wearer's routine, gathering data that helps you develop healthier habits—if you don't mind a wearable nagger, er, trainer that tells you when to sleep and if you've been sitting for too long. — *R.O.*



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**KELTY ASCENDER 22 (\$350)**

4 For the traveler who needs a bag for every adventure, the Ascender 22 is essentially three in one: carry-on size, check-in size, and backpack. It expands in two directions, comes off its chassis, and has backpack straps that you can easily stash away. The multipurpose bag is one part of a series that

includes a water-resistant duffel and a customizable trunk—both of which strap into the same frame that comes with the 22—and several travel accessories. Ditch the old clamshell luggage for this matching, versatile collection that you can take anywhere (go to popularmechanics.com/adventuregear). — *J.B.*

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EDITOR TESTED



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With every key sporting its own microswitch—no mushy plastic dome—each stroke is rewarded with a tactile click. And since this keyboard dampens the typewriterlike staccato, I can pound away in text files or circle-strafe bad guys without producing the din of a midcentury newsroom.

— STEVE ROUSSEAU, special projects assistant



KARMA HOTSPOT (\$80)

Yes, the Karma rewards you for being nice. When you share your Internet with others by turning on the open Karma network, you'll get 100 MB of data free for each person who connects. In turn, any person who connects will get 100 MB of use. Take your time. Data, like karma, never expires.

— RACHEL Z. ARNDT, assistant tech editor



BOXEE CLOUD DVR (\$100)

As soon as I get home from work I switch on the Boxee to play music while I make dinner. Then I use it to stream TV shows or watch odd but great movies (*Sharktopus*, *Piranhaconda*). It plays just about every video format without stutter or lag, and its remote is the easiest to use of the 10 in my living room.

— ANTHONY VERDUCCI, interactive designer/illustrator

UPGRADE

LEVI'S 511 SLIM FIT COMMUTER JEANS & SHIRT (\$90 EACH)

The Commuter line blends utility and fashion, with a dash of safety. The dash: The 3M reflective lining at the pants' cuffs barely catches a motorist's attention. But I stand by the other design choices: pockets on the lower back of the shirt, a waist loop for easy U-lock storage (inset), stretchier denim that doesn't get loose, reinforced crotch, higher rise to avoid the plumber look, and a water- and odor-resistant finish that keeps rain off your skin and stank out of your office.

— JENNINGS BROWN, associate editor

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Time travel at the speed of a 1935 Speedster?

The 1930s brought unprecedented innovation in machine-age technology and materials. Industrial designers from the auto industry translated the principles of aerodynamics and streamlining into everyday objects like radios and toasters. It was also a decade when an unequaled variety of watch cases and movements came into being. In lieu of hands to tell time, one such complication, called a jumping mechanism, utilized numerals on a disc viewed through a window. With its striking resemblance to the dashboard gauges and radio dials of the decade, the jump hour watch was indeed "in tune" with the times!

The Stauer 1930s Dashtronic deftly blends the modern functionality of a 21-jewel automatic movement and 3-ATM water resistance with the distinctive, retro look of a jumping display (not an actual



True to Machine Art esthetics, the sleek brushed stainless steel case is clear on the back, allowing a peek at the inner workings.

jumping complication). The stainless steel 1 1/2" case is complemented with a black alligator-embossed leather band. The band is 9 1/2" long and will fit a 7-8 1/2" wrist.

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Android smartphones are enjoying a moment. They have never been more popular or powerful. We tested three mobile slabs to separate the great from the merely good.

BY GLENN DERENE

UPGRADE

DROID RAGE



HTC ONE



LG OPTIMUS G



SAMSUNG GALAXY S4

BUILD QUALITY

Sleek, almost seamless aluminum frame with comfortable arched back.

1ST PLACE

Solid brick of glass and plastic. Elegantly understated and pleasing to the eyes and hands.

2ND PLACE

Plasticky, cheap-feeling, and slippery in the hand. But has a removable battery.

3RD PLACE

SCREEN

4.7-inch; LCD. With the highest pixel density in the business, the HTC is crisp and beautiful.

2ND PLACE

4.7-inch; LCD. The look is beautiful and crisp but slightly less vibrant and detailed than that of the other two options.

3RD PLACE

5-inch Super; AMOLED (Active-Matrix Organic LED). Incredibly bright and big—although colors seem almost unnaturally vivid.

1ST PLACE

CAMERA

HTC's sensor uses UltraPixels, which are larger and capture more light. Great for nighttime shots, but daytime shots are oversaturated and low-res.

3RD PLACE

13-megapixel photos are impressive and crisp but inexplicably not wide-format. Camera app is basic but has a few cool options.

2ND PLACE

Different modes erase people who walk through shot, produce GIFs, or merge multiple images into one. Also takes slow- or fast-motion video.

1ST PLACE

BELLS & WHISTLES

Front-facing speakers are the best we've heard on a phone. Built-in infrared remote control. BlinkFeed home page collects Facebook, Twitter, and news into infinite scroll.

2ND PLACE

Polaris productivity suite is nice, but not a lot of gee-whiz options here. LG's interface is the closest of the bunch to stock Android—yet not close enough for Android purists.

3RD PLACE

Almost too many: eye-tracking scroll, gestural inputs, hover-over finger inputs, multi-language translation, infrared remote. Fascinating stuff, but haphazardly applied.

1ST PLACE

PERFORMANCE

Quad-core 1.7-GHz processor, 2 GB RAM—fast enough for gaming, video, or anything else you can throw at it.

2ND PLACE

Quad-core 1.5 GHz, 2 GB RAM. Slowest of the bunch, but still fine for most apps.

3RD PLACE

Quad-core 1.9-GHz processor, 2 GB RAM. The fastest in the bunch. But not much of a difference in everyday use.

1ST PLACE

OVERALL

Best-looking phone since the iPhone—a true pleasure to use. The interface is attractive but clunky and confusing. Camera philosophy is interesting, but photos are disappointing.

2ND PLACE

Handsome and satisfying to use, but interface feels out of date and unremarkable. Then again, it's a nice alternative if you hate feature bloat.

3RD PLACE

By far the best phone when it comes to performance and features, although the fit and finish lag behind rivals'.

1ST PLACE



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—JOHN SCALZI, BESTSELLING AUTHOR OF
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Auto

I N T E L

- TEST DRIVES
- TOP TECH
- HOT RIDES

Edited by
ANDREW DEL-COLLE



TEST DRIVES

JUST OUR TYPE

THE 2014 F-TYPE IS JAG'S FIRST ROADSTER IN 52 YEARS—AND WORTH THE WAIT.
BY ANDREW DEL-COLLE

The residents of Spain's Navarra region have every right to be displeased with us. After all, who wants to be awakened by a 495-hp sports car racing through their bucolic villages at 8 am? Yet we couldn't help ourselves. For two days, our group of American journalists tested all three variants of Jaguar's new 2014 F-Type against the backdrop of the Pyrenees Mountains in northern Spain, and despite the peaceful surroundings, it was impossible to

DOWN THE ROAD

JULY/
AUGUST

TEST DRIVES ▶



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Bolt



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Leaf
Fiat 500e

drive a car like this without causing some ruckus.

The F-Type is Jaguar's first new roadster in more than 50 years. The last one was the E-Type—perhaps you've heard of it. Although Jag's new low-slung roadster bears only a distant resemblance to its sultry predecessor, the F-Type is stylish in its own right. It's also powerful. Both V-6 engines are supercharged, with 340 hp in the base version and 380 hp in the tuned S version. Then there's the V8 S model's supercharged V-8, which churns out an aggressive 495 hp. All engines come paired to a ZF eight-speed automatic transmission—the same one found in the Ram 1500 and many other vehicles—that can be worked through the ratios with a flick of the steering wheel paddles or a nudge of the center shift lever.

Compared with Jaguar's other convertible, the four-seat XK, the F-Type rides on a 5.1-inch-shorter wheelbase and is 12.7 inches shorter in overall length. On Spain's tightly kinked Circuito de Navarra racetrack, we unleashed the F-Type V6 S at full throttle and found exact steering and a flat attitude through curves. Maximum traction to propel out of each corner was aided by the car's limited-slip differential (the gutsier V8 S has a predictive electronic limited-slip differential).

Despite a few hesitations, the automatic transmission is diligent, but we still prefer the manual control available through the F-Type's paddle shifters. Manual shifting also allows the driver to hear the car's distinctive, sputtering snort of an exhaust note more often. Jaguar says it spent four years developing the sound, and we believe it. Gear changes are noticeably sharper—almost abrupt—in the F-Type's Dynamic Mode setting, which holds gears to redline in manual-shift mode, loosens up the stability-control system, and adjusts the steering and throttle calibration. To further increase the F-Type's sports car chops, both S trims additionally

THE F-TYPE'S BLOODLINE

Jaguar's roadsters have a rich history—on and off the track.



C **1951–1953** With its undulating sheet metal and six-cylinder mill, the C-Type won the Le Mans 24-hour race in 1951 and 1953.



D **1954–1957** Sporting a monocoque tub and a variation of the C-Type's engine, the D-Type won Le Mans in 1955, 1956, and 1957.



E **1961–1974** Jaguar's most famous creation, the E-Type was once called "the most beautiful car ever made"—by Enzo Ferrari.

TEST DRIVES



"The F-Type's exhaust note is addictive, urging you to play with the paddle shifters like a little kid with a new toy."

— Andrew Del-Colle, associate editor

come equipped with an Adaptive Dynamics suspension system.

The F-Type's interior is luxurious, but not in an over-the-top way. Leather-bound surfaces, glass-fronted HVAC knobs, and silver trimmings balance plushness and sportiness—with the scale tipping toward the sporty side. The F-Type's fanciest parlor trick is its hidden air vent unit in the dash. Intended to improve the cabin's visual cleanliness, the vents rise only when the automatic climate control decides extra airflow is necessary. It might sound gimmicky, but the effect is impressive.

Within minutes behind the wheel of the V8 S, we understood why Jaguar had us drive this one last. The extra 115 horses makes the V-6 models feel positively lethargic. A little raw and absolutely thrilling to drive, the V-8's instant torque and power provide an irresistible glee when dipping into the gas pedal. Driven alone, either V-6 version feels more than adequately fast. But 495 hp has a way of rearranging your worldview. The F-Type's price tag will keep it out of reach for most. If coin weren't a concern, there's no doubt we'd pick up the V8 S, but either V-6 model won't disappoint. With all three versions of the new F-Type, Jag delivers a driving experience worthy of its royal roadster heritage.



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AVAILABLE: NOW
MPG (CITY/HWY): 27/35 (EST.)

2014 Ford Fiesta ST

Ford is still putting the final touches on the North American variant of the Fiesta ST, but we couldn't pass up a sneak preview in the European three-door hatchback. Our version will be offered only as a five-door, which means about 130 extra pounds and the requisite suspension tweaks to compensate for the added weight. Regardless, the combined effort of Ford's American and European performance divisions has wrought one of the best small performance cars on the market. What really sets the Fiesta ST apart is the combination of its 197-hp 1.6-liter EcoBoost four-cylinder engine with driver aids such as enhanced Torque Vectoring Control, which helps keep the car going where it's pointed during heavy acceleration. Add in the extra turbocharger power surge from an overboost function that is all too easily called into action by a generous right foot, and the 2014 Fiesta ST provides performance equal to that of more expensive cars of its ilk—namely, the vaunted Volkswagen GTI and Mini John Cooper Works. If there's one area of concern about the Fiesta ST, it's how close its \$22,195 price tag is to the \$24,495 base price of the Focus ST, which is slightly larger and more powerful, and just might be worth the extra cash. — **JAMES TATE**

TEST DRIVES



PRICE: \$29,650
(ELIGIBLE FOR \$7500
FEDERAL INCOME TAX
CREDIT AND
APPLICABLE STATE
TAX CREDITS)
AVAILABLE: NOW
MPG (CITY/HWY):
129/102



2013 Nissan Leaf

What's new: Several tweaks to improve driving range, including a reduction in peak torque from 207 to 187 lb-ft. MPGe ratings jump 23 city and 10 highway. There's also a new, more efficient cabin heater.

What's faster: An available 6.6-kw charger (relocated from the cargo area to under the hood) that cuts 220-volt charge time in half, to around 4 hours.

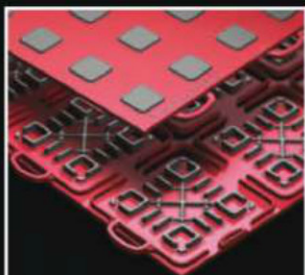
What's cheaper: The new S model brings the base price below 30 grand before tax rebates, and the SV and SL models get respective price cuts of \$3380 and \$2360.

What's patriotic: Owning a Leaf—the car and its reconfigured battery pack are now wholly assembled in Tennessee. (Just don't trace all of the individual parts.) — **MIKE SPINELLI**

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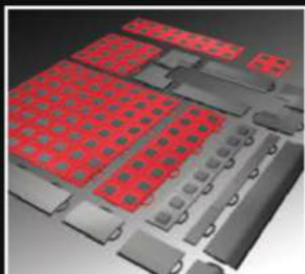
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TEST DRIVES



2014 Star Bolt

If the 2014 Star Bolt looks familiar, it's because this all-new cruiser bears more than a passing resemblance to Harley-Davidson's Sportster Iron 883, which is also within \$9 of the Bolt's starting MSRP. The Bolt, built by Yamaha's cruiser-focused sub-brand, serves up supreme rideability. Its air-cooled 942-cc V-twin hums along nicely with a soulful exhaust bark and reasonably gutsy throttle twist, and the suspension and low-slung saddle are less punishing than one might expect given the minimalist construction and 27.2-inch height. The R-Spec version gets remote-reservoir rear shocks, a suedelike seat material, blacked-out mirrors, and special paint colors—three-hundred bucks well spent. Both versions incorporate a sleek digital speedometer and modern details such as an angular air box and matte black exhaust pipes. Lean, clean, and armed with trick styling details for more contemporary sensibilities, Yamaha's Bolt proves to be a compelling alternative to Harley's Sportster. — **BASEM WASEF**

PRICE: \$7990-\$8290 AVAILABLE:
NOW MPG (CITY/HWY): N/A

SMALL SEDAN
\$6967
PER YEAR*

MEDIUM SEDAN
\$9151
PER YEAR*

LARGE SEDAN
\$11,248
PER YEAR*

COST OF DRIVING
According to the AAA's annual "Your Driving Costs" study, the average yearly cost of owning a sedan increased 1.96 percent in 2013. The study accounts for factors such as maintenance, fuel, and insurance costs.

* Averages based on 15,000 miles of yearly driving

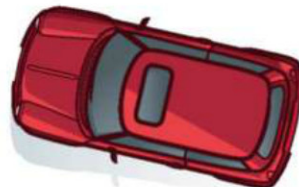


CAR CAMEOS

According to website Internet Movie Cars Database, which has cataloged car appearances in more than 31,593 movies and TV shows, Ford's Crown Victoria has been featured the most. Not surprising, as the Crown Vic was also the dominant cop car for almost a decade. Rounding out the top five are the Ford Mustang, Chevrolet Impala, Ford Econoline, and Volkswagen Golf.

10,000

Number of hybrid vehicles the Obama administration will make available to federal agencies, almost doubling the current hybrid fleet. The General Services Administration says the new vehicles will save 1 million gallons of fuel per year.



BLOODY TIGHT SQUEEZE

Two British brothers broke the Guinness World Record for parallel parking in April by e-brake sliding a Mini Mayfair into a spot with a total space of 5.13 inches to spare—a bit more than 2.5 inches on each end. Challenge accepted, guys, challenge accepted.

PRICE: \$32,500 (ELIGIBLE FOR
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AVAILABLE: NOW
MPGE (CITY/HWY): 122/108

TEST DRIVES



2013 Fiat 500e

What's new: The electrified Fiat 500 swaps gas power for 600 pounds' worth of batteries with 87 miles of range, but it's available only in California.

What's good: Brake feel, which is among the best for an EV. Also, lots of standard equipment and a swanky interior.

What's disappointing: The batteries result in improved front-rear weight distribution, but it still understeers like mad.

What's thoughtful: For longer trips, 12 free-rental-car days per year for three years are included with the purchase, though the convenience just might inspire you to trade in the 500e. — J.T.



AUTO INTEL

PRICE: \$35,900
AVAILABLE: NOW
MPG (CITY/HWY): 19/28



2014 Kia Cadenza

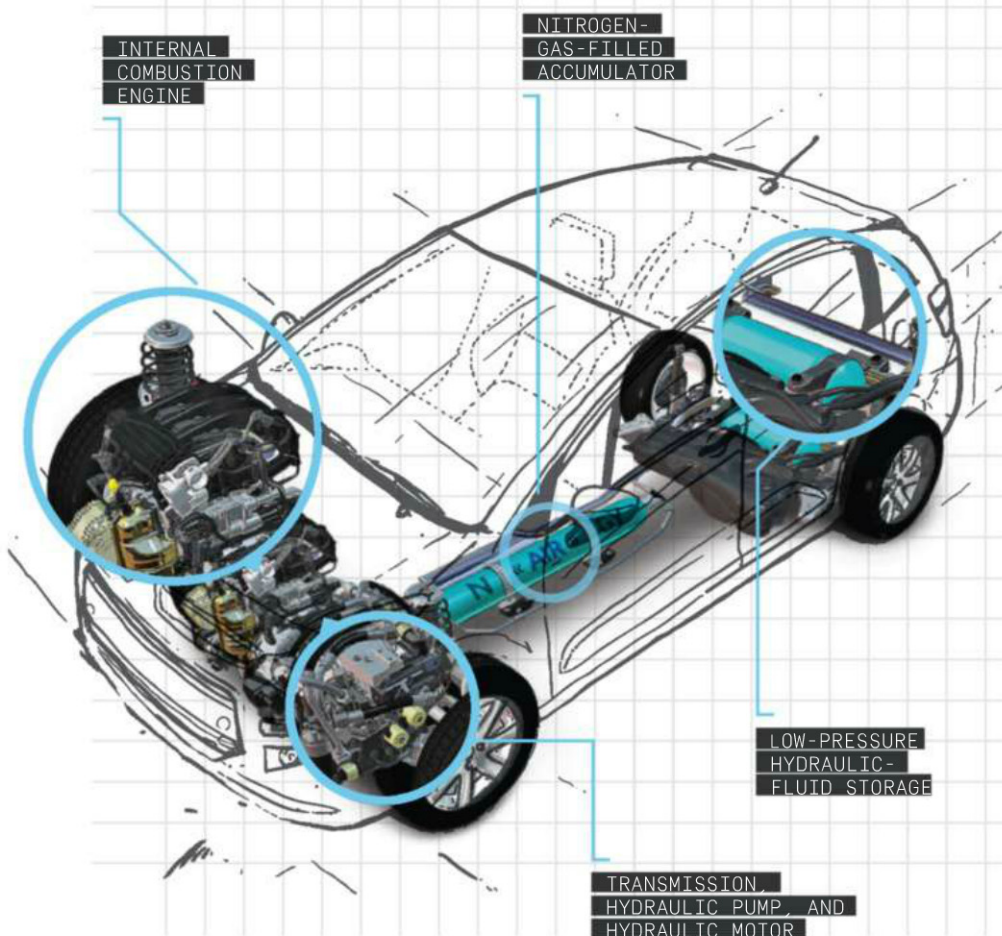
With its supple freeway ride and hushed interior, Kia's new front-drive sedan initially reminded us of the luxury cruisers of yesteryear. But that was before we pushed the Cadenza on mountain roads near California's Napa Valley. The biggest sedan in Kia's history, the Cadenza is agile, with controlled body motions and surprising grip. The 3.3-liter direct-injection V-6 provides adequate thrust—293 hp, 255 lb-ft of torque, burning regular unleaded—and the six-speed automatic is a smooth one, with the bonus of paddle shifting. The powertrain and basic architecture are shared with the Hyundai Azera, but, according to Kia, the extensive use of high-

tensile steel in the Cadenza (60 percent) yields a bit more torsional rigidity. "Luxury" is a nebulous term these days, but Kia's first car in the category is deserving of the designation, at least based on the list of standard equipment. Navigation, a 12-speaker stereo, leather seats, backup camera, and Kia's UVO connected infotainment system are included in the base price, and the UVO service is free for the duration of the 10-year/100,000-mile warranty, which is still one of the best. Factor in roominess, high-quality interior appointments, and the anticipation of top safety ratings and the Cadenza makes a strong case for itself. — TONY SWAN

AUTO UPDATE

AIR-POWERED CAR

Let's be clear: There's no such thing as a truly air-powered car. But PSA Peugeot Citroën has a new take on how to use compressed air to *store* energy that a car can use for propulsion. Showcased in two concepts, a Citroën C3 and a Peugeot 208, the Hybrid Air system powertrain combines air, hydraulics, and gasoline. Peugeot claims its system improves fuel economy by 35 percent and is capable of 81 mpg in the New European Drive Cycle test. A projected price of about \$26,000 means the Hybrid Air would be roughly \$7700 less than what a Toyota Prius costs in Europe. If Peugeot brings out the Air Hybrid in 2016 as promised, it could challenge electrical batteries as a hybrid power reservoir. — ANDREW ENGLISH



HOW IT WORKS

An 82-hp 1.2-liter gasoline engine provides most of the power, driven through an epicyclic automatic transmission (see Glossary). During deceleration, the wheels' energy drives a hydraulic pump that pushes hydraulic fluid into an accumulator and compresses the nitrogen gas within. When the car needs to accelerate, the system works in the opposite way: The pressurized nitrogen gas pushes the hydraulic fluid, which drives a hydraulic motor connected to the transmission.

DRIVING MODES

Gas only: Intended for highway driving

Air only: For speeds below 43 mph, where the engine stops and hydraulics power the wheels 80 percent of the time

Combined: Powered by the gas engine and hydraulic motor

FEASIBILITY

Hydraulic systems are an established technology. The motors and pumps are simple, relatively low-cost, and easy to package—as are epicyclic gears—so the Hybrid Air could be lighter and cheaper than a gas-electric hybrid. And unlike chemical batteries, hydraulics have fewer recycling issues.

ROADBLOCKS

With no big battery to run the air conditioning at standstill, the engine would have to run, using gas; a crash-safe accumulator large enough to hold the requisite amount of pressure (up to 4351 psi) might be heavy enough to negate any benefit. With unproven reliability, hydraulic systems could find it difficult to gain consumer acceptance.

GLOSSARY

EPICYCLIC AUTOMATIC TRANSMISSION

A compact system of planetary gears that makes it simple to divide or combine multiple inputs with a single output. For this reason it's popular in hybrid cars that mix multiple electric motors with a gas engine.

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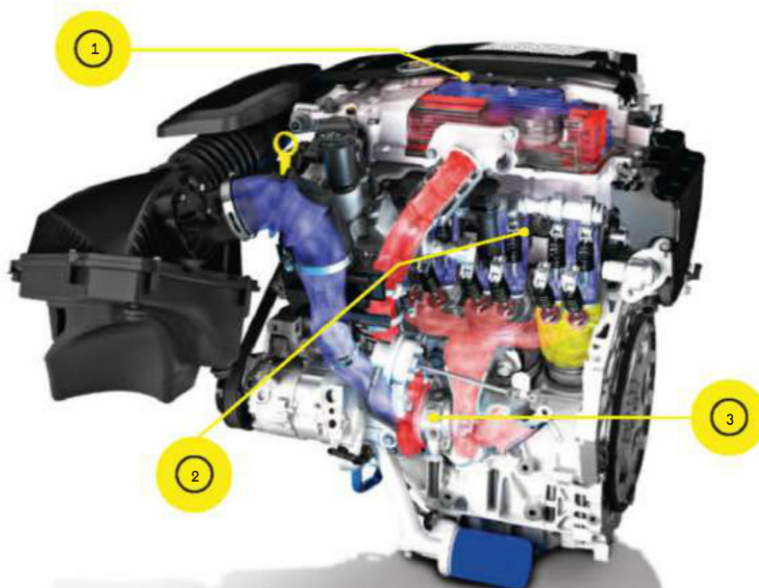


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ENGINE OF THE MONTH

CADILLAC LF3 3.6-LITER TWIN TURBO



GM'S NEWEST SIX IS READY TO TAKE ON HEAVYWEIGHT V-8S.

AUTO INTEL

In boxing, they call it punching above your weight. The new twin-turbo 3.6-liter V-6 in the 2014 Cadillac CTS is 37 pounds lighter than the BMW twin-turbo 4.4-liter V-8 that GM engineers set as a benchmark. And despite two fewer cylinders, the V-6 makes more power (420 hp) than the German motor. The results came through reengineering 90 percent of the parts from the current 3.6-liter, including new designs for the block and heads, and adding a pair of turbos that kick out 12 psi of boost. It also fits under the hood of the XTS in a transverse layout with minimal modification (although output drops to 410 hp). These are three key innovations on the new mill. — **MICHAEL AUSTIN**

1

By mounting the water-to-air intercooler on top of the engine instead of at the front of the car, engineers reduced the air volume between the turbo and intake by 60 percent. This results in cooler intake air, better throttle response, and less turbo lag.

2

The high pressure from the turbo boost allows for a head design with more intake tumble, or turbulence, which helps the fuel and air mix for better combustion.

3

With exhaust gas temperatures as high as 900 C, the turbos get hot. Extra oil passages routed from the block help keep the bearings cool, and heat shields prevent parts such as the starter from wilting.

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GRILL ON.



POPMECH TESTED



PLUG-IN HYBRIDS

TESTED: FOUR CARS THAT CAN RUN ON BATTERY POWER AND CHARGE FROM THE WALL WITH NO ELECTRIC-VEHICLE-RANGE ANXIETY. A PEEK INTO THE PLUG-IN FUTURE. BY MICHAEL AUSTIN



he big fear of drivers of electric vehicles? Getting stranded with a dead battery. But what if you could bring a charger along with you? That's the idea of a plug-in hybrid electric vehicle (PHEV), which offers electric-only power for short daily commutes, backed up by a gasoline engine that provides propulsion for longer distances. It seems like a win-win—the eco-friendliness of an EV with no range restrictions. Depending on your driving habits, you could go weeks or months without filling up at a gas station, and electricity is about one-third the cost per mile of petroleum. Of course, critics note that a lot of that energy for charging a car comes from coal or natural gas electricity, not renewable sources. And when running on gasoline a plug-in can't match the fuel economy of a conventional gas-electric hybrid or even a fuel-efficient economy car. Plus, those extra batteries are expensive—the additional cost takes years to pay off in fuel savings.

Why, then, do carmakers even bother with plug-ins? Government mandates are a big reason. Starting with the 2015 model year, California requires that 3 percent of an automaker's sales in that state come from zero-emissions vehicles. And PHEVs play a big part in raising corporate average fuel economy numbers, so they have a role in nearly every automaker's future product plans. What's certain is that we're going to see more PHEVs on

the market in the coming years. Do they offer the best of both worlds, or are they boondoggles aimed purely at satisfying government regulations?

To find out, we took a car from each of the four brands that currently have plug-ins on the showroom floor: Chevrolet, Ford, Toyota, and Honda, which sells its PHEV Accord only in California and New York. Starting from our Manhattan offices, we drove highways and back roads up to Monticello, N.Y., and tested straight-line performance at the Monticello Motor Club. Then we put each vehicle through a maximum-range city-driving loop with the climate control and radio off. For that last test only the Volt guarantees full-time electric operation; the other three kick in the gasoline engine under situations such as full throttle or high speeds. With careful driving we still kept up with traffic in the other three without the use of the gas engines, so our results reflect electric-only power. Only the Prius was a disappointment; the rest offer a rewarding driving experience and are a compelling preview of a piece of the automotive future.



2013 Ford Fusion Energi SE

RANKING



Base price/as tested:

\$39,495/\$40,585

Federal tax incentive:

\$3751

l x w x h:

191.8 x 72.9 x 58.0 inches

Wheelbase:

112.2 inches

Curb weight:

3957 pounds

Likes: The glowing ring on the charge port that indicates the battery level is a nice addition to the Fusion's futuristic looks. Inside, the reconfigurable instrument cluster shows exactly what's going on with all the components of the powertrain. This is one of the best brake pedals of any hybrid we've driven, with a natural feel and a seamless transition between regenerative mode and the physical brakes. The engine is equally smooth as it shuts on and off as needed to keep the fuel consumption low.

Dislikes: Compared with the 1.6-liter EcoBoost Fusion in our last test, the Energi feels underpowered, and the continuously variable transmission lags in adjusting revs after a dip of the throttle. Batteries eat up half of the trunk, leaving only 8 cubic feet of storage.

AUTO INTEL



HYBRID TEST



2013 Chevrolet Volt

RANKING ★★★★★

Base price/as tested:
\$39,995/\$43,375

Federal tax incentive: \$7500

l x w x h: 177.1 x 70.4 x 56.6 inches

Wheelbase: 105.7 inches

Curb weight: 3761 pounds

Likes: When the batteries have juice the Volt runs completely fuel-free. Even when the gasoline engine kicks in, it usually acts as a generator and revs independent of how you push the gas (at highway speeds the engine helps drive the wheels as well), so the electric-driving sensation is ever present. With the Volt's low center of gravity and sharp reflexes, we found ourselves growing fonder of the Chevy with each passing mile.

Dislikes: An open hatchback body makes for a noisy cabin, and when the engine kicks on at low speeds the exhaust note buzzes annoyingly. Capacitive-touch controls on the center console lack response and tactile feedback. Gas-powered fuel economy is the worst of the group.



2014 Honda Accord Plug-In

RANKING ★★★★★

Base price/as tested:
\$40,570/\$40,570

Federal tax incentive: \$3626

l x w x h: 193.5 x 72.8 x 57.7 inches

Wheelbase: 109.3 inches

Curb weight: 3783 pounds

Likes: With the most responsive powertrain and quickest steering reactions, the Accord feels a lot like the lighter, non-Hybrid version. An upright seating position and excellent visibility add to overall comfort. Seat fabric made of eco-friendly plant-based materials increases the green appeal. And the Accord gives the highest miles-per-charging-hour performance, with short intervals to top off the battery.

Dislikes: The battery pack chops cargo space down to 9 cubic feet. During highway cruising we felt a noticeable bump when the powertrain switched between gas power and electric regeneration. Driving information is spread all over the instrument cluster, making for the most confusing display in the test.



2013 Toyota Prius Plug-In

RANKING ★★★

Base price/as tested:
\$32,795/\$33,098

Federal tax incentive: \$2500

l x w x h: 176.4 x 68.7 x 58.7 inches

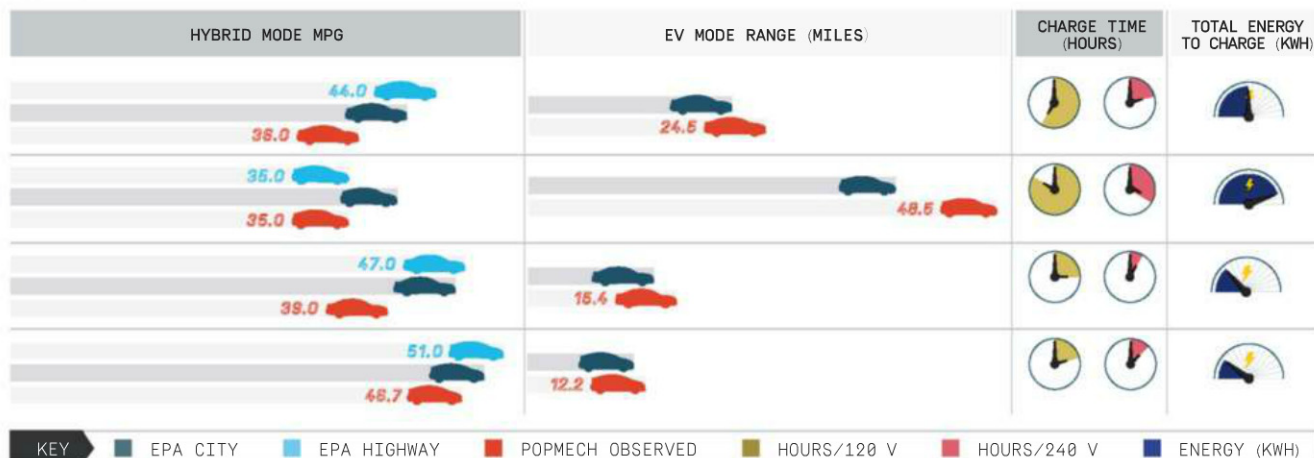
Wheelbase: 106.3 inches

Curb weight: 3186 pounds

Likes: If you're a driver who wants a hybrid to feel different from a normal ride, Toyota has the car for you. From the *Star Trek* shuttle-pod looks to the sweeping dashboard and toggle-lever gear selector, the Prius is distinctive in a most refreshing way. And it kicks back the best fuel economy in gasoline driving.

Dislikes: The Prius is no fun to drive. The steering and brakes are numb, the engine groans, and the car is so sluggish that it feels like it's dragging a boat anchor. This is also the loudest interior, letting in all manner of road and wind commotion. Our biggest issue: Limited EV range means the Prius Plug-In isn't a substantive improvement over the standard Prius, which costs less and has higher mpg ratings.

AUTO INTEL



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THE WELL-EQUIPPED GARAGE

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The garage isn't just a place to park cars. It's a storage shed, a shop, a hangout, an office, and even a place to get the band back together, man. What was once merely a permanent structure to keep your car out of the elements has evolved into the focal point of many homes. Only the kitchen gets more attention, yet the garage offers far more possibilities. Attached or free-standing, with one, two, or three parking spaces, the potential of a big empty space is only limited by your imagination and willingness to spend.

This special section is meant to guide two kinds of people: The first is garage owners who want to organize the mess they have; the second is those working with a blank slate. In either case, we're here to help you figure it all out. Based on the magazine in your hands, we assume your interests lie in the general direction of mechanical toys and greasy fingers. But for even the most casual weekend do-it-yourselfer, this guide will walk you through everything you need to think about and invest in when designing your ideal garage.

THE RULES

In your garage, as in the projects it is sure to spawn, planning is crucial. Remember that the goal is to make tasks easier and more efficient. Here are a few pointers to get you into the right mind-set.

No. 1

Know thyself. A garage is a place where hobbies happen—enable them. Whether you're into cars, woodworking, kayaking, bikes, motorcycles, model planes, or ATVs, make sure to set aside space for the particulars of the hobby. And plan the storage so you don't trip over your hobby every day.



No. 3

Decide how many cars you plan to park. This will have a big impact on how you design the layout. A basic one-car is 12 feet by 24 feet, and most garages add spaces in 12-foot increments. Figure on a minimum 9-by-18-foot reserve per car so you can open doors.



No. 5

Let there be light. In terms of bang for the buck, fluorescent light fixtures are still hard to beat. Three well-placed eight-foot fixtures can provide all the light a one-car garage needs. Pay special attention to workbenches and project areas. Remember, too, that the garage door opens and consider how that will impact the available lumens.



No. 7

Think in three dimensions, not just two. Cars go on the floor, storage and work space go near the walls, but there's also the empty space higher up. Storage volume above the cars, workbenches, entries, and the garage door is usually wasted. Unfinished garages also have space between the studs that you can use.



No. 2

It all begins at ground level with the concrete slab. If renovating, start with a good inspection. A few small cracks or rough spots are okay, but if the surface is deeply pitted, visibly uneven, or has cracks more than a quarter-inch wide, patching or resurfacing is your first task.

No. 4

You can't have too many power outlets. An outlet box every six feet is a good rule of thumb. Garage wiring can range from up to date to archaic, so consider that you might need a total overhaul. Swing by your town's building office to find out which version of the National Electrical Code is in effect (probably the 2008 or 2011). You or your electrician will need a building permit and all work will need to be inspected. Expect a requirement for all garage outlets to be GFCI protected and tamper resistant. The regulations are there for good reason, so read and follow them closely.

No. 6

Remember what your mom said and get that stuff off the floor. Hooks, shelves, racks, and bins are your friends. Prioritize what goes where based on how often you'll use an item, and label or outline everything to help maintain storage discipline. Ready-made modular storage systems can be great, but make sure they suit your purposes, otherwise they'll just eat up floor space.



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HOW TO LAY OUT YOUR GARAGE

Every garage is different, but the bigger the space, the greater the possibilities. Here's a modular approach to laying out and outfitting one-, two-, and three-car bays. Mix and match as you see fit.

Flammables cabinet

As fun as garages can be, they're also rife with danger. It's where you store explosives, poisons, acids, dangerous power tools, and other big-boy paraphernalia. Keep scary items sequestered from kids inside a locking cabinet. And keep that positioned as far as possible from any source of heat or sparks.

Storage rack

You'll never regret buying the biggest, heaviest-duty storage rack that can fit in your space. Whether you're stashing the kids' Big Wheels, holiday decorations, or a spare transmission, a rack makes it convenient. Keep the shelves spaced correctly, and you can even store the mower there. Combine it with labeled see-through plastic bins for maximum organization and storage density.

Material storage rack

Are you a fabricator or welder? Make sure you have a place to keep your material with a simple storage rack to hold a stock of metal or wood at all times. Heavy stuff goes down low, sheets should be vertical, and light items go up high.

Milling machine

If you can convert it to run on single-phase power even pro shops will envy you.

FOLD OUT FOR INFO ON HOW TO SET UP TWO- AND THREE-CAR SPACES.

Retractable drop-down power

You haven't lived until you've experienced the convenience of a retractable extension cord. It will change your life.

Sink

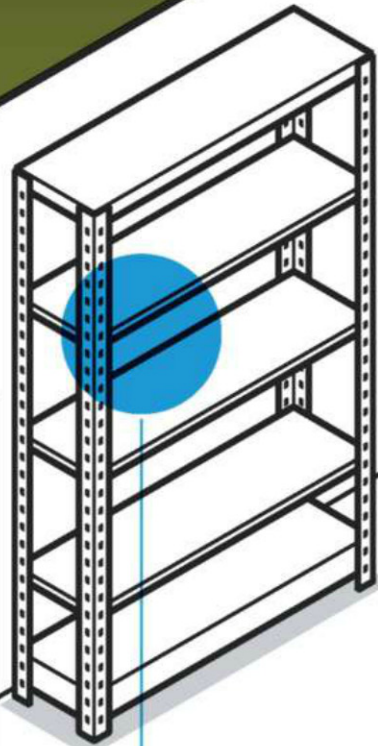
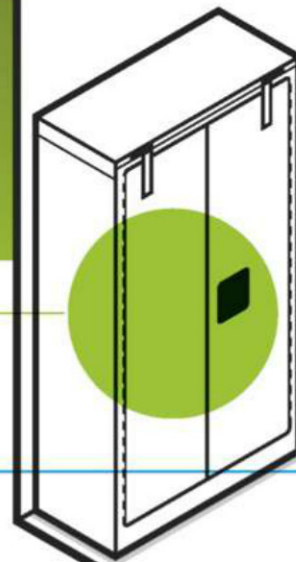
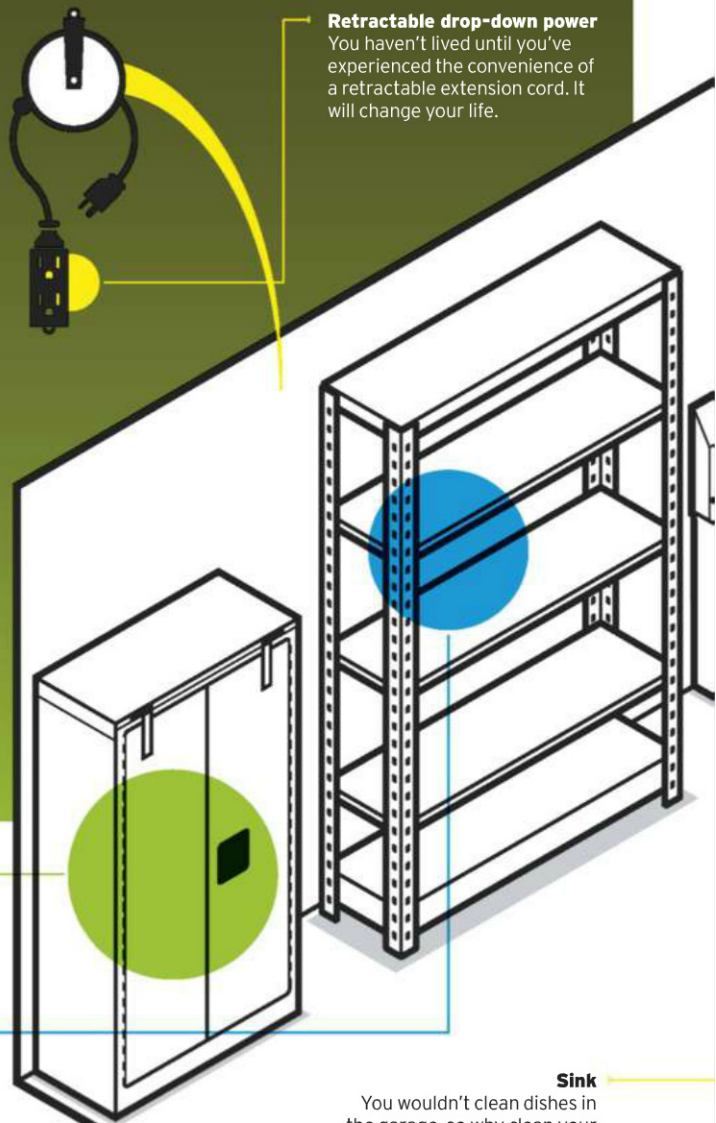
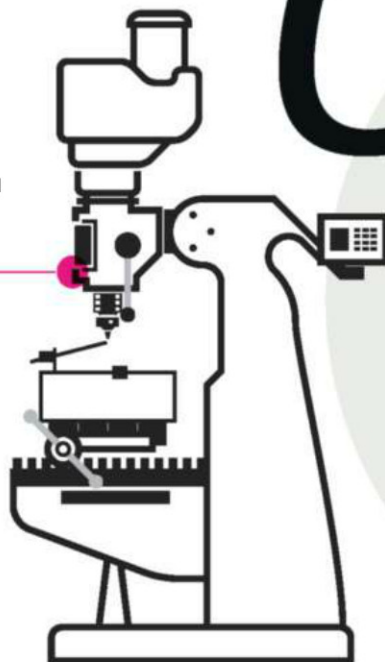
You wouldn't clean dishes in the garage, so why clean your greasy hands in the kitchen? A dedicated garage sink can be abused to no end, keeping messes out of the house.

Sofa

Be sure to locate this far from any open flames or sparks. Your dog will probably spend as much time on it as you and your friends do.

One.

We recommend a focus on efficient vertical and wall storage with a small workbench area for hobbies and projects. You'll have just enough room for basic car maintenance as well.



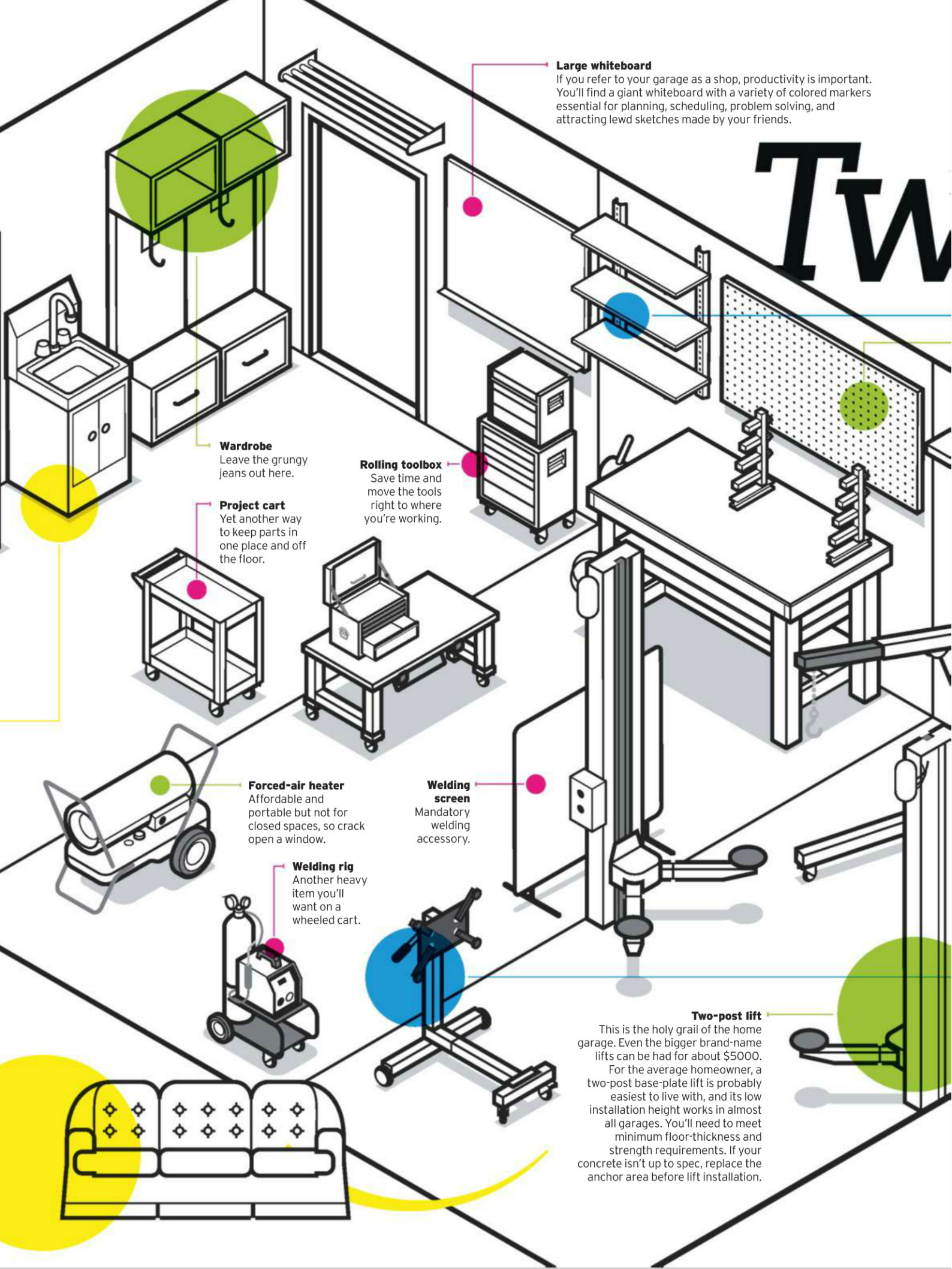


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Large whiteboard

If you refer to your garage as a shop, productivity is important. You'll find a giant whiteboard with a variety of colored markers essential for planning, scheduling, problem solving, and attracting lewd sketches made by your friends.

Wardrobe

Leave the grungy jeans out here.

Project cart

Yet another way to keep parts in one place and off the floor.

Rolling toolbox

Save time and move the tools right to where you're working.

Forced-air heater

Affordable and portable but not for closed spaces, so crack open a window.

Welding rig

Another heavy item you'll want on a wheeled cart.

Welding screen

Mandatory welding accessory.

Two-post lift

This is the holy grail of the home garage. Even the bigger brand-name lifts can be had for about \$5000.

For the average homeowner, a two-post base-plate lift is probably easiest to live with, and its low installation height works in almost all garages. You'll need to meet minimum floor-thickness and strength requirements. If your concrete isn't up to spec, replace the anchor area before lift installation.



Bench-top tools

Installing a long workbench means you have space for bench-mounted tools. Put a grinder, a vise, and a drill press on your must-have list.



Overhead storage

There's a reason people are superstitious about ladders. An easily raised and lowered shelf like the HeavyLift Storage Platform (\$150) makes for a quick and easy solution for where to store a lot of your ugliest junk, and it avoids any potential slip-and-fall mishaps. Consider building a mezzanine over the garage-door tracks for seasonal stuff-stashing.

Two.

You have more space, so the potential (and budget) can expand accordingly. Consider heavy-duty items such as a car lift, cabinetry, and big tools that work for both automotive and general use.

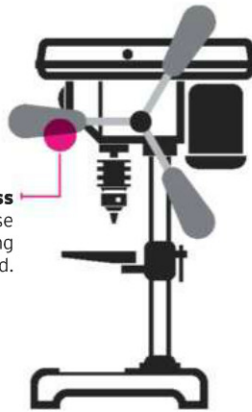
Modular wall-storage system

These come in tons of flavors and while fiber pegboard is the classic option, it tends to buckle under loads exceeding 15 pounds. Galvanized-steel pegboard is a stronger, more expensive upgrade, but we like Flow Wall slatted board for its higher weight limit (100 pounds per square foot) and easy racking and storage accessories. Install the backing board all the way to the ceiling for maximum utility.

Shelves

Shallow shelves give you the freedom to adapt as your needs evolve. Since it might just turn into a service-manual library, start with 12-inch spacing, and don't be afraid to

store items like battery chargers, heat guns, and air tools here.



Drill press

Far more precise and less tiring than a handheld.

Engine hoist and stand

At some point in every gearhead's life, an engine will be removed from a car. A folding engine hoist and an engine stand make plucking and rebuilding much easier. Buy the heaviest-rated equipment, as that generally means better components and build quality. A warning, though: These tools can be a magnet for your friends' projects. You may want to rent.

Band saw

Stick to metal and wood—don't think about starting a butcher shop.

Permanent air lines with retractable reel

Air tools are useful (not to mention impressive), but their flexible hoses are a pain. Go big with a large compressor and install permanent lines along the walls. Take it a step further and run air to a retractable reel in the middle of the room for the same life-changing advantage bestowed by central electrical power.

The challenge here is not what you can do, but how to arrange it logically. Designate sections for every category: storage in one area, woodworking or fabricating in another, and the man cave in its own corner.

Three.



Urinal

For those with the means and the plumbing, a urinal is the ultimate convenience item in the garage. But have a little decency and put up a curtain as well.

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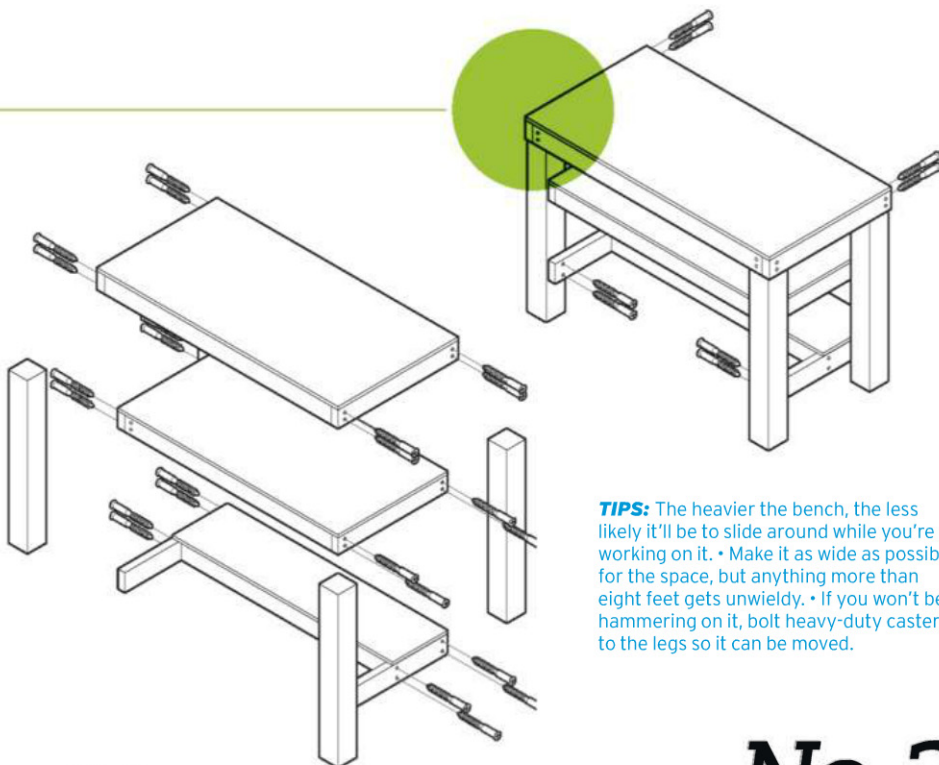
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BUY VS. DIY

Sure, you can pay for this stuff, but these projects are easy to master.

No. 1

The workbench is the foundation of the garage. It serves many roles: storage, anvil, computer stand, junk collector, a spot to tinker, and a place to set your beer. It is an essential part of any good garage. You can easily hit up a home-improvement or hardware store, or even Craigslist, and find ready-to-assemble models starting around \$175. But why not consider building a workbench customized for your needs and your body geometry?

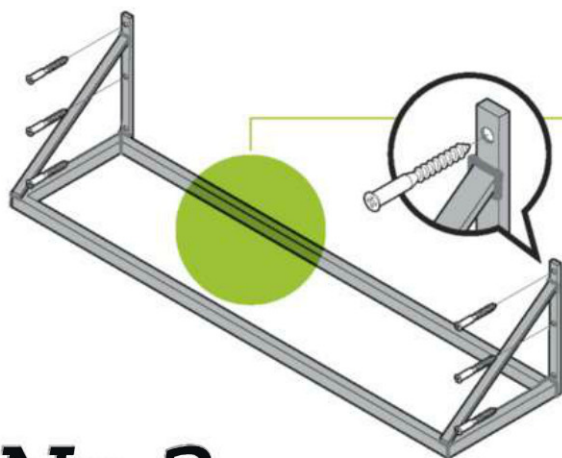


TIPS: The heavier the bench, the less likely it'll be to slide around while you're working on it. • Make it as wide as possible for the space, but anything more than eight feet gets unwieldy. • If you won't be hammering on it, bolt heavy-duty casters to the legs so it can be moved.

No. 2

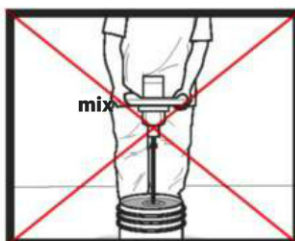
Tire racks are like coat hangers for a car nut. Between the summer set, the winter set, and the weekend-racing set, the garage would be littered with tires without a rack. You can buy one for around \$130, or put your welder to work and make one for about \$40 in materials. If you're not a welder, you can just as easily make one out of wood.

TIPS: Be sure to size the depth for your tires. Spec Miata tires probably won't fit well in a rack designed for 35-inch truck tires. • Use beefy lag bolts drilled into the studs to mount the rack—no deck screws. • Clean the tires before putting them up to avoid mysterious dirt falling from above.



No. 3

Flooring can play a big part in the total budget and affects how work happens in the shop. A fancy laminate floor means DIY oil changes are out. Rugged options like interlocking PVC and industrial flooring cost anywhere from \$2.50 a square foot up to \$6 for the primo stuff. Epoxy-coating the concrete makes the space clean-up-friendly and costs just 20 to 30 cents per square foot if you do it yourself.



TIPS: Sweep, then etch the concrete with muriatic acid, using a hard-bristled brush on an extension handle (your back and knees will thank you). Rinse and allow to thoroughly dry. • Mix the epoxy in small batches and apply as instructed. Don't use a power mixer if you select a clear epoxy—it'll introduce permanent air bubbles. Maintain good ventilation. • Don't paint, or rather epoxy, yourself into a corner.

TIPS FROM THE MASTERS

Our garage gurus share their collective wisdom.

Roy Berendsohn

POPULAR MECHANICS SENIOR HOME EDITOR

- Every shop needs a bench. To gauge the bench height that's correct for you, stand with your arms at your side and raise the palm of one hand so that it is parallel to the floor. The height from your palm to the floor is approximately the right height for the top of a woodworking bench. Benches for mechanical work are at least several inches higher, maybe waist height or a little more.
- Everyone needs at least two vises. One is a standard machinist's vise and the other is a woodworking vise. Both are uniquely well suited to their operations.
- Debris management is key: Don't keep more scrap than is necessary. "I was holding onto every piece of scrap wood, but I never had exactly the right size or shape," recalls *PM* associate editor David Agrell, a cabinetmaker and carpenter. Be decisive, and throw out unusable scrap, such as plywood and pressure-treated wood, but bag hardwood and softwood scraps for firewood. Also, no decent shop is without a stout, professional-grade shop vacuum, push broom, bench broom, and large dustpan.
- Contributing *PM* editor Joe Truini takes full advantage of the sturdy, simple, and versatile nature of bike hooks, which can be used in floor joists or wall studs to hang everything imaginable, from air hoses and extension cords to tool belts.



Don Sherman

CAR AND DRIVER TECHNICAL DIRECTOR

Two decades ago, I built my dream garage as a spacer under my home office. Since then, a dozen car, bike, and tractor restoration projects ranging from a Honda 50 motorcycle to a finned Cadillac convertible have motored through these premises. Here's what I learned:

- Thermostat-controlled heat is essential for a comfortable winter working environment. (My man space is in Michigan.)
- Box the air compressor to muffle its noise. Mount a wind-up hose reel near the door to inflate tires in the driveway.
- A steel I-beam built into the ceiling is ideal for hoisting engines and car bodies.
- If codes permit, install a floor drain to facilitate clean-up. Anchors sunk into the floor are handy for installing suspension springs.
- Welders, blast cabinets, and paint booths deserve dedicated space to avoid contaminating other areas in the garage.



Larry Webster

ROAD & TRACK EDITOR-IN-CHIEF

- Floor space is always at a premium in my shop, especially now that I share the garage with three kids and their collection of Big Wheels, bikes, and scooters. For me, wading through this clutter has the potential to kill the joy of tinkering, so I'm always looking for new ways to organize.
- Overhead space is rarely maximized because it's hardest to access, but that's easy to fix. I built shelves that go along the length of the garage and are about two feet down from the ceiling. Thanks to heavy-duty steel brackets that are secured to the wall studs, these shelves support heavy, rarely accessed items

such as snow tires and my welder.

- Some self discipline is always required to get rid of the things that are rarely used. Everyone has their own preferences, but I use the three-year rule: Anything not touched in that time period gets pitched. Also, nearly all of my workbenches and tool boxes are on wheels so I can move things around according to project requirements.
- No organization system is perfect, so be adaptable. I usually reorganize every year or two to make sure I have a clear "work triangle" between the tools, the workbenches, and the car. The payoff is clear: The fewer hurdles you face before you get working, the more likely you are to enjoy the therapeutic effects of doing it yourself.

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FINISHING TOUCHES

The last few details turn any shop into a haven.

1. Supplementary lighting

Should you make a floor lamp out of a crankshaft? Yes. You can also illuminate your space with recessed ceiling lights, table lamps, and accent lighting if you want to get fancy.

2. Games

There's nothing wrong with entertaining yourself or your friends with pool, Ping-Pong, pinball, darts, a classic arcade box, or a MAME (Multiple Arcade Machine Emulator).

3. Wall art

Good art provides inspiration, not just decoration. Paste giant vintage-racing posters or technical drawings on the walls because that's faster and cooler than paint. Visit allposters.com for easy sourcing.

4. Visual stimulation

You totally need a 60-inch 3-D TV or nine-foot projection screen to watch how-to videos streamed from YouTube. These items are also perfect for epic console-gaming tournaments.

5. Ridiculously overpriced dream tools

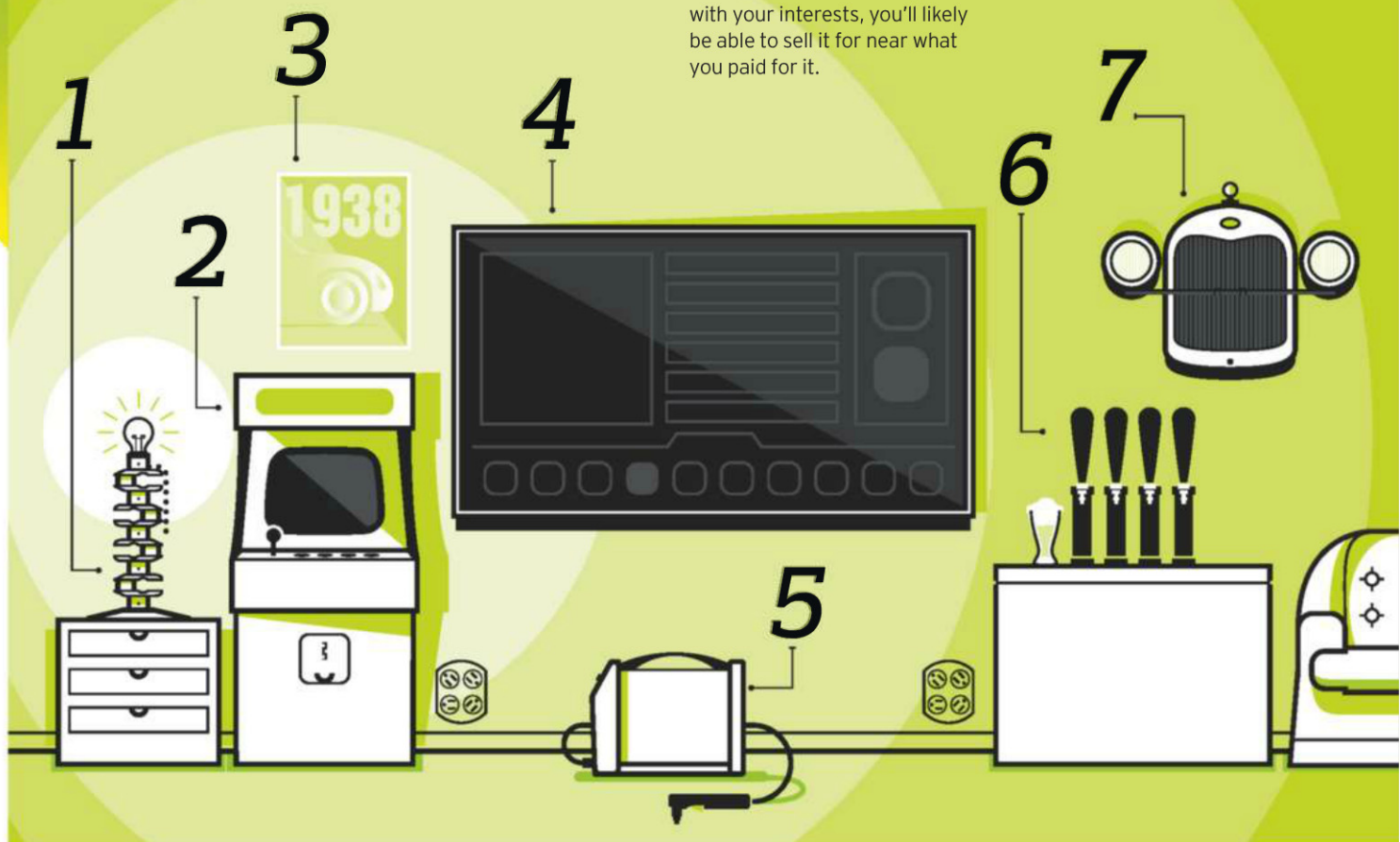
If you're serious about making stuff, go ahead and budget for that plasma cutter, lathe, Bridgeport mill, English wheel, planishing hammer, press brake, or any other goody you're interested in toying with. Even if you buy a big-boy tool and find it doesn't agree with your interests, you'll likely be able to sell it for near what you paid for it.

6. Kegerator

If the garage becomes a man cave, a properly sized kegerator is an absolute necessity. Separate wrenching from imbibing, though, because remembering how things go back together is usually important.

7. Classic automobilia

Dive into the local junkyard and look for neat stuff—hoods, intake manifolds, whatever looks cool to you. Reclaim the castoffs of the automotive age.





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Russian car designers often ripped off other models. The GAZ-21 Volga is jokingly referred to as Russia's Volvo because it shared similar styling with the Swedish carmaker's 122 and 122S sedans.

JAY LENO'S GARAGE • BY JAY LENO

My '66 Volga: It's a GAZ



JAY'S 1966 GAZ-21 VOLGA IS AN UNABASHEDLY COMMUNIST, STATE-BUILT RELIC OF THE FORMER U.S.S.R.

Back in the mid-'50s, the Soviets were building highly advanced MiG-15 and MiG-19 jet fighter planes. They launched their Sputnik satellite months before we launched Explorer I.

And in 1961 they catapulted cosmonaut Yuri Gagarin into orbit. With all this superior technology you'd think Soviet cars would have been equally impressive. Nope. Soviet and, more specifically, Russian cars in the mid-20th century were about as cutting-edge as an anvil.

Communist Russia's totalitarian government fostered a planned, state-run economic system that encouraged heavy industry. Public

right behind it. The Russians may have made boring cars, but at least their factories were efficient.

In those days, if you owned a Volga or you were assigned one because of your job or political status, it was proof you'd made it in Soviet society. Everybody wanted one. After his space trip, Gagarin was rewarded with a brand-new Volga and a VIP visit to the factory. The Volga is exactly what you'd think a car manufactured in a Communist country of the 1960s would be like: It's overbuilt, it's slow, and it's as utilitarian as a screwdriver. But that's what makes it fascinating compared with American cars of the period. Planned obsolescence drove the U.S. auto industry. American cars had plenty of style and performance, and they were updated nearly every year. GAZ didn't have to make big model changes year to year—there wasn't any real competition—so the

transport was the priority, not privately owned cars. As a mid-level party bureaucrat, engineer, or physician, even if you could afford a car, your options were limited to ordering a plain-Jane, industrial-strength, Russian-built four-cylinder Moskvitch, Pobeda, Lada, or Volga. Even worse, because new cars were in such limited supply, you had to get your name on the official list and then wait a long time before your order became available.

About a year and a half ago, I acquired a 1966 GAZ-21 Volga, a Russian sedan from the Communist era. (GAZ roughly translates as Gorky Automobile Factory, which is located in Nizhny Novgorod, about 250 miles northeast of Moscow.) My Volga is a Series 3 GAZ-21. GAZ built more than 635,000 of them from 1956 to 1970. The last one rolled down the assembly line in July 1970, with the model GAZ-22

cars stayed relatively the same.

Forget Falcons, Continentals, and Eldorados—GAZ named the Volga for Russia's longest river (now that's evocative!), which flows right by the factory. The Volga is known as the Russian Volvo because it looks like GAZ engineers basically copied the Volvo 122 and 122S (known as the Amazon in Scandinavia), which were sold from 1956 to 1970. But the Russians made everything just a little thicker and a little sturdier than Volvo and most other automakers. The Volga isn't particularly well-made, but it's very strong, like bull.

The engine is a 2.45-liter 75-hp overhead-valve I-4—hardly a powerhouse. In tests conducted by a British car magazine, a Volga delivered nearly 23 miles per imperial gallon (roughly 27 mpg U.S.). That's pretty good for back then, and certainly helpful for those 1000-mile jaunts across the endless Russian steppes.

The Volga has some unusual standard features. Under the hood, there's a metal shield in front of the radiator that blocks airflow because it's so cold in Russia the engine is never going to overheat. There's also a massive electric plug for an engine block heater on those frigid Siberian nights. (A block heater is like a heating coil in the crankcase—really an electric dipstick to keep the oil from congealing.) I haven't tried the in-car heater, but I'm sure it's like a furnace. I'll never need *that* in L.A. My Volga has a three-speed manual with a column shift, which is odd because most imports of that era already had a more efficient four-speed. And because Russian cars had to deal with rough or snow-covered roads, they sit a little high.

The badge on the Volga's hood has a stylized design with a leaping deer that looks like the Chevy Impala's. That makes me laugh. Trust me, the Volga is no Impala. Once you get moving, it's slow, the steering is heavy, the transmission whines, and don't even think about cornering fast. There was also an optional leaping-deer hood ornament, but people stole them, so GAZ discontinued that feature. The interior has a speedometer housing that rises above the dash and is backlit by sunlight, like on the '59 Corvette. That's really the only nod to flashier styling details that were found on American cars at the time.

Any shade-tree mechanic could easily keep a Volga running. It's very simple mechanically, like a tractor. I mean, here's the cooling system, here's the water pump, here's the distributor. Other than having some oddball 8-mm spark plugs, it's pretty conventional. We don't need a manual to work on it. Of course, because these cars were never sold in the U.S., there's no owner's club or parts sources over here. You'd have to make any component you couldn't rebuild or get the fax number for an auto supply store in Moscow. Good luck with that!



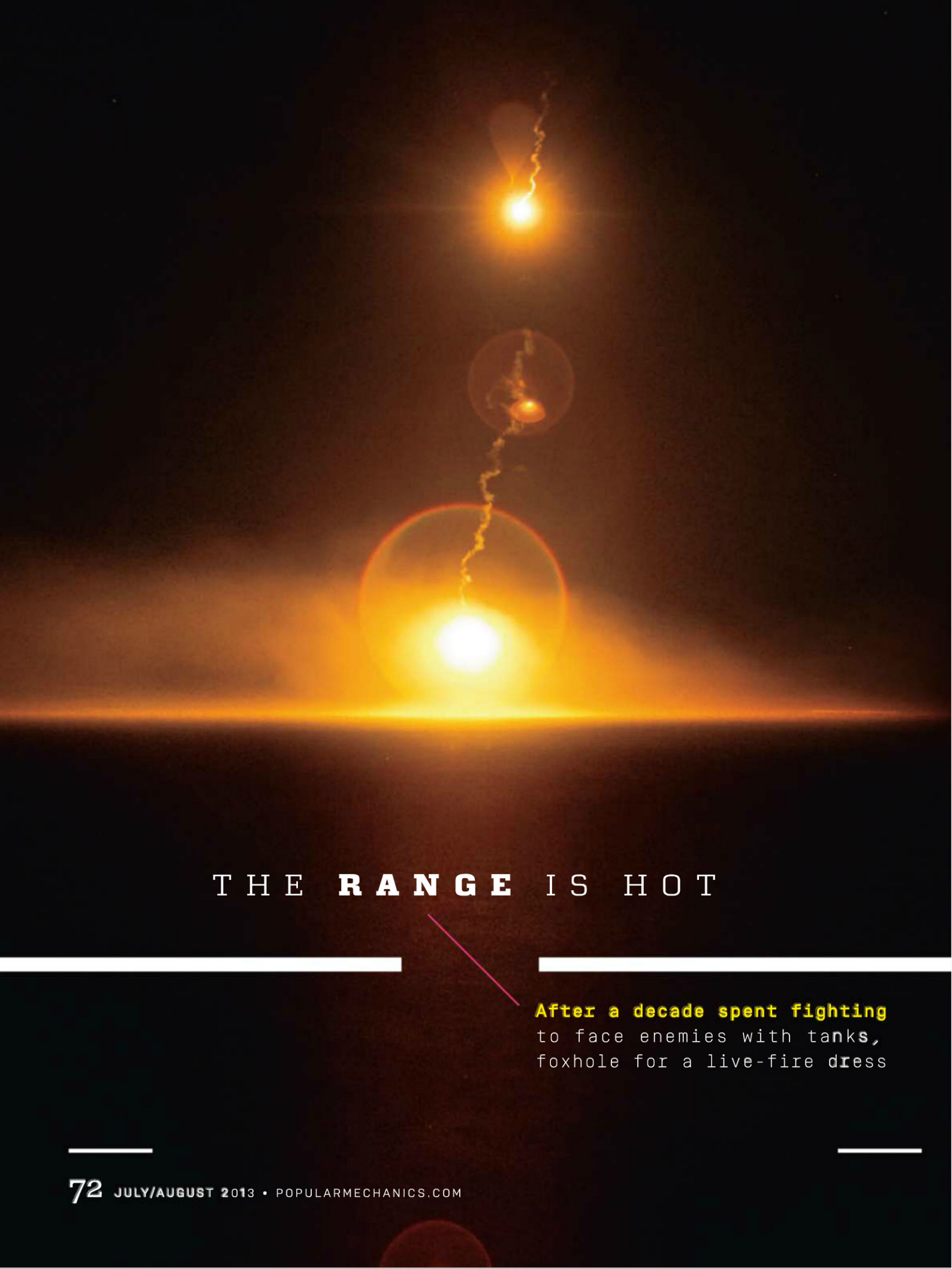
Clockwise from top: As with the rest of the GAZ-21, the powerplant is mechanically straightforward and easy to repair. The Cyrillic script on the radio reveals the car's Russian roots. A transparent speedometer similar to a '59 Corvette's is the GAZ-21's flashiest feature.



Volgas had a sinister side too. The KGB (the dreaded Soviet secret police) used Volgas, and their squad cars were usually painted black. Russians called them Black Ravens, and they really scared a lot of people. You never wanted to see *this* car pull up in front of your house, with guys in military trench coats packing Makarov PMs.

The GAZ factory built a V-8-powered Volga called the M-23 for the KGB's high-speed pursuits, but the handling was reportedly so scary that even the secret police wouldn't drive them. Eventually GAZ stopped making them. I'd love to find one of those.

The Volga is still widely recognized in Russia, but when I take mine around L.A., no one knows what it is or cares. The novelty of being a vintage Russian car is about all the Volga has going for it. Still, I like it for what it is, and cruising in the Volga puts me into an entirely different frame of mind. Driving down the road, I find myself yelling, *Perestrooiikkaa!* But I have to remember that if I wander into a Russian community, a few older people might still get a chill down their spines. **PopMech**



THE RANGE IS HOT

After a decade spent fighting
to face enemies with tanks,
foxhole for a live-fire dress



low-tech insurgents, the Marine Corps is again preparing missiles, and other modern weapons. PM climbs into the rehearsal of the next possible war.

BY JOE PAPPALARDO PHOTOGRAPHS BY CHAD HUNT

The shell from an M777 lightweight howitzer leaps out of the barrel at half a mile per second and doesn't slow much during flight. The 3-foot-long round, aimed at a piece of desert earth labeled Gays Pass-13 (GP-13), won't give up its kinetic energy without a fight. It gouges the rocky ground of the Mojave Desert before exploding in a spout of brown dust and black smoke.

Artillery impacts are commonplace here at Marine Corps Air Ground Combat Center at 29 Palms, Calif. The guns of 3rd Battalion, 3rd Marine Regiment (3/3), have been hammering their target at the sloping base of a ridge for more than 20 minutes, making GP-13 a very unpleasant place, shredded with metal fragments and pitted with craters. It's only going to get worse.

The bombardment of this patch of the Mojave Desert marks the start of a three-day live-fire drill, the last stage of the month-long Integrated Training Exercise (ITX). GP-13 is just one of many defensive positions the Marines need to shatter with artillery and airstrikes before the M1A1 Abrams tanks and eight-wheeled Light Armored Vehicle-25s (LAVs) can push their simulated enemy out of Gays Pass.

The U.S. Marines were founded on the ethos of expeditionary warfare, the ability to fight in enemy territory without established bases. The Second Continental Congress founded the service in 1775, not just to protect ships but to deploy from the sea to fight on land. (Hence its name.) The concept proved itself in modern combat during World War II, especially during the Corps' island-hopping campaign in the Pacific.

But the wars in Afghanistan and Iraq, grinding counterinsurgency campaigns, didn't fit this tactical model. Those conflicts were fought against shadowy enemies wielding rifles, rocket-propelled grenades, and roadside bombs. Since 29 Palms is the place where Marines prepare for deployment, training here was based on the capabilities of insurgents the Corps would face.

The need to prepare for this type of combat came at the cost of preparation for expeditionary conflicts against better armed opponents. Jim Dunnigan, author and Pentagon consultant, says U.S. forces have lost their skill at operating while "getting shot at a lot, often with big stuff." Now the Marines must relearn how to survive

The Mojave Desert erupts in simulated warfare at the Marine Corps Air Ground Combat Center at 29 Palms, Calif., where Marine battalions can conduct simultaneous live-fire training with tanks, artillery, warplanes, and infantry. From left: The mushroom cloud of a 2000-pound bomb dropped by an F/A-18 fighter jet; M1A1 Abrams tanks ready for an advance at sunrise; Maj. Andrew Fanning, an instructor at 29 Palms, follows the action around him by marking a map and keeping in constant radio contact with his fellow combat-center personnel.



enemy tanks, howitzers, and anti-aircraft missiles. "Infantry now have lots of experience, but the artillery and air-support forces have to adapt to more hostile environments," Dunnigan says. "Senior commanders and planners have to practice procedures specific to high-intensity combat."

At GP-13, stacks of tires, shipping containers, and dirt-filled barriers stand in for enemy bunkers, T-72 battle tanks, and armored vehicles called BMPs. These are the weapons used by the standing armies of rogue regimes and geopolitical peers, not insurgents. This is only the second time ITX has been run—the combined-arms exercise changed names when it swapped prospective enemies. It's no coincidence that the 800 Marines of the 3/3 are preparing to deploy to the Pacific, where tensions are rising between the U.S. and the well-equipped militaries of North Korea and China.

The concept of expeditionary warfare is evolving as new gear—particularly aircraft—enter the Corps' inventory, but any changes are built on a foundation of classic Marine doctrine. "The key is to synchronize firepower with maneuver," says Maj. Andrew Fanning, watching GP-13 from atop a slender ridge nicknamed the Gator, 2.5 miles away.

The instructors here at 29 Palms are called Coyotes;



Fanning is the Coyote in command of those assessing the 3/3's ground assault.

An F/A-18 jet is inbound to GP-13, carrying a 1000-pound bomb that can turn a formidable T-72 into a smoldering ruin. But the warplane does not have a targeting pod—optical sensors that enable pilots to see the ground below from high altitudes, day or night—and the nearby fire-support team chose not to bring a laser designator that could guide the bomb. The Coyotes will certainly bring up this oversight during their after-action review. Close air support (CAS) is only as good as the pilot's aim.

The 3/3's solution is as old as World War I: A howitzer crew loads a flare into the M777 and sets the fuse to go off when the flare is on the ground. The flare skitters into GP-13 and ignites; the resulting bright light and tendril of smoke are a clear sign for the F/A-18. The warplane drops the weapon 5 nautical miles away from the target—the bomb is already streaking through the air when the ground forces glimpse the jet, looking pale and almost ghostly as it cruises overhead.

A fiery flash and curling bloom of black smoke herald the bomb's detonation, 11 seconds before the blast reaches the ears of observers on the Gator. "That's some old-school CAS

right there," Fanning says with gruff approval.

A sniper-scout team on a nearby ridge radios confirmation that the T-72 has been eliminated; the rumble of engines and squeals of tank treads soon fill the air as the M1A1s move forward, getting GP-13 in range of their main guns. The objective will soon fall to Marines carried to the fight by the LAVs—there are bunkers there that Fanning says "can only be taken by bayonet"—and the conquest of the pass will continue.

THE MARINES LIGHTEN UP

In some respects, the United States military is now the most combat-proven in the world. "Every Marine is supposed to be a rifleman, and the tough fights in Iraq and Afghanistan fit that model," says Michael O'Hanlon, director of foreign policy research at the Brookings Institution in Washington, D.C. "But combined-arms warfare does need reinvigoration. It's not a crisis, it's just the right thing to emphasize next."

Armored vehicles are perfect examples of how the past decade of combat changed the way Marines fight. The counterinsurgency campaigns in Iraq and Afghanistan were ill-suited to the bedrock tenets of what the Corps calls expeditionary maneuver warfare. That concept is built on rapid mobility, attacks from unexpected locations, and flexible battle planning.

Instead, Marines in Iraq and Afghanistan found themselves relying on fixed bases and conducting predictable patrols to show locals they were present. This enabled insurgents to plant cheap, effective roadside bombs that could demolish lightweight U.S. Humvees. The Pentagon spent \$45 billion to rush life-saving mine-resistant, ambush-protected (MRAP) vehicles to Army soldiers and Marines.

Now that the Afghan war is limping to a conclusion, MRAPs have outgrown their usefulness. The extra girth that made them so useful is now a liability. The Marines can't take them along during an invasion because the vehicles can't fit on the Corps' amphibious transports or rotorcraft.

So the Marines are jettisoning MRAPs, and that means changing the way 29 Palms does business. The exercise-support motor pool at 29 Palms has 185 MRAP variants, but Marine Corps headquarters ordered the number reduced to just 24, according to Lt. Col. Tim Silkowski, the officer in charge of the base's exercise-support division. "We were getting heavier and heavier vehicles, and that was bringing the Corps further from our roots," Silkowski says. "Now we have to start lightening up and get away from this land-locked mindset."

Officials in Washington, stung by the cost of extended campaigns in Iraq and Afghanistan, are likely to rely on the Marines' style of warfare in future conflicts. Retired Navy Adm. Gary

NEXT-GEN SHIP-TO-SHORE TACTICS

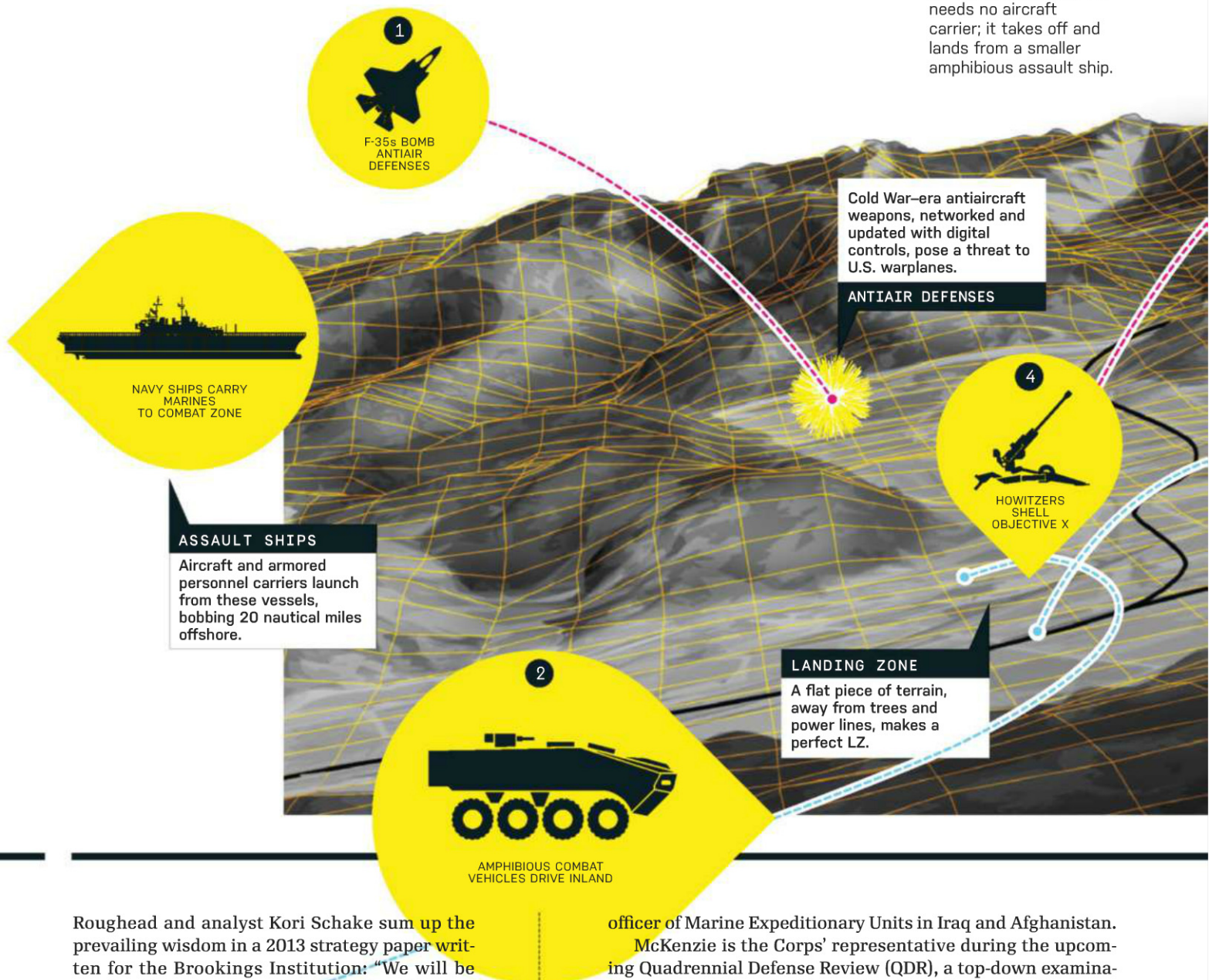
Amphibious invasions won't need beachheads to serve as staging areas—aircraft and weapons will enable Marines to strike deep inland directly from nearby bases or ships. In this scenario, the Corps follows its founding doctrine of expeditionary warfare, but uses modern gear to leapfrog the beach to take Objective X.

ILLUSTRATION BY ANTHONY VERDUCCI

1

Clear the Air

An F-35B Lightning II aircraft targets defensive command centers and mobile, radar-guided antiaircraft guns. This enables other aircraft to operate safely over the area during the coming attack. The jump jet needs no aircraft carrier; it takes off and lands from a smaller amphibious assault ship.



Roughead and analyst Kori Schake sum up the prevailing wisdom in a 2013 strategy paper written for the Brookings Institution: "We will be sending fewer forces to theaters of conflict, but we will expect those we do send to arrive faster."

The Marines are expected to be the first on the scene of any disaster or fight. During a wider campaign, the Marines will "buy time for the larger joint force" to arrive, says Maj. Gen. Kenneth McKenzie Jr., a former commanding

officer of Marine Expeditionary Units in Iraq and Afghanistan.

McKenzie is the Corps' representative during the upcoming Quadrennial Defense Review (QDR), a top-down examination of strategic priorities and budget choices. Budget cuts have already led to an upcoming reduction in active-duty Marines from 202,100 to 182,100 by 2016.

The Marines are figuring out how they can prepare to do everything the White House is asking of them—to face standing armies, expand their presence in Asia, and maintain forward-deployed forces that can serve as first responders.

2

Secure the Landing Zone

Amphibious vehicles deploy from the assault ship, land, and travel off-road to preserve the element of surprise. Infantry dismount from the vehicles and secure a landing zone with a defensive perimeter. The Corps' highest current priority is a new landing craft that can travel faster and farther over water.

3

Land the Artillery

MV-22 Ospreys, hauling M777 lightweight howitzers, arrive at the landing zone. The Marines set up the guns in minutes. The M777, more than 40 percent lighter than the gun it replaced in 2005, is one of the first pieces of Marine equipment that reembraced the Corps' lapsed expeditionary model.

4

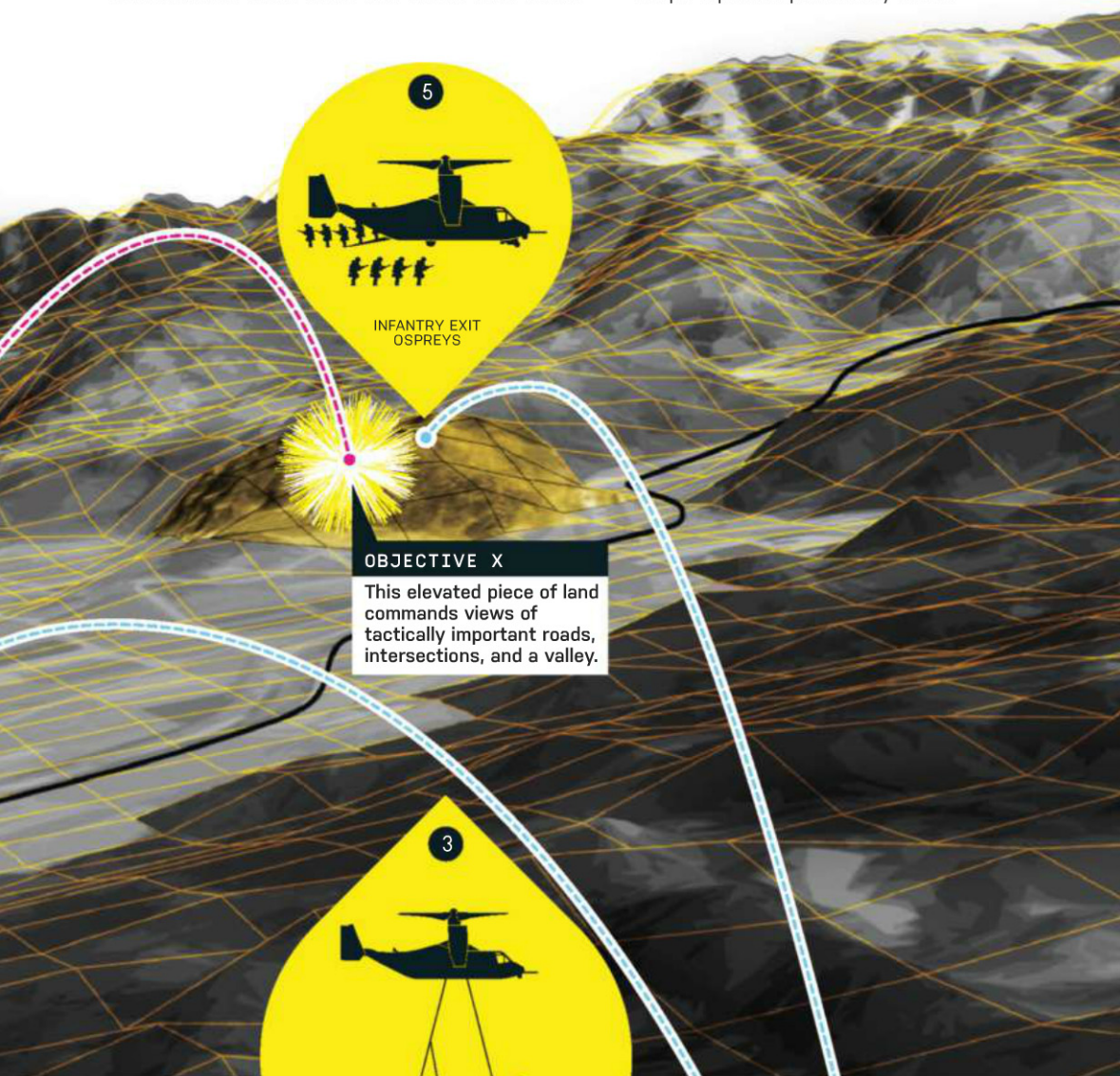
Suppress the Enemy

The howitzers bombard Objective X, forcing the defenders to take cover inside bunkers and underground shelters. The shelling is done to protect an approaching air assault from small arms and shoulder-fired missiles.

5

Assault the Objective

Another group of Ospreys, laden with dozens of Marines, flies toward Objective X. The M777s stop firing as the tiltrotors set down outside the target, disgorging infantry who secure the buildings and bunkers.



OBJECTIVE X

This elevated piece of land commands views of tactically important roads, intersections, and a valley.

OSPREYS HAUL
SLING-LOADED ARTILLERY

"You can use the QDR to go back to the president and say, We're not resourced to execute the vision that you have," McKenzie says. "Or say, We can do it, but it's going to be at a higher level of risk."

THE END OF BEACHHEADS

New weapons are giving expeditionary doctrine a fresh edge that the Marines say will defeat enemies who are better equipped than insurgents. In World War II and Korea, Marines secured beaches and used them to stage pushes to

inland objectives. Modern ship-to-shore invasions will attack those objectives directly. "We don't see fighting for beachheads anymore. There are a variety of ways to avoid that fight," McKenzie says. "We'll enter where the enemy isn't, or suppress parts of his defenses and reach deep inland."

A soon-to-debut game changer is the F-35B Lightning II, a multipurpose jet developed as one of three Joint Strike Fighter variants. The

GEAR OF THE FUTURE MARINE

1. Cargo Drones

Unmanned helicopters proved themselves by supplying Marines in Afghanistan since 2011. This March the Corps extended their tours of duty indefinitely. By that time the Lockheed Martin aircraft, called K-Max, had hauled 3 million pounds of cargo. More resupply and attack drones are expected in the future.

2. Robotic Pack Mules

The Legged Squad Support System (LS3) is a robot mule designed to navigate rugged terrain with 400 pounds on its back. To scope the best route, the robot uses a suite of sensors, including laser radar. Later this year the Marines will test the LS3 prototype's performance at Marine desert and mountain bases.

3. Laser Defenses

The Marines are researching a defensive laser that can be installed on a 4WD vehicle. "We're looking at a counter-unmanned-aerial-system capability right now, but in the future we'll look at rockets, mortars, and

artillery," says Maj. Gen. Robert Walsh, deputy commanding general of the Marine Corps combat development command. "We've left a gap [in these defenses] over the past 11 years. But we have to be able to counter them."

4. Portable Power

The Office of Naval Research is creating a hybrid solar, thermal, diesel, and JP-8 fuel system that can replace large, loud trailers that provide electricity to

Marines in the field. The project's managers hope the system will consume 40 percent less fuel than current systems, operate much more quietly, and run on biofuels.

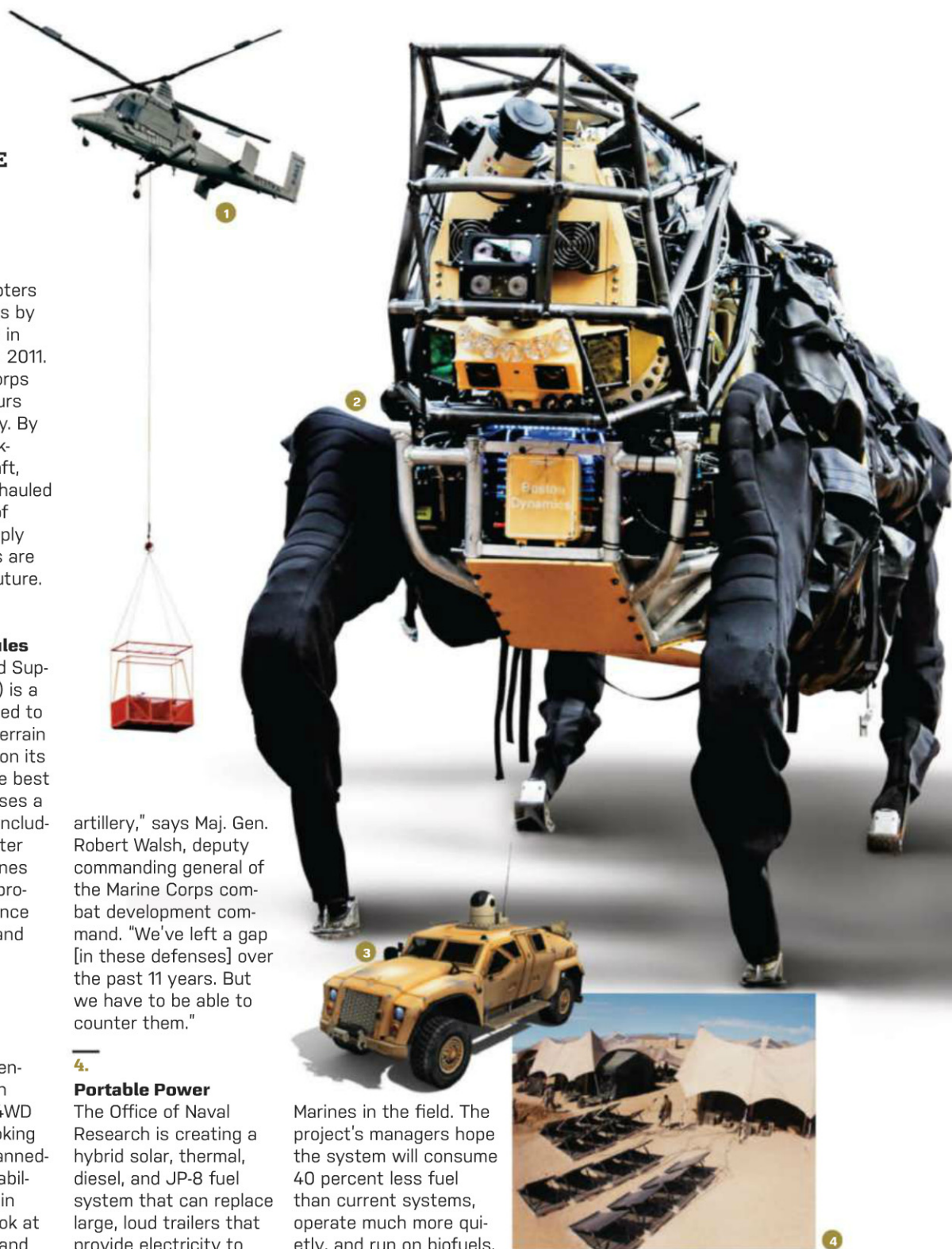
Marines started testing the first-delivered aircraft late last year. When it's ready for deployment, sometime in 2017, the F-35B will provide air cover like an F/A-18, but without the need for well-developed airfields or carrier decks.

"It will be hard to hold long runways from somebody who's going to be able to get at you with a high number of relatively cheap missiles," McKenzie says.

The Taliban harass air bases in Afghanistan

with suicide vehicles and mortars, but more advanced enemies can target them from thousands of miles away. Because the F-35B can take off and land vertically, it can transform tight patches of land into clandestine airfields, and troop ships into aircraft carriers.

One key piece of equipment in service now that will enable Marines to bypass beaches is the MV-22 Osprey. The tiltrotor can take off and land like a helicopter, then rotate its rotors to fly like an airplane. Despite a lethal development and high maintenance costs, the Osprey can carry cargo farther and



faster than any helicopter ("Fixing the World's Most Complicated Plane," June 2012).

The MV-22 can ferry Marine infantry, aviation fuel, or vehicles to landing zones deep inland. At ITX, Ospreys ferried a company of Marines to assault positions in the far northwest of Gays Pass, demonstrating the aircraft's reach.

The first day's advance of the final exercise of ITX is coming to a halt. The Marines have pushed northwest as far as they can go and now must defend against a day and two nights of counterattacks. A half-dozen entrenched M1A1s and three companies of Marines in freshly dug foxholes face the enemy. Marine utility vehicles roll forward to create defensive berms.

The battle is simulated, but the dangers of high-fidelity training are real and can come from unexpected sources. The first day ends in tragedy when a bulldozer crushes 20-year-old Pfc. Casey Holmes to death as he guards the line. ITX halts as the Naval Criminal Investigative Service begins its preliminary investigation. The desert is silent for hours before the mock battle resumes.

THE FINAL PUSH

By the morning of ITX's third and final day, the Marines of the 3/3 are haggard. They've been in the desert for more than two weeks, sleeping dirty in vehicles, on folding cots, or in rocky pits. Enemy attacks disrupted the night, causing a response of machine-gun tracers, frantic radio chatter, drifting flares, and shell bursts.

At sunrise, the tank crews and two companies of 3/3 Marine infantry are loading into LAVs to finally push the enemy out of Gays Pass. The ground attack's objectives—GP-3, GP-2, and GP-9—are just 4 miles away. Black smears from artillery and airstrikes darken the horizon.

Capt. Pat O'Shea, one of the Coyotes embedded with the tanks, is waiting in a Humvee for the advance to resume. Marines prize efficiency because they are never sure of resupply. But in recent years that ethos has eroded, and most Marines are aware of it. "I'm a veteran of Afghanistan," O'Shea says wryly. "Just keep it running—we'll never run out of gas."

Radio reports about GP-9 trickle in: BMPs destroyed, defending infantry in disarray, only one surviving T-72 tank. Right now, when the enemy struggles to react to the bombardment, is the best time for the ground advance to begin. Over the radio the company commanders plead to take the position, despite the presence of the remaining T-72 tanks. But the 3/3's battalion commander, Lt. Col. Thomas Wood, decides to crush resistance at GP-9 before

Visiting Marines and 29 Palms instructors (in orange vests) shelter behind a landing vehicle as an explosive charge removes a defensive berm from the path of their assault.



moving. The assault force stewes for an hour as air and artillery strikes ensue. The initiative has been sapped before the enemy even shoots.

The M1A1s finally receive orders to take the position but receive fire from enemy antitank units as soon as they move. With all the firepower focused on GP-9, the imaginary defenders in another position climb out of shelters and ready antitank rockets. The Marine attackers will be pinned down until those rockets are destroyed or disrupted by artillery. "They moved without suppression," O'Shea says. "There's an old saying: Shooting without maneuver is a waste of ammo. Maneuver without shooting is suicide."

A fresh bombardment of the antitank forces ceases, and the battalion commander is finally ready to unleash his Marines on GP-9. Tanks and LAVs advance, with O'Shea's Humvee trailing close behind.

Half of the armored vehicles halt and rip into the objective with 25 mm machine guns while the others approach from another direction. The gunfire stops as the forward LAVs come to a halt; the rear ramp opens and infantry dash forward. All the technology and artistry of modern combat comes down to this—armed men running through the heat, boots kicking up dust. **PopMech**

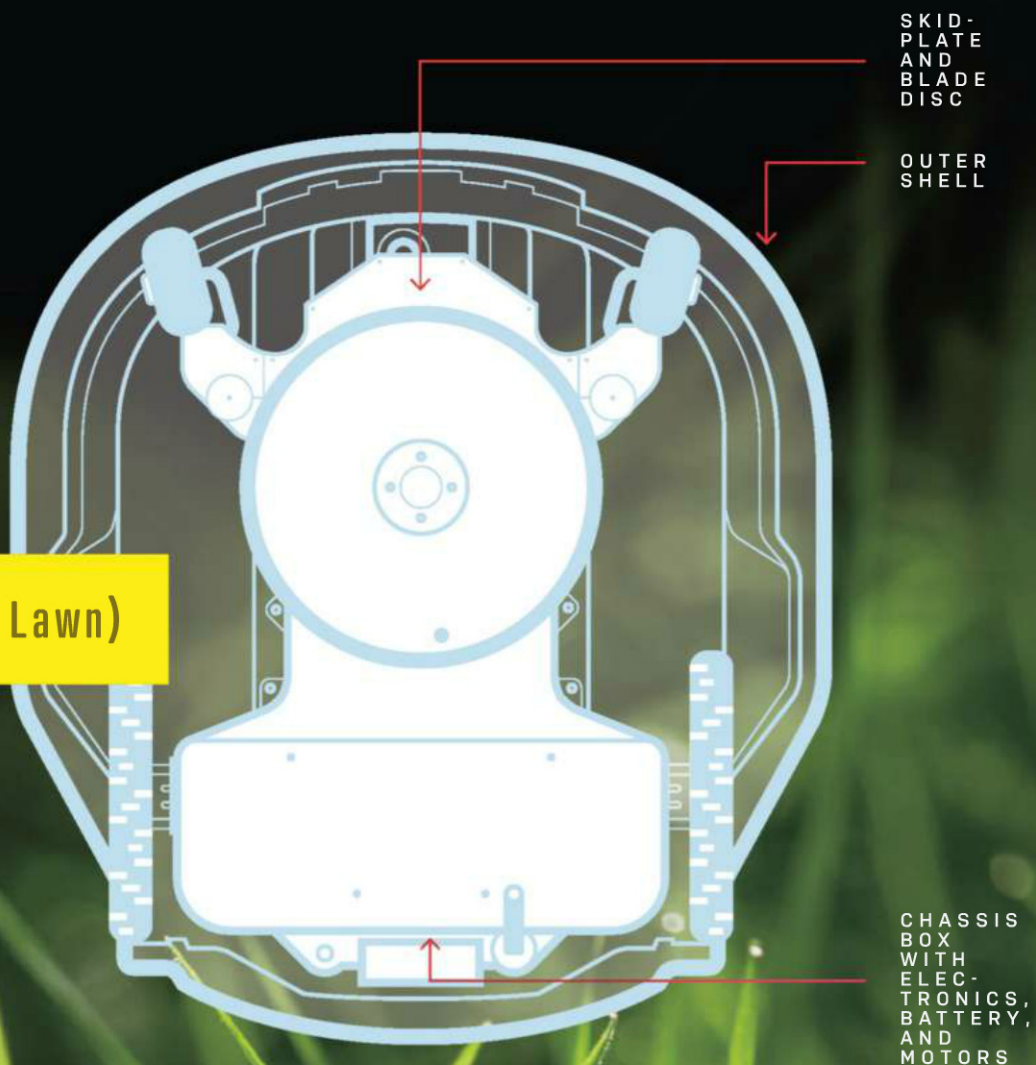
A HIGH-TECH
APPROACH TO
WEEKEND CHORES

The Robots Are Coming . . .

by
Glenn
Derene

- One suburban homeowner's quest to automate his lawn into submission.

(to Mow My Lawn)



For some people,

mowing the lawn is a meditative experience—a chance to tune out while getting a little exercise walking behind the lawnmower, inhaling the scent of freshly cut grass. It's good old-fashioned domestic man's work, like your father did before you, his father before him, and so on. Well, not me. I hate mowing the lawn. It's a numbingly repetitive, sweaty, noisy waste of time. My

father hated it too. And I'm pretty sure his dad did before him.

Tell you what I do like, though: robots—love 'em! In fact, I would gleefully surrender every thankless bit of home landscaping to an automaton. So I decided to see if I could piece together a system wherein my lawn essentially would take care of itself. Yes, I could have hired a landscaping crew, but to me that was a dodge. I didn't want to pass off my dirty work to someone else. That's the beauty of robots—one day they may take over the world, but for now, they get the grunt work.

And, it's worth mentioning, I wanted a beautiful lawn—green, lush, carpet-like—something my family and I could really roll around on during a midsummer day. I just didn't want to sweat for it. The good news is that, for mowing, there's already a robot solution—a couple of them, in fact. Honda sells the Miimo; a company called LawnBott offers a variety of, well, lawn bots; and Friendly Robotics has a bunch of really friendly looking mowing robots. All of these systems seem pretty similar and promise essentially the same thing: to

consumer model in 1995. Now it sells two: the Automower 230 ACX (\$2700) and the Automower 265 ACX (\$3700). A few weeks after my call, I got a big box with a 265 ACX and an appointment with company representatives Quinn Derby and Gent Simmons. They arrived a few days later, surveyed my postage-stamp-size lawn, looked at the box from their company, and concluded that the 265 was complete overkill. But the machine was there, so they decided to install it anyway.

Now, two animal analogies are useful for understanding the operation of the Automower. First, the machine works like a sheep, roaming about your lawn at random, nibbling away at the blades of grass in small increments. Second, the Automower is prevented from leaving your lawn in much the same way that a dog can be contained within an electric fence. That's what Derby and Simmons installed on my lawn—a fence for the robot. They laid down a low-voltage wire that creates a mild electromagnetic field so the robot can sense when it has reached the prescribed boundary, then back up, turn randomly, and proceed off in another direction.

Derby informed me that my lawn was an unusual one for the Automower. That's because I really have two lawns: a small one in the front of the house, and a larger one in the back, separated by a fence and a patio. I could tell that Derby is by nature a problem solver, as he described several ways he could attempt to string the wire to allow the robot to travel from my back lawn to the front lawn. But I imagined the poor, confused machine attempting to nudge aside patio furniture along the way, and I told Derby to fence them off separately—occasionally I'd just pick the thing up and move it to the front lawn myself.

The two men installed the perimeter wire and base station and then gave me some brief advice on programming the mower—1 hour, for four days a week, would keep the back lawn neat and tidy; 1½ hours once a week would handle the front.

It was bliss. Every Monday, Tuesday, Wednesday, and Saturday at 1 o'clock, the mower would back out of its charging dock and quietly go about its business until 2 o'clock, when it would find its way back. The mower is so

PM editor Glenn Derene with his son Owen and their lawnmowing robot.



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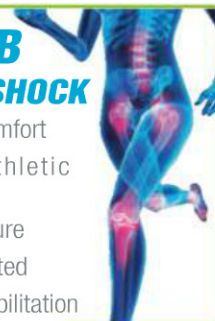
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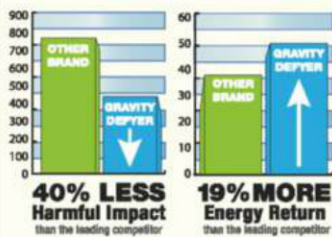
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quiet that I considered rescheduling it for the middle of the night. My 4-year-old son, Owen, protested. Watching the mower cruise across the lawn had become one of his favorite activities. On Sundays, after setting it on the front lawn, I would uncup a beer and hand Owen a juice box, and we would sit in the rocking chairs on our porch and watch the Automower go—ironically, paying more attention than ever to our lawn.

It was easy to anthropomorphize the thing. We found ourselves talking to it (“You missed a spot!” “Look out for that tree!”), dogs barked at it, and the sidewalk passersby found it fascinating. “It’s so cute!” said the woman from two houses down. “It’s like a Roomba for your lawn.” Then there were those who found it ominous: “Aren’t you afraid it’s going to cut your toes off?” said one kid who nearly fell off his bike when he first saw it. The answer was no. The Automower is loaded with sensors designed to prevent injuries. In addition to collision detection that makes it back off the instant it touches anything, it has a lift sensor that stops and retracts the recessed blades if you try to pick it up. According to Derby, the biggest problem Husqvarna has seen with the Automower is kids trying to ride on top of it. It’s enough of an issue that the mower now ships with a sticker warning against it.

Robotic mowers are a rarity on American lawns, though they are popular in Europe, where landscaping services are particularly expensive. But automated seed and fertilizer spreaders don’t exist anywhere. I know, because I checked. So I decided to create such a machine myself.

Well, not entirely by myself. I called up Randy Sarafan, technology editor at Instructables and an occasional PM collaborator. He had previously robotized an RC monster truck, which I figured would make a good platform for a spreader. I thought we could mount a handheld spreader to the top of Sarafan’s robot truck,

then connect a belt drive from the axle of the truck to the crank of the spreader. Every time the truck moved, it would spread the good gospel of grass. I bought an RC truck to test it out. The truck struggled to move itself through thick grass, so there was no way it was going to power a spreader as well. Sarafan suggested starting from scratch with an Arduino-controlled, dual-motor, tracked platform with an independent third motor driving the spreader. He could pull that off easily, he said.

Guidance would be the tough part. At first I figured the little spreader could use the same guide wires as the Automower, but a quick talk with PM senior home editor Roy Berendsohn exposed that as a bad idea. It’s okay for a mower to move randomly within a defined space, he explained—you can’t overmow a lawn as long as the blades aren’t set too low—but letting a seed-and-fertilizer spreader loose like that would be a waste. Sarafan designed the robot with a sonar proximity detector and a clever set of instructions. My main patch of lawn is rectangular and bordered on two sides by a fence, so the robot would start at one edge and count the number of revolutions of its wheels until it sensed the fence in front of it. Then it would turn around and progress back the same number of wheel revolutions until it reached the other side of the lawn, and repeat. He tested the thing

at the Instructables headquarters in San Francisco, then shipped it to me on the East Coast.

It was quite a ceremony at the Derene house when I first brought out the seed bot. My wife and Owen and his baby brother, Elliot, all came out to see its maiden voyage. I had high hopes for the little machine—the only one of its kind on earth. I filled the hopper and flipped the robot on, and off it went, rumbling slowly on its treads with a spray of seeds shooting out in front of it. But our excitement was short-lived. The little bot made it halfway to the fence, stopped, turned, and progressed back at a cockeyed angle, lumbering diagonally across the lawn toward my wife’s Volkswagen in the driveway. “Daddy, stop it!” cried Owen. “It’s going to hit mommy’s car!”

I ran after the wayward bot, which was still flinging grass seeds all over the place, picked it up, and turned it off. In its undisciplined way, it had spread seed on about one-quarter of my lawn. Not a complete failure, but not quite a success, either. Sarafan and I would have to make some code corrections and maybe adjustments to the sonar. But that would come later. Right then, I did what any good husband, father, and homeowner would do. I got out my old conventional seed spreader and finished the job myself. Total robot lawn domination would have to wait. **PopMech**



Home Brewed

Fertilizer and Seed Bot

PopMech teamed up with the DIY website Instructables.com to design a robot to feed and seed lawns. You can build it yourself—and, hopefully, improve on it. Go to <http://itbl.es/seedbot>.



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Only one planet has been proven to support life: Earth. But evidence is mounting that we are not alone. Scientists now think the galaxy contains at least 11 billion Earth-size worlds orbiting in their stars' habitable zones, where life is most likely to be found. And new studies show that strange creatures may thrive far beyond that boundary—on nearly any of the galaxy's 100 billion planets or their moons. Popular Mechanics presents . . .

THE CASE FOR

The search for alien life in distant star systems is accelerating. Here, each triangle represents 2.25 million worlds in the Milky Way galaxy. The colors provide information on the sizes of these worlds and their positions within their star systems. These factors may affect the odds of life emerging, and what course evolution would take.



* Small planets are from about half to 3x the size of Earth.

** The habitable zone is the range of distances from a star where liquid water can persist on the surface of a planet.



(10,000 x)

LEVE

BY SARAH FECHT

On Feb. 9, 2013, NASA's Curiosity rover found something on Mars that set a milestone in the search for alien life. Packed with instruments, the rover was an SUV-size speck crawling across the floor of the Gale Crater, whose distant walls climbed 15,000 feet in the thin air. The rover had been lowered to the ground six months earlier by means of a complex, jet-propelled sky crane. Now, almost 221 million miles from home but just a quarter-mile from its landing site, Curiosity was exploring a shallow depression called Yellowknife Bay. The machine trundled up to an outcropping of bedrock, which lay dry and cracked beneath a yellow sky. It drilled into the rock and within minutes pulled a fine gray powder from the narrow borehole. Curiosity scooped up the dust and tasted it.

The sample contained smectite clay, which on Earth is found in alluvial plains and regions washed by monsoons. Today, Mars is a largely arid world whipped by global dust storms, where temperatures can swing 170 F in a day. Three billion years ago, it seems, a river of sweet water cascaded over the rim of Gale Crater and emptied into a lake in Yellowknife Bay. The sky was probably bluer then, and cloudier, and the terrain hadn't yet rusted from gray to red. Mount Sharp, which rises 18,000 feet above the crater floor, may have been capped in ice and snow.

Curiosity found in the ancient clay many of the elements needed for life: carbon, hydrogen, oxygen, nitrogen, and phosphorus. We don't know whether bacteria, let alone Earth-like plants and animals, once teemed in Yellowknife Bay, but they could have. The rover was just the newest scout in humanity's decades-long exploration of Mars, an effort that currently includes the dogged 10-year-old Opportunity rover and three orbiters in space. But Yellowknife Bay is the first site ever observed, on Mars or anywhere else, that clearly could have supported extraterrestrial life.

Generations of scientists and science-fiction fans (often, those are the same people) have thought we'd find life strewn throughout the stars—if not civilizations, at least bacterial mats, or tentacled beasts on ocean floors, or something. But for decades the evidence was thin. Now, in 2013, the data is on the side of the believers. It has been provided by increasingly sophisticated probes, space telescopes, and rovers. Planets were once thought to be rare; by the time the Kepler space telescope ran

into severe mechanical problems in May, it had proved that alien worlds actually number in the billions. Scientists imagined the universe to be parched; new studies show that it's filled with watery planets. And, surprise: Life isn't some delicate thing, like a pasty tourist stuck beneath a beach umbrella; it's now known to be more like a hardy soldier, able to infiltrate the harshest environments.

The exciting exobiological news keeps coming: In April, astronomers identified a trio of planets that appear capable of supporting Earth-like life. They orbit their stars' habitable zones, the just-right distance where water neither freezes nor boils, but collects in sloshy, life-friendly oceans. One of the worlds, dubbed Kepler-62e, even shows signs of a humid atmosphere strewn with clouds. More such discoveries will come.

Louisa Preston, an astrobiologist at Open University in the U.K., investigates the telltale signs of biology that could help us locate life in space. "It's now predicted that there are 17 billion Earth-like planets in our galaxy alone," Preston says. "And since our galaxy is one of hundreds of billions in the universe, the chances of finding life are increasing exponentially."

Here are three reasons, in detail and based on current research, why we are much more likely to find life than to discover we are alone.

1. WATER IS COMMONPLACE, NOT RARE.

On its milky-white surface, Europa doesn't seem like a good place to go life hunting. The small Jovian moon gets blasted with high doses of radiation. It has almost no atmosphere, and temperatures can dip to minus 370 F at the poles. But beneath a thick shell of ice, Europa appears to be covered by an ocean that may be 60 miles deep and contain as much salty water as the Earth's seas three times over. A rocky seafloor, perhaps home to hydrothermal vents, may spew out chemical nutrients. On Earth such locations are crowded with tube worms, eyeless shrimp, and other strange creatures.

3 SPOTS TO SEARCH FOR LIFE IN OUR SOLAR SYSTEM

TITAN

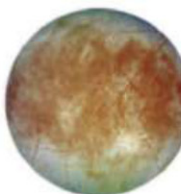
WHAT: Largest of Saturn's 62 moons. **WHERE TO LOOK:** Lakes of ethane and methane. **MISSION:** NASA and the European Space Agency are considering a plan to drop landers into one of Titan's lakes.

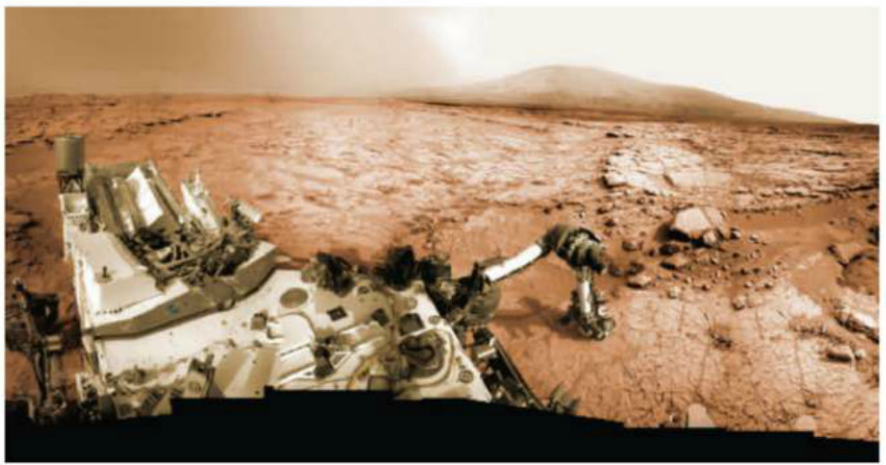
EUROPA

WHAT: One of Jupiter's 67 moons. **WHERE TO LOOK:** The ocean, beneath miles of ice. **MISSION:** The Jupiter Icy Moons Explorer (JUICE), to launch in 2022, will search for organic molecules and use ice-penetrating radar to find the thinnest sections of the crust.

ENCELADUS

WHAT: Geologically active moon of Saturn. **WHERE TO LOOK:** The ice-crusted ocean. **MISSION:** A proposed 2020 mission would swoop through cryovolcanic plumes. No lander is necessary, so future sample-return missions could be affordable.





Until recently, liquid water was thought to be a rarity in space. No longer, according to James Green, director of NASA's Planetary Science division in Washington, D.C. "What we're finding out is that water seems to be everywhere," he says. Scientists considered the surface of Mars to be bone-dry until 2011, when they noticed dark streaks that grow during warmer months, recede in the winter, and then return again in the spring, possibly indicating a seasonal freeze-thaw cycle. Some scientists speculate that microbes could be living beneath the Martian surface today. In November 2012, a team of NASA researchers revealed that Mercury, where temperatures can climb as high as 800 F, holds more than 100 billion metric tons of water ice in its permanently dark craters. Even the moon—once thought to be the driest place in our solar system—has an active water cycle, scientists discovered in 2010. And evidence is mounting that other moons, including Saturn's Enceladus and Jupiter's Ganymede, are home to vast subsurface oceans like Europa's.

And that's just in our solar system. NASA's Submillimeter Wave Astronomy Satellite, which flew until 2005 and imaged a variety of star-forming clouds in the Milky Way, turned up evidence of water nearly everywhere it looked. The Keck and Hubble telescopes have spotted water vapor in the atmospheres of planets in other star systems, and research conducted by Jay Farihi at the University of Cambridge suggests that liquid water is actually typical of rocky planets such as our own.

The same chemical plenty extends beyond the aqueous. All of Earth's life ingredients seem to be scattered liberally throughout the galaxy. The Hubble telescope uncovered the first evidence of an organic molecule—methane—in the atmos-

JAMES WEBB SPACE TELESCOPE

After it launches in 2018, the JWST (above left) will analyze light from the planets orbiting distant stars for signs of water, oxygen, methane, and other biologically meaningful molecules in their atmospheres.

CURIOSITY ROVER

The newest Mars rover found evidence of ancient freshwater at this site in Yellowknife Bay in the Gale Crater.

phere of an extrasolar planet in 2008. The Spitzer Space Telescope revealed in 2005 that the galaxy is littered with nitrogen-containing polycyclic aromatic hydrocarbons—ring-shaped molecules that may become the building blocks of DNA, RNA, chlorophyll, and hemoglobin. Simpler organic compounds have been detected on Mercury, Ganymede, and Enceladus. And analyses of meteorites that have struck Earth suggest that asteroids are zooming through the cosmos carrying water ice, nitrogen, sulfur, ready-made sugars and amino acids, and some of the components of genetic material. (One line of thinking even suggests that life on Earth was seeded by space rocks.) "The kind of chemistry that could have been used for life exists everywhere," says David Blake, a geologist on the Curiosity rover team. "There's no reason that life wouldn't have happened on other solar systems. The ingredients are everywhere we look."

2. LIFE IS MORE VERSATILE THAN WE BELIEVED.

The sun never stops shining during the Antarctic summer. "Time doesn't mean much there," says cryobiologist Brent Christner. "Morning, night—it all pretty much looks the same." Ironically, given all that sunshine, Christner had traveled to Antarctica from his Louisiana State University lab in Baton Rouge to look for microbes that live in perpetual darkness. He and his colleagues spent months in the cramped quarters of Antarctica's McMurdo Station preparing a drill system to bore into Lake Whillans. The shallow lake is buried below 2600 feet of ice and measures 20 square miles. A crew spent two weeks dragging the drilling equipment 600 miles to the lake

THE SEARCH FOR INTELLIGENT LIFE

● DRAKE EQUATION, 1961 ESTIMATES

● RECENT ESTIMATES

HOW MANY?

In 1961 astronomer Frank Drake presented this equation, which has since been named for him, to express the factors that affect the odds of finding alien civilizations. Some values that Drake guessed at can now be estimated with confidence. But the biggest question remains: How often does life evolve? We just don't know.

HOW TO SEARCH

Researchers at the Search for Extraterrestrial Intelligence, or SETI, Institute, listen for alien radio waves. Astronomer Jason Wright from Penn State University plans to look instead for heat signatures in the mid-infrared range, possibly given off by alien cities. "If even 5 percent of a star's light were being used and reradiated at a low temperature, it would be an obvious outlier," he says. "That's too much mid-infrared radiation for it to be normal."

conditions, on a place like Europa or any of the icy worlds in the solar system, could also support life," Christner says. "And if they don't, I think a larger question would be, why?"

The study of extremophiles was already well-advanced a decade ago, but work such as Christner's is continuing to extend the known boundaries of life. Organisms thrive in the deepest reaches of the ocean, in the driest of deserts, and in the saltiest of sands. The red algae *Galdieria sulphuraria* can prosper in sulfuric hot springs and old mineshafts with waters as caustic as battery acid. Even our skies are swirling with microbes, a paper published in January revealed. Researchers collected thousands of bacteria from as high as 9 miles above the ground. The airborne ecosystems withstand rough winds and large doses of radiation—and may never touch the planet surface. "Most of the environments we used to think were

civilizations
in our galaxy that use
detectable
communications

average rate of
star formation
per year in
our galaxy

fraction of stars
that have planets

$$N = R \times f_p \times$$

500 2100 10 PER YEAR 7 PER YEAR 0.5 1.0

site, following the route that Robert Falcon Scott had used to reach the South Pole 100 years earlier, and along which Scott and his crew perished during the return trip.

Using hot water, the drill cut down to the lake in 30 hours. A sample was rushed to a mobile microbiology lab on the surface. As he peered through the microscope, Christner delighted in what he saw: tiny footballs, basketballs, and springs—strains of bacteria that had been thriving in Lake Whillans, cut off from the Antarctic surface for thousands of years. The scientists reported the findings in January. They aren't sure how the microbes manage to survive down there in the dark and frigid water, but their discovery bodes well for the search for life beneath alien ice. "It isn't that much of a stretch to suggest that similar

sterile are proving to have life," Open University's Preston says. "Every time we think we've found somewhere on Earth that life can't survive in, we go and find a part of life that can."

Astrobiologists say that the watery worlds in stars' habitable zones are still the likeliest places to search for life. But new extremophile studies suggest that organisms might also survive on desert worlds and in the thick atmospheres of Venus-like bodies. They might even live on hurtling asteroids and the starless rogue planets that roam the galaxy. In our own solar system, Jupiter and Saturn are outside of the sun's habitable zone, according to the standard definition, yet several of their moons (including Europa, Enceladus, Titan, and Ganymede) are considered among the most promising sites to search. Liquid water is possible even in the coldest reaches of the universe, on worlds heated from within by nuclear processes or geothermal activity. On other planets, salt, ammonia, or methanol could serve as antifreeze. To Steven Desch, an astrophysicist at Arizona State University, these insights require new thinking. "If life might exist in the subsurface oceans of moons, heated by their own radioactivity," Desch says, "then no distance from the sun is too far. It's beginning to look like the definition of a habitable zone is out the window."

That would be especially true if alien life were truly weird. Titan, for instance, has rivers and lakes of hydrocarbons. Could organisms have evolved there without incorporating water? Ariel Anbar, a biogeochemist, also at Arizona State University, points out that distant star systems will have varying proportions of elements such as carbon, oxygen, and silicon. Such variety could drive evolution in hard-to-imagine directions. "The things we can conceive of are probably a very small set of the possibilities that are out there," Anbar says. "We know we're going to be surprised."

number of worlds
(planets and
their moons) per
star system with
an environment
suitable for life

fraction of
habitable
worlds where
life originates

fraction
of life-bearing
worlds
where intelli-
gence develops

fraction of
civilizations
that develop
detectable
communications

how long such
civilizations
generate
detectable
signals

$$n_e \times f_l \times f_i \times f_c \times L$$

1 3 0.1 0.1 0.1 0.1 1.0 1.0 10,000 YEARS 10,000 YEARS

3. PLANETS ARE THE RULE, NOT THE EXCEPTION.

In the past decade, science lost one planet—Pluto, which was downgraded to dwarf status—but it gained billions of others. “For most of history, we’ve learned that there were a handful of planets, and that was it,” says Michio Kaku, a theoretical physicist at City College of New York. “Anything beyond that was just speculation. It was a shock to find scores of exoplanets. We find about two a week now, so the catalog is just bursting.”

Credit goes to the Kepler space telescope. Since it began operating in 2009, Kepler has orbited the sun, trailing behind Earth and staring up at a patch of sky that encompasses more than 100,000 stars. Its central task: Measure the light coming from each star, and patiently wait for it to dim temporarily, signaling that a planet is eclipsing the field of view. As of January Kepler had discovered 2740 potential planets—up from 1235 in February 2011. The findings need to be confirmed by further study, but if past experience is predictive, 90 percent will turn out to be real planets.

Extrapolating from the Kepler findings, astronomers now estimate that at least 100 billion planets occupy the Milky Way galaxy. In January researchers analyzed the planetary candidates circling 4000 red dwarf stars and calculated that nearly 11 billion Earth-size exoplanets could have liquid water on their surfaces. The real number may be much higher. Ravi Kopparapu, a physicist at Penn State University, updated the formula for defining the habitable zone to include newer data about how water vapor and carbon dioxide absorb heat—essentially applying research on earthly global warming to the larger cosmos. His team arrived at a figure of 36 billion such planets—and, he says, “that is a conservative estimate.”

Kepler’s useful life may be coming to a close, but two new space instruments will soon follow in its footsteps. The recently announced TESS

(Transiting Exoplanet Survey Satellite) telescope, which is supposed to launch in 2017, will scan the entire sky for nearby exoplanets. It should be able to detect everything from Earth-size bodies in their stars’ habitable zones to gaseous giants. The long-anticipated James Webb telescope, scheduled for a 2018 deployment, may analyze the atmospheres of such planets for evidence of life, while also providing insights on galaxy formation.

The new research on red dwarf stars is even shaping the scientific thinking on alien civilizations. Seth Shostak is an astronomer for the SETI (Search for Extraterrestrial Intelligence) Institute, which uses an array of 20-foot satellite dishes in northern California to search for anomalous radio signals that could have been transmitted by alien technology. “Red dwarfs don’t burn out nearly as quickly as the bigger stars,” Shostak says. “On average they’re older. And when you think of intelligent life, it might need a long time to get going.” Shostak would like SETI to begin pointing its antennas at more red dwarf systems.

The odds of finding alien civilizations remain slim—yet that does not diminish the excitement surrounding off-world biology. “Soon we’re going to have an existential shock,” Kaku says. “In the next 50 years, there’s a very good chance that we’ll make contact with an extraterrestrial life-form. In the familiar constellations that we learned as children, we will find twins of Earth, and that’s going to change our understanding of who we are in this universe. Even if we find a fossil, a DNA strand from another species, that would be absolutely staggering.” It could be viewed as an upheaval equal to Copernicus’s proof that Earth isn’t the center of the universe, or to Edwin Hubble’s discovery that our entire solar system is a tiny speck of dust in a galaxy full of billions of stars—and that even the galaxy is one of countless many.

Of course, there’s no guarantee that we’ll ever find organisms on distant worlds. We can’t calculate the odds of life arising spontaneously, because we can only confirm that it has happened once. But life here on Earth proves that the probability is greater than zero. And in an infinite universe with billions of planets, there are billions of opportunities for evolution to commence. “Is life a universal phenomenon, a planetary process just like plate tectonics?” Anbar asks. “Or is life some weird statistical fluke? The only way we can answer that is by searching.”



ALIENS:

HOW SCI-FI
MOVIES CAN SAVE
HUMANITY

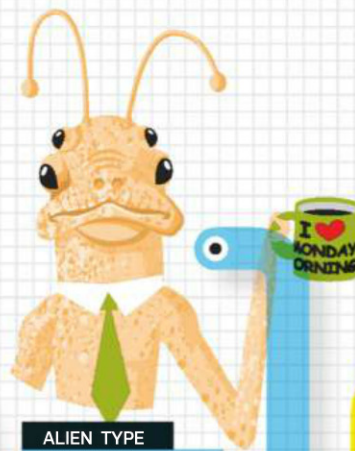
START
HERE!



ALIEN TYPE FRIENDLIES

What happens if aliens come calling on Earth? Science has little to say on this subject, but sci-fi films do. Hollywood has imagined dozens of alien encounters. Here, Popular Mechanics mines the movies to identify all likely alien scenarios—and the best strategic responses.

E.T., title star of the 1982 movie, is deeply nonhuman: benevolent, selfless, and greedy for nothing more than some Reese's Pieces. So did the poor guy deserve to be terrorized by thugs in hazmat suits? Yes. It's all fun and flying bicycles until some alien sneezes out a pandemic virus. Required action: quarantine.



ALIEN TYPE IMMIGRANTS

Some off-worlders may want to settle on Earth for the barbecue and sitcoms. Or they may just get stranded by engine trouble. *Men in Black*, 1997, had the scenario about right: The new normal is a messy melting pot with over-worked gumshoes and visa clerks. (For darker versions, see *Alien Nation*, 1988, and *District 9*, 2009.)



ALIEN TYPE PARASITES

The space virus that lands on Earth in *The Andromeda Strain*, 1971, isn't evil; it's an innocent crystal-line microbe that just happens to turn human blood into sand. Even the slobbering creature from *Alien*, 1979, isn't malicious, really. It's an over-size botfly—laying eggs in people is merely a quirk of its life cycle. Yes, biology can be ugly.

BY ERIK SOFGE

ILLUSTRATIONS BY PATSWERK

HUMAN RESPONSE QUARANTINE

Sorry, E.T., it's off to the plastic bubble with you, at least for a while. We'll supply free TV and snacks, along with the probes and blood tests. Then, once we know it's safe, you and the other aliens can go on your way.



HUMAN RESPONSE DIPLOMACY

Welcome to Camp David! Talks will be led by expert schmoozers and engineers. The aliens have advanced technology to share; in exchange, Earth can offer dim sum and a basic 12-bar blues progression.



HUMAN RESPONSE IMMIGRATION SERVICES

Give us your tentacled, your scaly, your bulbous-eyed masses. Appropriate agencies should be set up to handle difficult situations. Here come the Men in Black.



ALIEN TYPE
ROGUE CRIMINALS

In movies like *Predator*, 1987, which is set in a Central American jungle, the alien enemies aren't homesteading or scavenging for food. They're just remorseless psychopaths with advanced weaponry. Similar specimens appear in 1951's *The Thing From Another World*, which features a rampaging plant-man, and *The Hidden*, 1987, in which a fugitive alien runs amok in L.A. These creeps are born to die hearing Arnold Schwarzenegger one-liners.



HUMAN RESPONSE
EXTERMINATION

Hate to say this, alien life-form, but you're no longer welcome on Earth. First we'll try alcohol wipes. If that doesn't work, we'll introduce you to our friends Smith & Wesson.



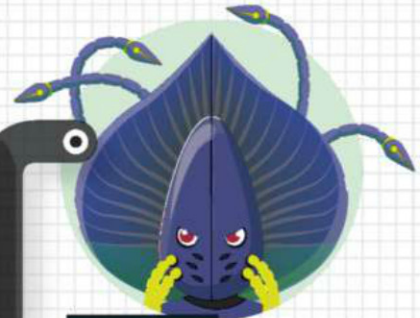
ALIEN TYPE
COVERT AGENTS

In sci-fi, would-be alien overlords often rely on a sinister combination of infiltration, subversion, and under-the-radar brutality. In 1956's *Invasion of the Body Snatchers*, humans are replaced by emotionless copies (grown in pods), who plot to expand their power base. In *V*, 1983, the visitors come bearing gifts and human smiles—but they're really fascist lizard people. In *They Live*, 1988, Earth's alien rulers pose as yuppies, including advertising execs.



HUMAN RESPONSE
GUERRILLA MOVEMENT

Vive la résistance, alien invaders! We can't fight you openly, considering your plasma bombs and/or your creepy ability to masquerade as freshman Congressmen. Instead, we'll be grabbing a beret and joining Will Smith at a secret location to launch an insurgency. The Anonymous hackers are on our side too (we think). This war ain't over yet.



ALIEN TYPE
INVADERS

Independence Day, 1996, was optimistic. If an advanced alien armada ever warp-drives its way to Earth bent on conquest, the jig is up. Humans will be helpless under the onslaught. In *Independence Day*, we repel the aliens using a computer virus uploaded from a Mac laptop, but could even Apple's product placement team really make that happen? In *Earth vs. the Flying Saucers*, 1956, and *The War of the Worlds*, 1953, we likewise prevail through lucky plot twists.



HUMAN RESPONSE
SURRENDER

We had a good run, but when a civilization that's mastered interstellar travel and death rays comes knocking, it's game over. Hopefully, unlike the genocidal aliens in *Independence Day*, the newcomers will accept unconditional surrender by our leaders. But not to worry, Earth patriots, groveling is just the first step in our master plan.

2014 JEEP® GRAND CHEROKEE: LUXURIOUS CAPABILITY AT ITS BEST



It competes with luxury SUVs. And prevails. In fact, the Jeep® Grand Cherokee is the most awarded SUV... Ever.¹



The Grand Cherokee has already set the standard for interior luxury² and unpaved-terrain capability.

But great still wasn't good enough. That's why the Jeep® brand pushed its engineers to do more. Give the 2014 Grand Cherokee best-in-class highway fuel economy without compromising power and ride quality. The jaw-dropping results: a manufacturer's estimated 30 MPG highway fuel economy³ from a powertrain that produces 420 pound-feet of pulling torque. The solution starts with a new-to-the-U.S. available 3.0L EcoDiesel V6 engine.

Refinement is key when pairing a diesel engine with a premium SUV. Specifics include casting the engine block from compacted graphite iron and using a water-cooled, variable-geometry turbocharger. Fuel is injected into each cylinder under 29,000 psi of pressure, which burns fuel more

efficiently, and the low CO2 emissions give the 2014 Grand Cherokee the cleanest diesel engine in its class.⁴

Efficiently transferring EcoDiesel power to the ground also brought out the best in Jeep brand engineering. An eight-speed automatic transmission allows the engine to remain in its low-rpm powerband longer — torque peaks at 2,000 rpm. The 2014 Grand Cherokee's Eco Mode optimizes transmission shift points to maximize fuel economy. This translates to up to 30 MPG highway and a best-in-class 730-mile driving range³ in a 4x2 Grand Cherokee equipped with the EcoDiesel.

The Jeep brand definitely stepped up its game on the 2014 Grand Cherokee. Thanks to the available 3.0L EcoDiesel engine, this ultra-refined SUV now offers V8 power with V6 fuel economy. The 2014 Grand Cherokee is Detroit at its best. The world is on notice.

¹ Jeep Grand Cherokee has received more awards over its lifetime than any other SUV.

² 2013 Ward's Middle/Sport Utility vehicle segmentation (excludes other Chrysler Group LLC vehicles). Based on Summit model offerings.

³ Based on manufacturer's testing results of the 3.0L EcoDiesel V6 (30 hwy mpg, 4x2) engine and competitive data. 2013 Ward's Middle Sport/Utility Vehicle segmentation (excludes Chrysler Group LLC vehicles). Over 730-mile range based on one tank at manufacturer's estimated 30 hwy mpg, 4x2. Actual mileage may vary.

⁴ Based on manufacturer's testing results of the 3.0L EcoDiesel V6 (30 hwy mpg, 4x2) engine and competitive data according to the EPA fuel economy website. Cleanest as defined by lowest CO2 emissions when compared to Jeep Brand "Full Size Diesel SUV" segmentation.



THE BEST OF WHAT WE'RE MADE OF.



2014 JEEP GRAND CHEROKEE

THE BEST

OF WHAT WE'RE

MADE OF

NOW WITH A BEST-IN-CLASS 30 MPG HWY AND A 730-MILE DRIVING RANGE*

THANKS TO ITS NEW, AVAILABLE ECODIESEL V6.

ANOTHER POWERFUL INNOVATION FROM THE MOST AWARDED SUV EVER**:



Jeep

Optional EcoDiesel engine late availability. *Based on manufacturer's testing results of the 3.0L EcoDiesel V6 (30 hwy mpg, 4x2) engine and competitive data. 2013 Ward's Middle Sport/Utility Vehicle segmentation (excludes Chrysler Group LLC vehicles). Over 730-mile range based on one tank at manufacturer's estimated 30 hwy mpg, 4x2. Actual mileage may vary. **Jeep Grand Cherokee has received more awards over its lifetime than any other SUV. Jeep is a registered trademark of Chrysler Group LLC.

Jeep.com/GrandCherokee

FREEDOM OF THE ROAD

SEVEN DAYS IN THE VALLEY

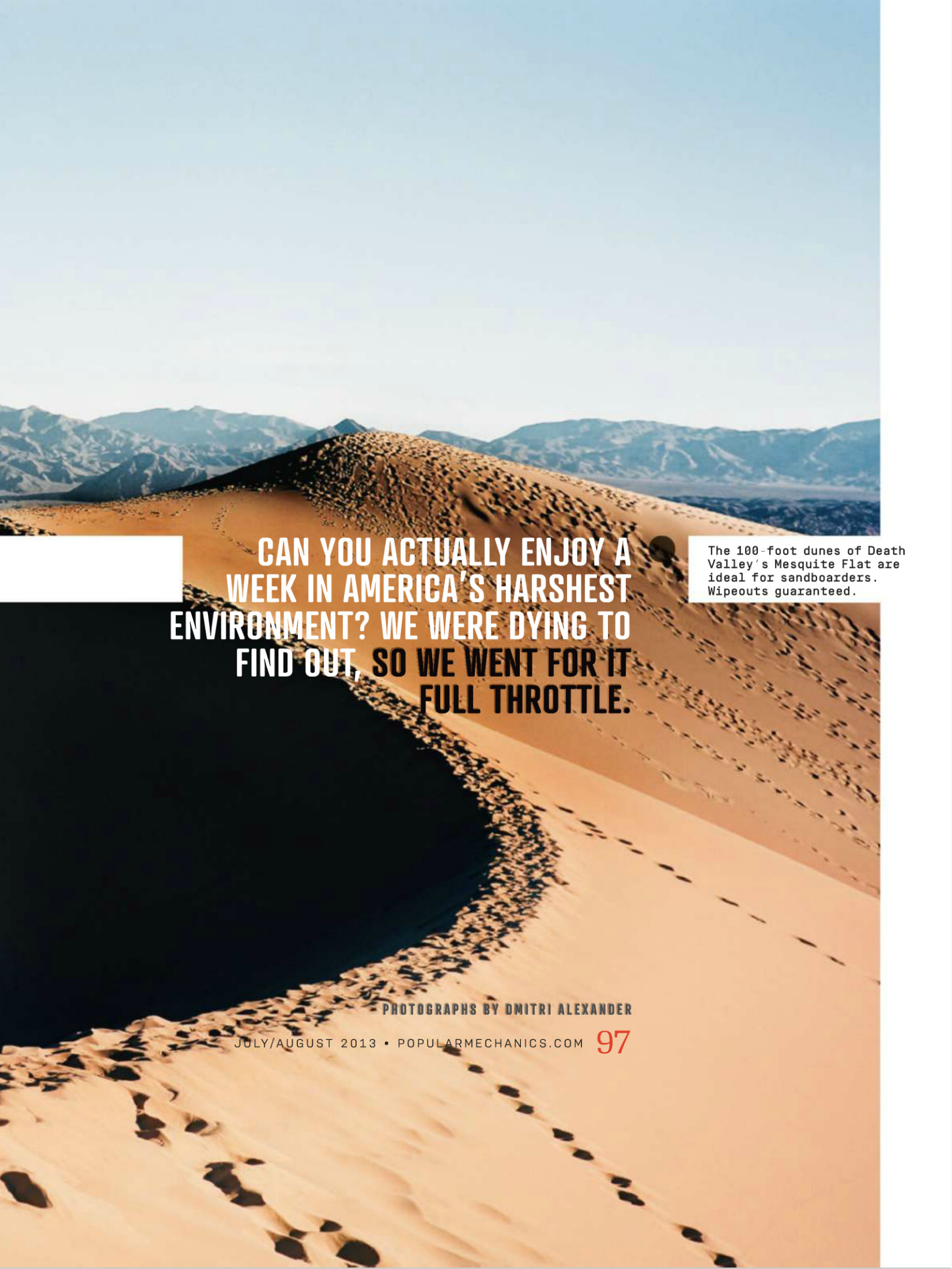
BY JAMES VLAHOS

A curved front half (for easier turn initiation) and a flat back half (for greater stability) made this a beginner-friendly board.



VENOMOUS RAPTOR
SANDBOARD (\$180)





**CAN YOU ACTUALLY ENJOY A
WEEK IN AMERICA'S HARSH
ENVIRONMENT? WE WERE DYING TO
FIND OUT, SO WE WENT FOR IT
FULL THROTTLE.**

The 100-foot dunes of Death Valley's Mesquite Flat are ideal for sandboarders. Wipeouts guaranteed.

PHOTOGRAPHS BY DMITRI ALEXANDER

JULY/AUGUST 2013 • POPULARMECHANICS.COM

97

THIS IS LUKE GALYAN'S IDEA OF FUN: TAKE TWO NOVICES ON A CANYONEERING TRIP IN

California's Death Valley National Park. From a diabolical lineup of gorges—Bad, Hades, Styx—choose the most ominous-sounding one, Coffin. Lead the beginners from a 4500-foot ridgetop into a treeless chasm of crumbling red rock. Warm up with a couple of 20-foot rappels. Then, when the canyon sides rise into cliffs and squeeze around a blind left turn, announce that “you guys should go first here.” I step around the corner and gulp hard. Ten feet ahead, the ground simply ceases to be.

Creeping forward with my friend Tom Colligan, I peer over the lip of the cliff. Only hot, dry air separates us from the bottom of the canyon 190 feet below. Boulders strewn in the wash look like grains of sand. Galyan, an expert canyoneer who is leading the descent along with his buddy Mark Duttweiler, catches up with us and chuckles. Goofy and good-natured, with more than a little Jeff Spicoli surfer guy in his looks, Galyan picks up a fist-size rock and chucks it over the edge. I count one Mississippi, two Mississippi, three Mississippi, and then hear the rock smack the ground. “Thanks,” I say. “You’re really helping.”

Higher. Bigger. Wilder. Death Valley defies moderation, in canyoneering and everything else. The mountains climb to 11,000 feet and the desert floor drops to -282 feet, the lowest spot in North America. There are claustrophobic slot canyons, sand dunes the height of skyscrapers, and a volcanic crater deep enough to stash the Superdome. Death Valley is the hottest place in the world, holding the record of 134 F. At almost 5300 square miles, nearly the size of Connecticut, it's the largest national park in the Lower 48. Duttweiler, a studious-looking mechanical engineer, describes the scale as “awesome, gruesome, overwhelming.”

It's an extreme place for extreme gear. Carmakers torture-test new models here; NASA did the same with its latest Mars rover. It's an extreme place for extreme people, from the unlucky gold miners who got lost here in 1849 and gave the valley its name, to the masochists today who compete in the Badwater Ultramarathon, 135 miles in temperatures that climb past 120 F. Travelers visit from continents away just so they can get out of their air-conditioned cars in July and proudly suffer. Inhospitability, perversely, is the park's biggest draw. The bonus is discovering that it's also fun and beautiful—in a spring-break-on-Tatooine kind of way.

The superlative that enticed Tom and me was that Death Valley contains at least 600 miles of dirt roads. With a week to take a trip in Ford's burliest 4x4, the F-150 SVT Raptor SuperCrew, we reasoned that using a beast like that only on pavement would be like hunting squirrels with a flamethrower. We loaded the truck with tents big enough to house family reunions, camp furniture more comfortable than the stuff in my living room, and enough sporting equipment for a desert Olympics. We figured that if you wanted to put yourself and your gear to the test—and have a blast doing so—this was the place.

Thirty minutes after reaching Coffin's big cliff, I'm attached to a line and tilting backward over the precipice. “Don't let go of the rope,” Duttweiler says. Again, thanks. My right hand,



Inspired by Baja race trucks and made specifically for off-roading, the Ford F-150 SVT Raptor SuperCrew is the best way to experience Death Valley in all its craggy glory.

down by my hip, has a death grip on the line. My descent is controlled by a palm-size rappelling device with metal teeth to brake the rope. The gadget seems too slight for the job, but it works. I lower myself slowly, toe-tapping the vertical face. Then the cliff veers inward and I'm dangling like a salami from a deli ceiling. As I slowly rotate, a dizzying tableau of rock, canyon, and sky drifts into view.

FURNACE CREEK, A PALM-FLANKED RESORT

area, recedes in the rearview mirror. The blacktop ahead slices north through the desert, drops over a distant swell, and disappears. A day after the Coffin climb, Tom and I are headed to the Mesquite Flat Dunes. We arrive after a half-hour drive and set out on foot.

Death Valley weather forecasts are daunting during spring and summer (“sunny and clear, with scattered lakes of fire”), but on this afternoon in early November, the temperature is agreeably warm. The plan is to go sandboarding, the desert version of what Shaun White does on snow. Our guide is Southern California sandboarder Jeremy Tutorow, who has the cropped haircut of a Marine and the bulging calves of a man who has done some serious dune climbing. He leads us along

A full-page photograph of a person rappelling down a steep, reddish-orange rock face. The person is wearing a blue long-sleeved shirt, dark pants, a yellow helmet, and a large backpack. They are holding a rope and standing on a rock ledge. The background shows the rugged, layered rock formations of a canyon.

With the highest peak reaching more than 11,000 feet and salt flats sinking to 282 feet below sea level, Death Valley offers some of the longest canyoneering descents in the United States.

a sandy crest that snakes skyward. Reaching the peak, we look out at a sea of sand turned blood-orange by the light of the sinking sun. Dunes rise and fall like ocean swells, bright to the west and tailed by lengthening shadows to the east.

"It's hard to stand on top of a dune and not want to slide down it," sandboarding pioneer Lon Beale told me when I phoned him before the trip. The question is how. Starting in the 1970s, Beale tried everything from waterskis to snowboards but found the equipment lacking. "It would be like if you took a baseball and threw it through a hoop—are you really playing basketball?" Beale says. He tinkered exhaustively, and in 1991 his company, Venomous Sandboards, released its first product.

We have a quiver of his boards with us now. Tom steps into his board's bindings and points the tip toward the steepest face in sight.

"I admire your fortitude," I say.

"You might not soon," Tom replies, taking off—and wiping out after 20 feet. Tom and I both know how to snowboard, but as Tutorow explains, sandboarding requires you to lean back, not forward, to avoid burying the tip. He demonstrates on a long, smooth run, spraying sand from the board's tail as he arcs through the turns.

This fluidity is a testament to his skill and to the board's design. Beale realized that sand behaves more like water than like a solid, so board tails must function like rudders. The other key is minimizing friction while maximizing durability. Beale found the ideal material in dense thermal plastic, which is like Formica but even harder. "That is what opened up the technology to allow the boards to glide at highway speeds," he says.

I crash in my first run, but in successive ones manage a few shaky turns as I swoop downhill. The board parts the sand with a pleasing hiss. The sensation is light, swift, intoxicating.

THE SIGN NEAR THE BADWATER

Basin parking lot proclaims 282 FEET BELOW SEA LEVEL, but reaching the true location of that depth requires a long trek on the playa, which is as flat as a frying pan and nearly as hot. To avoid melting like pats of butter, Tom and I set out after sunset, when the temperature is in the low 80s.

Hoping to pinpoint the lowest place in North America, we check a guidebook and load the coordinates into a GPS. We're glad to have electronic guidance as we traverse the salt flats, where the number of signs with terrain features is zero. In front of us loom the hulking black peaks of the Panamint Range. Overhead, stars fill one of the darkest night skies in America.

DESERT GEAR

BEFORE YOU EMBARK ON A DEATH VALLEY EXCURSION, MAKE SURE YOU PACK THE NECESSARY EQUIPMENT FOR THRILL SEEKING AND SURVIVAL.



After hiking for a couple of hours in the balmy evening air, we reach the bottom of the continent. The event is less climactic than, say, planting a flag on the top of Everest, but we celebrate anyway with a late-night snack. The moon rises from behind the peaks to the east, bathing us in brilliant lunar light.

The next day, after a long, dusty drive into the mountains, we look down on Badwater Basin from more than 2 miles above. We're standing atop the 11,049-foot summit of Telescope Peak, the highest place in the park. In every direction, desolate valleys sprawl between lines of rugged mountains. I remember something that Duttweiler had said during the canyoneering trip, that the park is so vast you could walk away from someone and just disappear. "You melt into the landscape for no other reason than that you're too small to be seen anymore," he said.

"WHEN I WAS DRIVING LAST NIGHT I

wanted there to be no laws." Tom says this as I gun the Raptor along a strip of blacktop slanting through tawny badlands. I fully grasp his craving for illegal speed as we turn onto the Saline Valley Road Back Country Byway, a 100-mile unpaved route that leads through some of the most striking and least visited terrain in the park. There's no posted speed limit, but I'm pretty sure we're breaking it as the speedometer needle creeps higher.

We blaze through sagebrush flats that stretch between arid mountains. Joshua trees blur in my peripheral vision while the 6.2-liter V8 roars—and I realize that we've truly entered Raptor territory. Inspired by Baja race trucks, the truck was made to go fast on nasty roads. Hefty, 35-inch tires help to smooth out the byway's stretches of washboard. The long-travel suspension absorbs serious body blows as we sail obliviously over a stream channel carved into the road.



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BIKES

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MOUNTAIN BIKE (\$1300)

The bike charged through loose gravel with the help of extra-wide, 29-inch wheels.



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4 BASE CAMP TENT (\$700)

Big enough to provide space between me and my snoring buddy; airy for cool sleeping in the desert.



To mountain-bike in Death Valley's sweltering heat requires passion beyond wearing your heart on your sleeve.

This is a ride to inspire envy, which I realize when Tom and I stop to camp at a hot-springs oasis shaded by palm trees. After sitting by a campfire and listening to a trio of guitar-strumming men—"Mamas, don't let your babies grow up to be nude sunbathers," they sing—we meet Jeff McLaughlin. He's an easy-going guy in his 20s who says he loves hot springs so much that he drove down from Oregon, by himself, to hang out here for a week. Tom, who doesn't want to brag, is cagey when McLaughlin asks what we're driving, but the truth leaks out.

"You've got a Raptor?" McLaughlin says. He looks at the glowing

embers and then back at us and jokingly asks, "Hey, could I come with you guys tomorrow?"

The next morning Tom and I head out on a rubbly road that climbs to 5000 feet on Steel Pass. Heading downhill into Dedeckera Canyon, we are stopped by the first in what will be a series of stairstep ledges, each one presenting a drop of several feet.

Tom hops out of the truck, looking worried. "This is the type of thing you could raft out on," he says. Using our hands, we build a ramp from rocks on the downslope side of the first ledge so that the Raptor's tail can clear the ledge. It does—but just barely—and we repeat the ramp-building routine several times as we creep down the canyon, me out in front on foot, directing Tom with my hands as if trying to guide a 747 to the gate.

At the bottom of the canyon, the road spits us out onto a straightaway that runs alongside the 680-foot-high Eureka Dunes, the second-highest sand hills in America. Now at the wheel, I push the Raptor past 70 mph and feel the truck drift slightly on and off axis as we roar along the sandy track, a mile-long cloud of dust rising in our wake.

OUR FINAL DEATH VALLEY

adventure, after a week in the park, is a mountain-bike ride through Titus Canyon, perhaps the most dramatic gorge in the park. For this we've brought

along two hardtail bikes that, like the Raptor, use brute force to handle extreme conditions. Mountain bikes traditionally have 26.5-inch wheels, but the Giant XTC Composite and the Focus Black Forest have 29-inch wheels. These make the bikes slightly less agile on tight single tracks but offer increased stability and control when plowing through sand and powering down rocky double tracks.

And that's exactly our plan. We pedal to the top of Red Pass (5250 feet) and begin the long descent into Titus Canyon. The canyon gets deeper, framed by jagged bluffs of orange and red volcanic rock and purple limestone. As we slalom through the canyon's narrows, rock walls press in on both sides of the road.

We descend back to sea level and finish the ride at sunset. I fish a couple of beers from a cooler in the bed of the Raptor, which is so filthy that you can barely tell what color it is. Blue, I think. But the vehicle is unscathed, and Tom seems disappointed. "Man, I really thought we were going to damage that truck somehow," he says. I hop into the cab, fire up the motor, and listen to it reverberate in the dark, still canyon behind us. **PopMech**



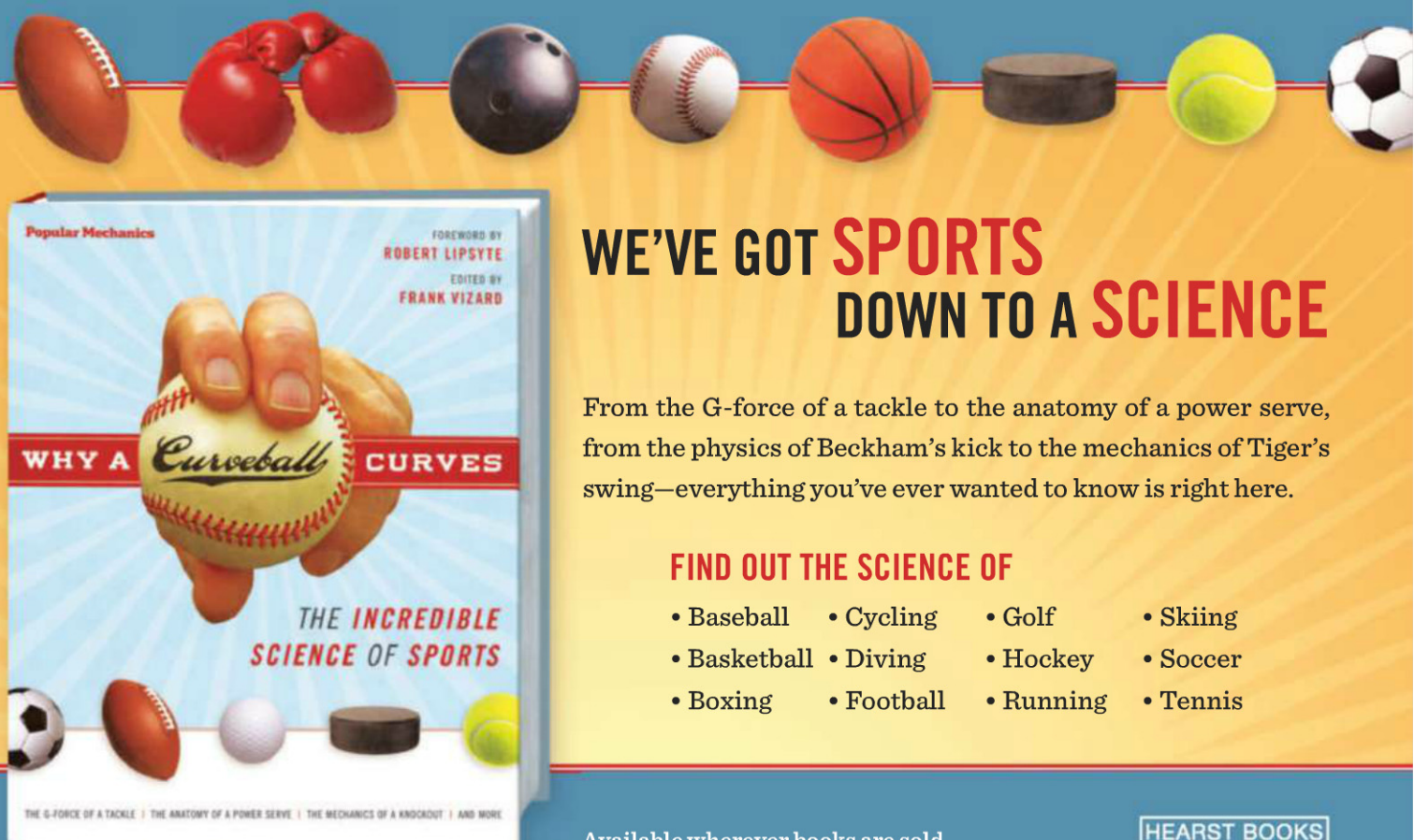
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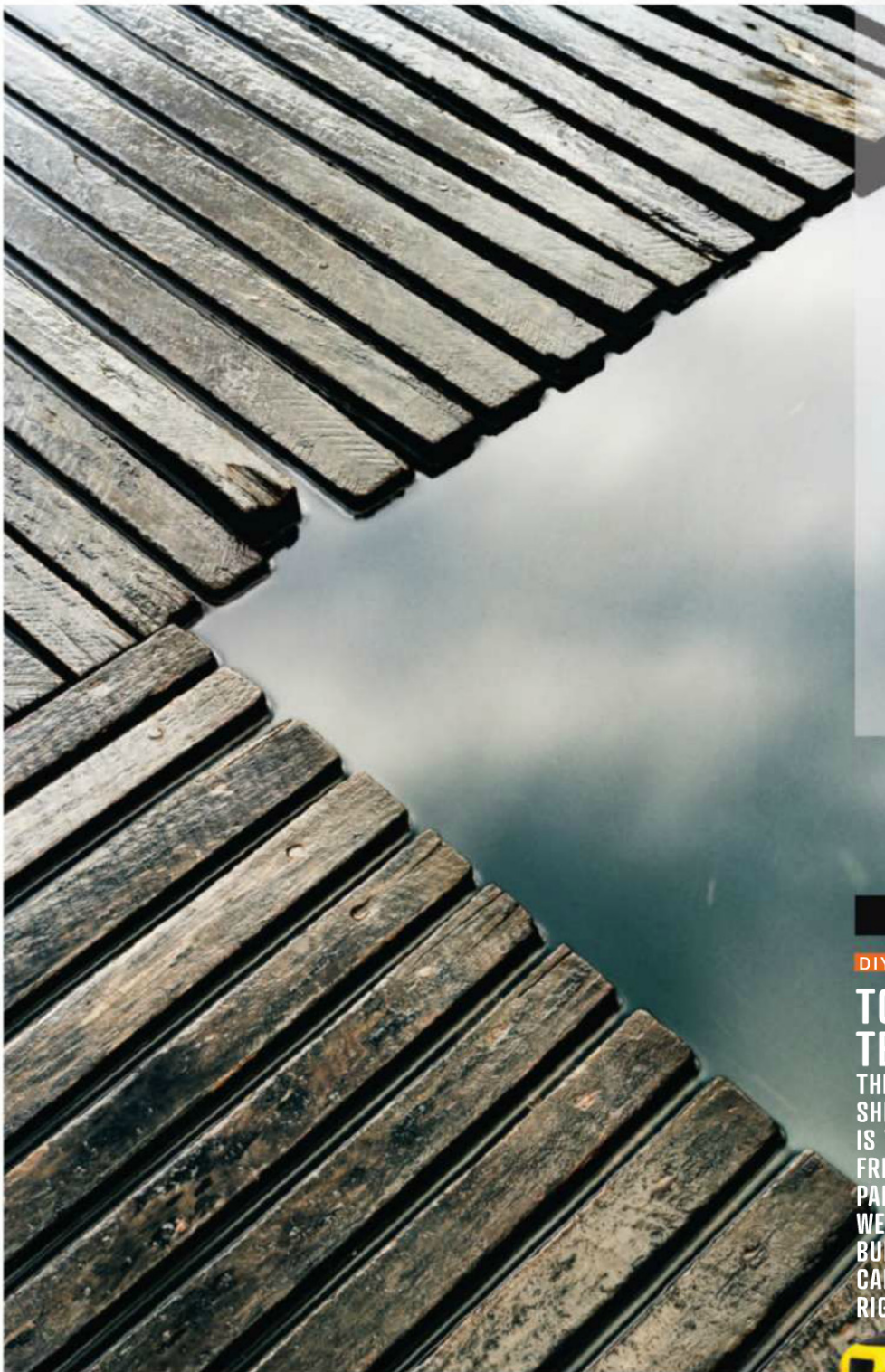
But one in five children struggles with hunger. Share Our Strength's No Kid Hungry campaign is ending child hunger in this nation by connecting kids in need with nutritious food and teaching families how to cook healthy, affordable meals. You can help surround kids with the healthy food they need where they live, learn and play.

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AUTO HOME TECH SCIENCE ADVENTURE

4

DIY HOME

TOOL TEST

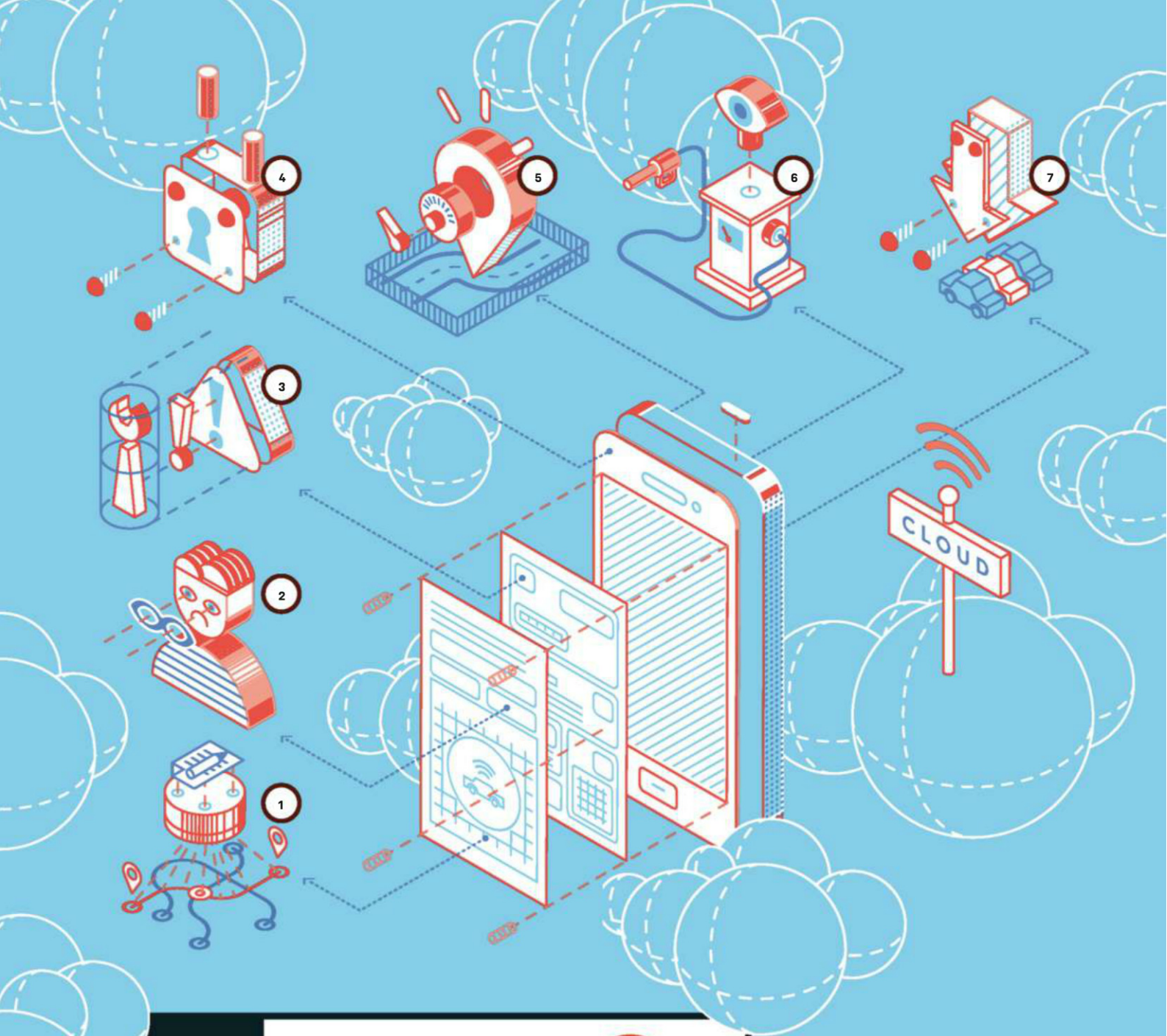
THE QUARTER-SHEET SANDER IS YOUR BEST FRIEND FOR PAINTING PREP. WE TEST A BUNCH SO YOU CAN CHOOSE THE RIGHT ONE. p. 118

Wood slats are cool for a walk in the sweet summer heat. They also make a nice seat (see p. 114).

Q+A

You have questions. Our experts have answers. Make your car nearly theft-proof. Build a handsome screen for your ugly garbage cans. Rig up a window a/c unit for smartphone control. And so much more. pp. 110, 122, 130





diy

Auto

• TRICK
SWITCH
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DEGREE OF
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A Cloud for Every Car

ANY CAR FROM '96 ON CAN NOW BE EASILY CONNECTED TO THE WEB. IS THIS REVOLUTIONARY, OR AN ANSWER IN SEARCH OF A QUESTION? *BY BEN WOJDYLA*

You probably haven't missed that every product in our lives is getting connected to the Web. Computers, phones, and tablets are old news;

now it's televisions, refrigerators, washing machines, yard sprinklers, home thermostats, and cars. And not just new cars—any car from 1996 on can get in on the act. Verizon's Vehicle Diagnostics by Delphi—yes, the GM spin-off—is a device that plugs into any car with an On-Board Diagnostics (OBD-II) port and sends a stream of vehicle and location data to the cloud. Not only does this allow you to view all kinds of info about your car, you

ILLUSTRATION BY RELAJAELCOCO

CAR-TO-CLOUD CONNECTOR

THE HARDWARE TO MAKE THIS WORK IS A COMPACT BLACK BOX. THE ONLY INDICATION ANYTHING'S HAPPENING IS A MULTICOLOR LED.



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- 4 **DOOR UNLOCKER**
Activates factory remote starts; ends lame keys-locked-in-car moments.
- 5 **GEO-FENCER**
Sends alerts if car leaves preset zones or exceeds speed limits.
- 6 **FUEL CHECKER**
Monitors whether it's time for a fill-up or a battery charge.
- 7 **CAR LOCATOR**
Uses GPS to end the era of "Dude, where's my car?"

can also control features such as door locks and remote starters from anywhere via the Internet. We gave it an Editor's Choice Award at last year's Consumer Electronics Show, but this was our first chance to give it an in-depth workout. The device costs \$250, plus monthly access—\$5 for existing data-plan subscribers or \$35 as a stand-alone account. Is it worth it? And what are the implications of adding a cellular connection to a car?

The Hardware

Put simply, Vehicle Diagnostics by Delphi is a cellphone without a screen. Contained in the little black box is a cellular radio that connects to the Verizon network, a Bluetooth radio, a simple computer, and a GPS receiver. The box plugs into the OBD-II port under the dashboard and stays there (the port is also the device's power source). Once installed, it transmits data automatically, and the information can be accessed from Android and iOS apps or a Web browser. Commands can be sent to the device from any

of those sources as well. Installation is easy: Just plug the dongle directly into the port or use a \$35 relocation kit to stash it somewhere more out of the way. Setup takes all of 60 seconds if you follow the instructions.

How It Works in Real Life

Verizon's website has a compatibility checker so you can see in advance if the Vehicle Diagnostics unit will work with your car. For our hands-on test, I first installed the device in my trusty, minimalist 2001 Ford F-150. With no power anything, the truck can evaluate only the Delphi system's basic capabilities. Battery-voltage and trouble-code reporting worked perfectly, as did the location-based tracking. On more than one trip I could have used the software to figure out mileage for an expense report. My truck doesn't broadcast its vehicle identification number, though, so it showed up as a generic Vehicle 1 on the home screen. The fuel-level report didn't work, and, gosh darn it, installing the device didn't give me an upgrade to remote-start.

The second vehicle we tested was a 2008 BMW 328xi. With the VIN reporting correctly, the make, model, and year came up in the menu. (You can move the dongle from car to car and look at separate data for each vehicle.) Fuel level reported out flawlessly, but, unfortunately, the vehicle's

key-fob functions were not supported. We also needed to employ the relocation kit: a connector, a flat cord, and a variety of mounting hardware that let you stash the device in a place where you won't kick it or bump it with your knee.

Our final test, on a 2011 Chevy Malibu, proved that the third time's the charm. The full suite of key-fob, vehicle-data, and remote-start features worked as advertised. It's so good, you could even leave the keys in the car if you don't want a pocket bulge. Just don't lose the phone, which brings us to another concern.

Can Someone Hack My Car?

We spoke with David Sperling, chief technology officer at Smith Micro, a company responsible for much of the software that covers security and interoperability of devices that hook up to the Web. His take: "This issue comes up every time we connect something new to the Web, and every time, we've solved it. There's always a risk that anything can be hacked, but cars are no different from phones or tablets." With the Delphi device, the data and connection are accessible only with a self-chosen username and password. The catch is that it's easy to stay logged in on the phone app. If you lose your phone and don't have a password lock (or leave a browser session open on a laptop that's then stolen), anybody could potentially find your car and unlock it. Which means that you probably don't want to leave your keys in the car. But even if you did, you could still track the crook via the Web. The Internet security practices you should already be using apply here as well. And if there is ever a security breach, change your password as soon as possible.

The Bigger Picture

Vehicle Diagnostics by Delphi is a small step in car connectivity that began with GM's OnStar service. Launched for the 1997 model year, OnStar used GPS and an analog cellphone to offer features similar to

 DIY AUTO

those now found on the Delphi unit. It also automatically called 911 in the event of a crash, and had the added perk of a concierge service—push the little blue button on the mirror and an operator would find the nearest gas station or restaurant. Now in its third generation, OnStar has a mobile app and can integrate directly into factory navigation systems. OnStar isn't alone—all major automakers now have connected-car systems available or are working on them. Delphi's system is unique in that it offers a lot of these features as a self-contained, bolt-on kit for the aftermarket.

Ubiquitous smartphones and the related deluge of apps have changed the way we interact with the world around us, and that includes how we look at cars. As these pocket computers bring more of the outside world into the car, it seems reasonable to use the same technology to harvest information from the car. This gives consumers more control over the vehicle, improving the ownership experience and increasing safety. These are undoubtedly benefits, but they also raise privacy concerns. The ownership of your data, and access to it, is a complex issue that has yet to be resolved. But the Delphi device skirts these concerns by working only when you want it to—nothing happens when the dongle is unplugged. You control the master switch. It's an example the rest of the automotive world should follow.

Essential Tool or Nifty Toy?

Many will find Vehicle Diagnostics useful. Whether it's worth \$250 plus a monthly subscription depends on the individual. Anybody looking for a good way to track trip data, such as fleet managers or those who regularly document business travel, will find that the Delphi dongle could pay for itself. For those in high-car-theft

areas (Southern California, we're looking at you), this is LoJack on steroids. It could bring peace of mind to parents of young drivers but also undermine trust and act as an electronic tether. For an early adopter and data addict, this device is amazing. All of our testers, including myself, were extremely impressed. Even if we're not sure where all this technology will go in the future, we love that Delphi is helping bring our older cars along for the ride.

Car Clinic

BY BEN WOJDYLA

Kill Your Car

I have a pickup I absolutely love, and would like to prevent it from being stolen. Have any ideas to make it theft-proof?

Car theft is a perennial problem that everybody worries about. In 1991, the peak of auto theft according to FBI crime statistics, a staggering 1.66 million vehicles were stolen in the U.S. Manufacturers responded to this problem with factory alarm systems and sophisticated electronic validation between the car and the ignition key. In 2011, thefts dropped to a reported 715,373 incidents, but even though fewer cars are being lifted, nobody wants to walk out to his parking spot and find it empty. Anecdotal evidence

indicates that mid-1980s to late-'90s Japanese cars are highly prized owing to their lucrative parts market and easy hot-wiring, but we have a good, cheap solution for any car, new or old.

Since parking in safe-looking spots is about as effective as wishing on a star, installing a well-hidden kill switch is a smart way to deter potential thieves. These switches disrupt the flow of electricity at the battery or ignition switch or

A toggle switch like this is only a few bucks and can defeat even the savviest car kleptomaniac.

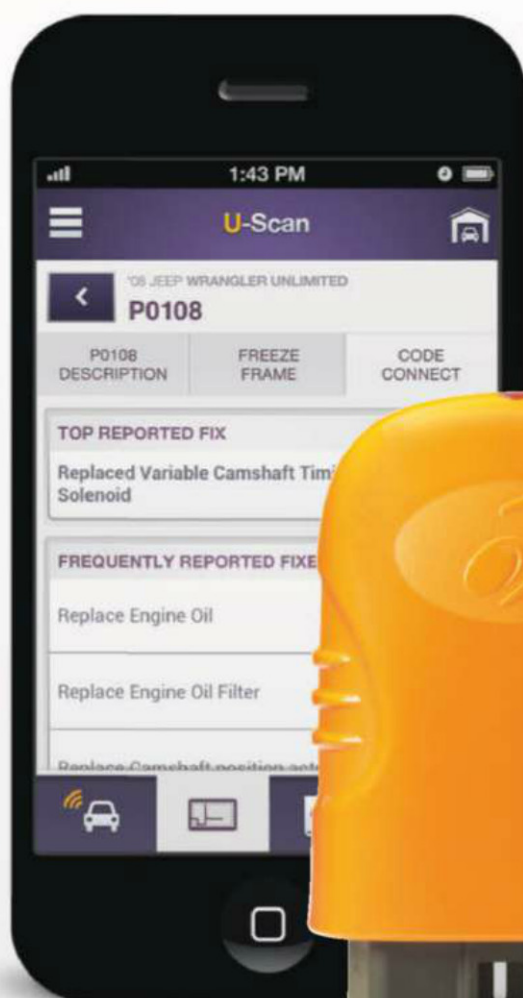
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DIY AUTO / CAR CLINIC



What you're doing is moving the thief to another vehicle, which is good for you but still bad for another guy. A kill switch is an effective tool to prevent vehicle theft. Just don't install it in the middle of the dash and label it **KILL SWITCH**.

◀ **Frank Scafidi, director of public affairs, National Insurance Crime Bureau**

disable the fuel pump. Any of these will quickly frustrate the bad guys into moving on to an easier target, but two or three will render a car virtually theft-proof.

Before making any modification, be sure to have a complete wiring diagram in hand, just so you're aware of which wires are which. The easiest method is to connect a simple on/off toggle to the positive circuit of the fuel pump. These small switches can be hidden and secured pretty much anywhere—under the seat, in the trunk, under the dashboard, in the glovebox—you're limited only by how much work you want to do running new wire. More involved but supereffective is fitting a racing-style battery-disconnect switch on the positive battery cable. This could be located under the hood, or the cable could be extended to put the switch under or beside the driver's seat (be sure to use 0-gauge cable and a heavy-duty rotary switch). The downside of this approach is that disconnecting the battery will reset the radio settings every time—no power means no memory features. The trickiest option is an ignition kill switch. Using your wiring diagram, find the wire responsible for activating the starter solenoid and install a switch as far from the ignition as possible in that circuit (you don't want the potential crook to easily find it).

Or, if you just want to do it the free and inconvenient way, pull the fuel pump relay from the main fuse box (usually under the hood) as you're stepping out of the car and put it in your pocket: 100 percent effective.

A Furry Disaster

I have a dog, a big slobbery one, and although I love taking him with me on car rides, cleaning up the hair on the seats and slobber on the windows afterward almost makes me want to leave him home. How can I lessen his mess?

Dogs are great company on rides around town; however, they routinely lack the manners to clean up after themselves. I have a few suggestions to reduce the mess, although I doubt anything will eliminate it completely. The first is to have a dedicated blanket to drape over the dog's seat (we recommend the back bench—in accidents an airbag can cause serious pooch injuries). A cheap felt blanket is probably best because it's a magnet for hair. Label the "dogward" side with a paint pen so you can lay it hair side up and shake it out after you get home. Even with this in place, stray hair make its way to the floor and into cracks. A lint roller can pick up small amounts quickly, but if the fur gets out of hand, resort to a vacuum with a few hose attachments to make the inside livable again.

As to the drooled-on windows, put a layer of plastic wrap on the inside of the glass before each outing. Race car drivers use tear-off plastic sheets on the visors of their helmets that they yank away as they get dirty, leaving a clear view. Slobbered-up plastic wrap peels off the same way and leaves crystal-clear windows that won't need to be scrubbed down. **PopMech**

GOT A CAR PROBLEM? ASK BEN ABOUT IT.



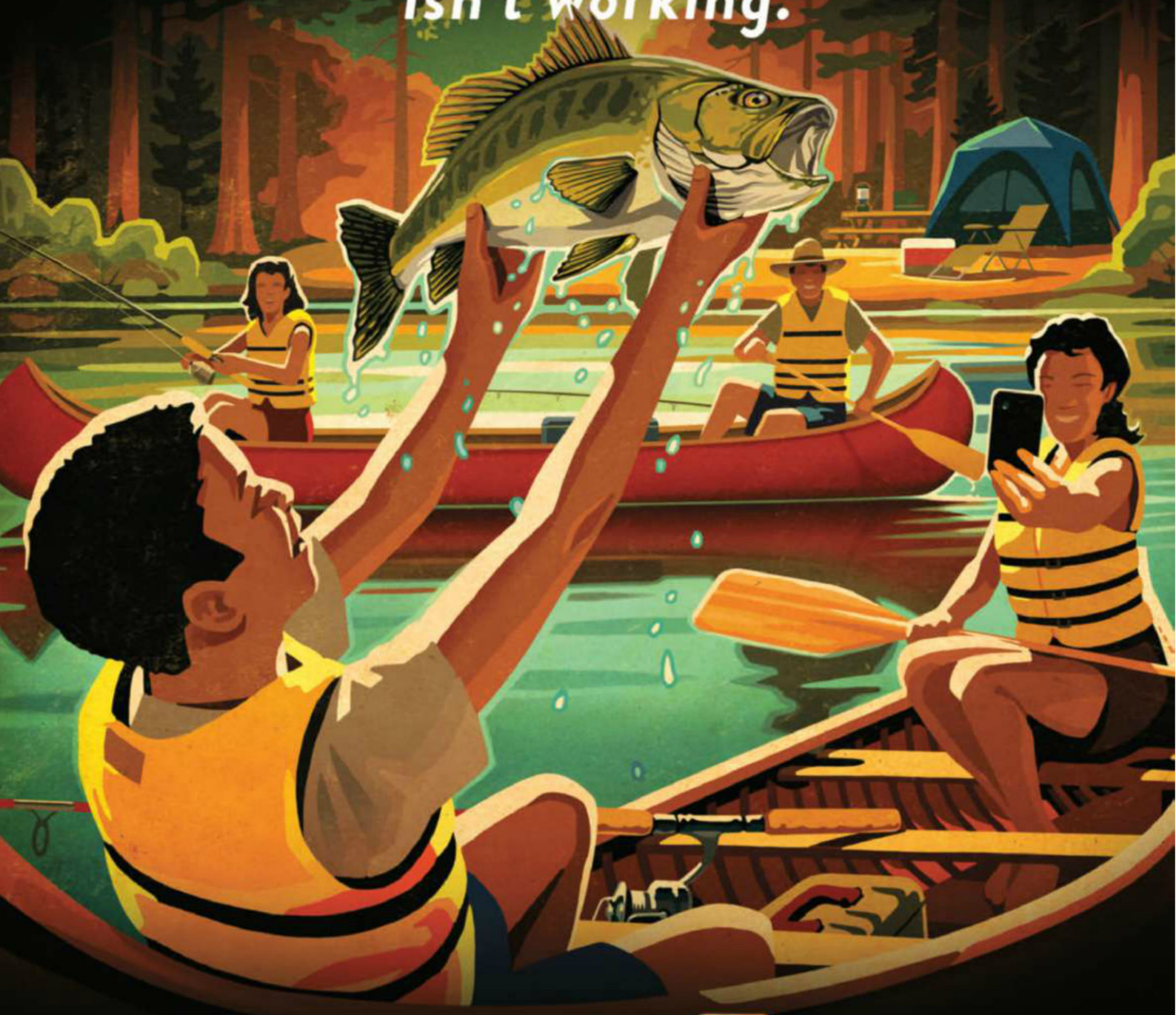
Send your questions to pmautoclinic@hearst.com or over Twitter at @PopMechAuto or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we can't answer questions individually, problems of general interest will be discussed in the column.

W

WEEKEND



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diy

Home

- PRIVACY SCREEN
- PALM SANDERS
- ANT-FREE HOME



u

WEEKEND

Tools Needed

- ☐ Miter saw
- ☐ Table saw with sliding miter gauge
- ☐ Dado set
- ☐ Jigsaw
- ☐ Clamps
- ☐ Palm sander
- ☐ Sanding block
- ☐ Sandpaper (120-, 150-, 180-, and 220-grit)
- ☐ Cordless drill
- ☐ Drill press or drill-guide attachment
- ☐ Flush-cutting handsaw

It's a weekend project, but this heirloom-quality Adirondack chair is worth the time investment.



THANKS TO CRAFTY JOINERY AND CONTEMPORARY STYLING, A BACKYARD BEAUTY GETS A WELL-EARNED MAKEOVER. BY TED KILCOMMONS

THE NEW ADIRONDACK

For more than a century the Adirondack chair has been synonymous with casual but elegant outdoor lounging. I've updated this American classic with a modern slat design that recalls George Nelson's 1940s platform bench but retains the original's low-slung comfort. I also left ample room on the armrests for beverages and snacks.

The most efficient way to build this chair is to mill all the parts first before completing the joinery and then to assemble the piece. This avoids having to switch back and forth between your table saw's ripping blade and the stacked dado set, which you'll use to cut the half-lap joints. Don't have a dado set? Don't worry—you can complete the joinery without one. Use a handsaw, miter saw, or table saw to make the shoulder and relief cuts at the correct depth, then remove the waste with a sharp, flat chisel.

1 / MILLWORK

BEFORE YOU START

• I used 2 x 10 planks of vertical-grain western red cedar for this chair, as it's naturally weather-resistant. Any lumber will do, but apply a preservative to woods that don't fare well outdoors, such as pine and Douglas fir. Avoid wasting material by first figuring out how you'll cut up the lumber (see page 116). Then crosscut the planks into more manageable pieces.

BACK AND SEAT SLATS

• Crosscut two pieces 37 inches long and one piece 17 inches long, and rip them into 1½-inch strips. Using a miter saw, cut blanks for eight back slats and seven seat slats that measure ¾ inch longer than their finished lengths. Each piece should have a freshly cut square end. To bevel the other end on the table saw, tilt the blade 20 degrees and attach a stopblock to the miter gauge at 36 inches for the back slats and 16 inches for the seat slats [1].

REAR LEGS

• Crosscut two 30-inch pieces. Ensure both legs are exactly the same by making a plywood template according to the plan on page 116. Lay out each leg so the long side is against the

edge of the blank [2]. Cut out with a jigsaw or circular saw. If needed, clamp a straightedge to the workpiece to guide the saw [3].

SUPPORTS

• Crosscut a 30-inch piece. Make the rear support by tilting the table-saw blade to 27 degrees and ripping a piece 2½ inches wide [4]. Trim this to 28½ inches long. From the remainder of the 30-inch piece, rip two 1½-inch strips. Trim one to 22½ inches for the back cross support and the other to 19½ inches for the seat cross support.

FRONT LEGS

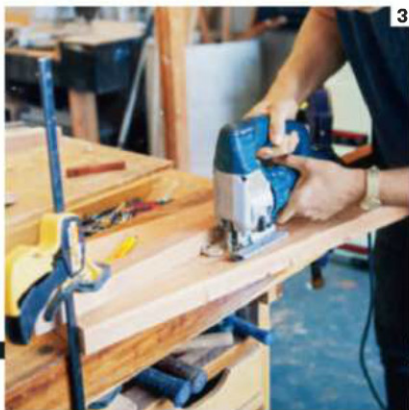
• Crosscut a 25-inch piece. Rip it into two 3-inch pieces and trim both to 24 inches long.

ARMS

• Crosscut a 25-inch piece. Rip it into two 4½-inch pieces and trim both to 23 inches to create blanks. Just as you did for the rear legs, make a plywood template and transfer the shape onto the blanks. Cut out with a jigsaw, using a straightedge as a guide.

FINISHING UP

• Sand all the parts, starting with 120-grit paper and working toward 220-grit. A palm sander will save time; if you don't have one, use a sanding block to make sure your work is even.





DIY HOME / ADIRONDACK CHAIR



2 / JOINERY

CUT HALF-LAP JOINTS FOR ARMS AND REAR SUPPORT

• Tilt the table-saw blade 20 degrees and, using the sliding miter gauge, make a cut in the underside of each arm $2\frac{1}{2}$ inches from the end and $\frac{3}{4}$ inch deep. Reset the saw to 0 degrees and install the dado set. Set it to a height of $\frac{3}{4}$ inch, and complete the half-lap joint by removing the waste [5]. Cut a corresponding joint 3 inches wide and $\frac{3}{4}$ inch deep in each end of the rear support.

CUT HALF-LAP JOINTS FOR SLATS

• Using the sliding miter gauge and the dado set, positioned to a height of $\frac{3}{4}$ inch, cut $1\frac{1}{2}$ -inch-wide half-lap joints in the square ends of the slats [6]. These joints will house the cross supports.

DRILL HOLES IN SLATS

• The back and seat are held together with a dowel that passes through a hole in each slat. Using an awl, mark the hole's location on the side of each piece so that it's centered along the width and positioned $\frac{3}{4}$ inch from the beveled end. Bore a $\frac{5}{8}$ -inch hole in each slat with a drill press or a drill with a guide attachment.

CUT HALF-LAP JOINTS FOR CROSS SUPPORTS

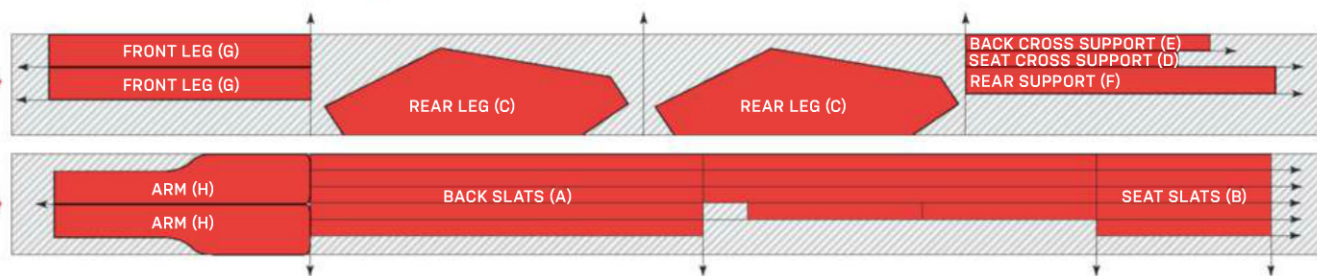
• You can mark the locations of these half-lap joints one of two ways: Use a tape measure and mark every $1\frac{1}{2}$ inches to establish each side of the joint, or dry-assemble the seat and back and then hold the cross supports in position. Either way, mark an X on the waste areas to avoid confusion when cutting them out. Cut the joints $\frac{3}{4}$ inch deep and $1\frac{1}{2}$ inches wide with the dado set [7].

Shopping list

- Two 10' planks of 2 x 10 lumber
- One 3' length of $\frac{5}{8}$ " dowel stock
- 22 2" No. 8 stainless-steel wood screws
- Four 1" No. 8 stainless-steel wood screws
- Scrap plywood for templates
- Exterior-grade PVA wood glue

Part Qty. Size and Description

A	8	$1\frac{1}{2}$ " x 36" (back slats)
B	7	$1\frac{1}{2}$ " x 16" (seat slats)
C	2	$9\frac{1}{2}$ " x 30" (rear-leg blanks)
D	1	$1\frac{1}{2}$ " x $19\frac{1}{2}$ " (seat cross support)
E	1	$1\frac{1}{2}$ " x $22\frac{1}{2}$ " (back cross support)
F	1	$2\frac{1}{2}$ " x $28\frac{1}{2}$ " (rear support)
G	2	3" x 24" (front legs)
H	2	$4\frac{1}{2}$ " x 24" (arm blanks)



= SCRAP



8



9

**EXPERT
tip**

AVOID MESSY FINISHES WITH A DRY RUN.

PVA wood glue sets fast—often in less than 20 minutes—so prepare yourself for any challenges by first performing a dry run. Work through all the steps as if you were assembling the piece—but without the glue. Note which clamps and fasteners you used and whether you need to trim any joinery, and resolve any problems you encountered.



10

11



3 / ASSEMBLY

GLUE ARMS TO REAR SUPPORT

- Spread a thin layer of glue on each joint, and clamp. Drill two evenly spaced holes through the joint with a $\frac{3}{8}$ -inch countersink bit, and fasten with 1-inch screws. Plug the holes with $\frac{3}{8}$ -inch dowel glued into place and trimmed flush [8].

GLUE SEAT AND BACK ASSEMBLY

- Organize back and seat slats, and spread glue everywhere they meet and in each hole. Slide a 24-inch dowel through each hole to tie the slats together [9]. If you encounter

some resistance, tap the dowel into place with a mallet.

Rip a 20-degree bevel into a 24-inch piece of scrap, and apply masking tape to the angled side. Clamp this to your workbench and use it to set the seat and back assembly at the correct angle. Glue and clamp each cross support to the slat assembly using cauls made from scrap lumber to ensure each joint is tight. Let the assembly cure for a couple of hours [10].

ATTACH LEGS

- Hold each rear leg in place and countersink two evenly spaced holes through the seat slat and into the top of the leg. Spread glue on the joint and fasten with 2-inch screws.

Make a reference mark on each front leg 17 inches from the bottom. This is where the leg aligns with the

top of the seat. Glue and clamp each leg flush with the front edge of its corresponding back leg. Countersink two evenly spaced holes through the back leg and into the front leg. Drill another hole through the front leg and into the seat assembly. Fasten with 2-inch screws.

ATTACH REAR SUPPORT

- Set the chair upright, and position the back support—arm assembly so it wraps around the back and sits level on the front legs. Attach it to the front legs by countersinking two evenly spaced holes and driving 2-inch screws down into the leg. To attach the rear support to the seat back, drill through the support and into each slat and fasten with 2-inch screws. Plug holes with dowel stock and trim flush [11].



Tool Test

QUARTER-SHEET SANDERS

WITH ITS LIGHT WEIGHT AND SMALL SIZE, THE QUARTER-SHEET SANDER IS TRULY USEFUL FOR SUMMER PAINTING AND REPAIR WORK. SO WE GATHERED 11 AND SANDED HARDWOOD AND SOFTWOOD. THEN, USING 60-GRIT PAPER, WE TIMED THEM AS THEY REMOVED TWO LAYERS OF LATEX PAINT A FOOT SQUARE FROM MDF. TWO INEXPENSIVE PRO MODELS TIED FOR FIRST, AND THERE ARE OTHER LOW-COST OPTIONS. FOR LESS MONEY THAN A BAG OF GROCERIES, YOU CAN SAND WITH SPEED AND EASE. *BY ROY BERENDSOHN*

It's
a Tie for
Best
Overall!

RIDGID R2501

RANKING ★★★★★

Price: \$50**Weight:** 3.8 pounds**Amperage:** 2.4**Time trial:** 1 minute,
40 seconds

Likes: Sanding speed, a comfortable shape, sanding quality, and a lack of vibration enabled the Ridgid to tie for first place. Its sandpaper clamp is second only to the Bosch's for a secure grip and ease of use.

Dislikes: None.



▼ **BLACK & DECKER**
QS900

RANKING ★★★★★

Price: \$30**Weight:** 2.6 pounds**Amperage:** 2.0**Time trial:** 1 minute,
48 seconds

Likes: The B&D sands well, and it's fast too. Its hard-body dust collector with a paper filter ensures that it cleans up after itself.

Dislikes: Uncomfortable vibration and a stubby 6-foot cord.



▼ **BOSCH**
1297D

RANKING ★★★★★

Price: \$50**Weight:** 3.3 pounds**Amperage:** 2.0**Time trial:** 1 minute,
58 seconds

Likes: What it lacks in speed the Bosch model more than makes up for in vibration-free sanding. And it has the industry's best sandpaper-clamp mechanism.

Dislikes: None.



▼ **CHICAGO
ELECTRIC**
95020

RANKING ★★★

Price: \$23**Weight:** 2.9 pounds**Amperage:** 2.0**Time trial:** 3 minutes,
29 seconds

Likes: If your tool preference runs to basic equipment and 1970s pricing, look no further. This comfortable tool will get the job done.

Dislikes: It does sand well, but it's a bit on the slow side.



▼ **CRAFTSMAN**
27670

RANKING ★★★★★

Price: \$50**Weight:** 3.7 pounds**Amperage:** 2.4**Time trial:** 1 minute,
47 seconds

Likes: Very little vibration is transmitted to its handle. It also feels good to operate, due to plentiful rubber overmold and a nice shape.

Dislikes: Could use better dust pickup.



▼ **DEWALT**
D26441

RANKING ★★★★★

Price: \$49**Weight:** 3.7 pounds**Amperage:** 2.4**Time trial:** 1 minute,
45 seconds

Likes: Good sanding speed and rugged construction make this a perfect choice for outdoor woodworking and painting projects.

Dislikes: Bent-wire sandpaper clamp is primitive.



WEEKEND

w



▼ **MASTER MECHANIC**
134465

RANKING ★★★★★

Price: \$25

Weight: 3.2 pounds

Amperage: 2.0

Time trial: 1 minute, 50 seconds

Likes: Reasonably fast, and good dust collection with a hard-body dust-collection container.

Dislikes: Narrow nozzle on dust container prevents easy emptying.



▼ **PORTER-CABLE**
380

RANKING ★★★★★

Price: \$39

Weight: 3.0 pounds

Amperage: 2.0

Time trial: 1 minute, 49 seconds

Likes: This tool looks bland, but it sands remarkably well and quickly, with a lack of vibration transmitted to the grip surfaces.

Dislikes: The disc-shaped top is uncomfortable.



▼ **RYOBI**
S652DK

RANKING ★★★★★

Price: \$30

Weight: 3.5 pounds

Amperage: 2.0

Time trial: 1 minute, 51 seconds

Likes: The Ryobi is reasonably fast and very comfortable. We also like its 10-foot cord.

Dislikes: The dust bag's nozzle-shaped front and semirigid frame make it difficult to empty.



▼ **SKIL**
7292-02

RANKING ★★★★★

Price: \$30

Weight: 2.8 pounds

Amperage: 2.0

Time trial: 2 minutes

Likes: A good tool for beginners, it's equipped with a pressure-control light that tells you if you're bearing down with too much force.

Dislikes: The second-slowest sander in the test.



It's
a Tie for
Best
Overall!

tip

EASY DOES IT

You can't lean on a sander and grind off the top layer of wood and expect the workpiece will be ready to finish. The only way to get a smooth, properly abraded surface is to apply light and even pressure to the sander and move it in a slow and steady sanding motion. It's also important not to overwork the paper. When the paper stops cutting, replace it with a fresh piece.

◀ **MILWAUKEE** 6020-21

RANKING ★★★★★

Price: \$49

Weight: 3.6 pounds

Amperage: 3.0

Time trial: 1 minute, 26 seconds

Likes: The Milwaukee sped to a first-place finish in our time trials, but it's more than just fast. It also handles nicely, has good dust collection, and delivers a well-sanded surface.

Dislikes: None.



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DIY HOME

Brothers Will, 5, and Adam, 8, Raymond try to catch a falling star after detonating their popper.

HOW TO BUILD IT



DEGREE OF
DIFFICULTY
2/10

AGES: 5+

BUILD TIME:
30 MINUTES

PARTS COST:
ABOUT \$10

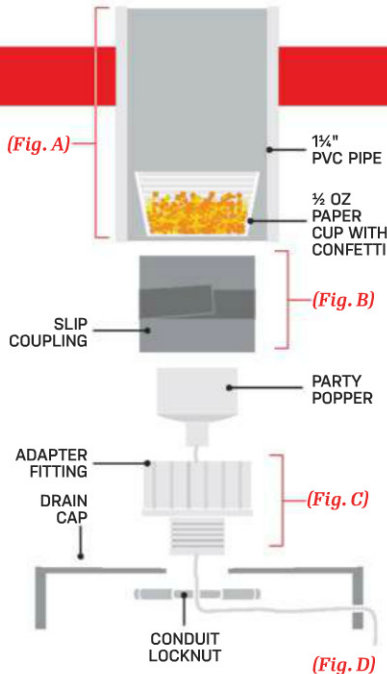
PARTY POPPER "MINE"

Early Adopter

EVERY PARTY HAS A POPPER—OR AT LEAST, IT SHOULD. BUILD THIS "MINE" TO FIRE OFF SPARKLING CONFETTI AT YOUR KID'S NEXT BASH.



In fireworks lingo, a mine is a device that shoots sparks out of a mortar tube. No dangerous explosives here; instead we utilized everyday party poppers to launch colorful trails of confetti. This project is a playful introduction to the world of pyrotechnics. Youngsters building the popper will wonder what exactly makes it pop (answer: compressed air) and how that energy forces the confetti out of the tube. But all that physics stuff aside, who are we fooling? The best part for the kids (and the adults) will be pulling the trigger on this explosive device, no matter the occasion. — WILLIAM GURSTELLE



PREPARE THE MINE

1. Refashion the $\frac{1}{2} \times \frac{3}{4}$ -inch adapter fitting (Fig. C) by sanding its ridges until it can be inserted into the 6-inch-long PVC pipe (Fig. A).
2. Wrap four to five layers of masking tape around the center of the slip coupling (Fig. B).
3. Drill a centered $\frac{7}{8}$ -inch hole in the top of the 4-inch PVC drain cap (Fig. D).
4. Lay the drain cap on its side and drill a small hole, centered, in the side.

MODIFY THE POPPER

1. Remove the top paper disc from the wide end of the popper and take out all contents, including the paper streamers and the bottom paper disc.
2. Extend the popper string and firmly tie a 12-inch-long string to its end with a square knot. (You'll pull this extended line to set off the popper.)

ASSEMBLE THE COMPONENTS

1. Push the modified party popper into the adapter fitting with the string extended out through the threaded end.
2. Insert the adapter fitting through the drain cap. Secure the fit by fastening

it with the $\frac{1}{2}$ -inch conduit locknut.

3. Place the taped slip coupling over the exposed popper so that it nestles into the adapter fitting.
4. Slide the 6-inch-long PVC pipe over the assembly, forming the mortar tubing.
5. Thread the popper's string through the small hole in the side of the drain cap.

DECORATE

1. Paint or apply contact paper, duct tape, and/or stickers to the barrel and base as desired.

LOAD THE "AMMO"

1. Fill a $\frac{1}{2}$ -ounce portion cup (the kind that you put ketchup in at McDonald's) about a quarter full with confetti. (The less you pack, the higher the pop.)
2. Push the portion cup down the barrel of the mortar tube until it rests on the slip coupling.
3. Hold the base firmly with one hand and grab the string with the other. Pull smartly and enjoy the show!

MATERIALS

- One 1 1/2-inch diameter PVC pipe, 6 inches long ("A")
- One PVC fitting: $\frac{3}{4} \times \frac{3}{4}$ -inch slip x slip coupling ("B")
- One PVC adapter fitting: $\frac{1}{2} \times \frac{3}{4}$ -inch slip x MNPT ("C")
- One 4-inch PVC DWV drain cap ("D")
- One $\frac{1}{2}$ -inch male adapter conduit locknut or one $\frac{3}{4}$ -inch conduit locknut
- Party poppers
- Confetti
- One $\frac{3}{4}$ -ounce paper portion cup (McDonald's ketchup cup)
- One 12-inch-long string
- Masking tape
- Drill with $\frac{3}{8}$ -inch bit and $\frac{7}{8}$ -inch spade bit
- Sandpaper
- Contact paper/decorative duct tape, paint, stickers

Special thanks to Arthur Tilford, a veteran of aerospace technology, for his original design of this project.

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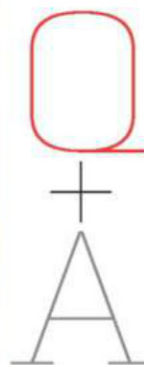
BY DAVID AGRELL AND
ROY BERENDSOHN

PHOTOGRAPH BY
REED YOUNG

We built this privacy screen just tall enough to hide a pair of trash cans. To avoid a muddy mess when it rains, we spread a 2-inch-thick layer of crushed stone on the ground.

The Great Cover-up

My yard is littered with unsightly items such as garbage cans and a generator. It's all essential stuff that I can't get rid of, but it's a mess. I might as well have a rusty old Dodge out there too. Any suggestions for bringing order to the outside?



Often our homes look better because of what we can't see rather than what we can. In other words, your best bet is to hide that stuff behind a privacy screen that complements your home's architecture.

We built ours for special projects editor Joe Bargmann to hide a pair of 30-gallon garbage cans at the end of his driveway. "We wanted to keep the trash away from the house without upsetting the neighbors," Joe says. We used off-the-shelf supplies from our local home-improvement center and put it together in an afternoon.

When designing your screen, don't forget that whatever you're hiding needs to be accessible. You're not building a closet. We built an L-shaped screen and attached it to an existing fence to create a three-sided structure. With one side open away from the street, Joe can easily fill the cans and the city can remove them unhindered on trash day. No fiddly door here. We also didn't add a roof, which would have made it impossible to flip the lids off the cans without pulling them out first. We left 6 inches of clearance around the cans so they slide in and out easily. Keep in mind that if you build a screen around a generator, make sure you can still access its

GLOSSARY

HOSE BIB

Also known as a wall hydrant, a hose bib is a water faucet with a threaded nozzle that typically accepts a garden or washing machine hose. Most hose bibs are also bibcocks, which means their nozzles bend downward.

W

WEEKEND



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controls and maintenance points—and don't block the exhaust vent.

To make the side panels, we started with 8 x 4-foot sheets of cedar lattice. Most home centers and lumberyards also stock lattices made of pressure-treated wood or vinyl, which is available in a variety of colors. Cut these to size with a circular saw (watch out for nails and staples) and then sandwich them between a frame made of 1x stock. Don't forget to use fasteners rated for outdoor projects, such as stainless-steel screws or hot-dipped galvanized nails. Attach these panels to pressure-treated 4 x 4 corner posts set in the ground or in pre-cast concrete deck blocks, which is what we used. Another solution is to fasten the panels to 36-inch-long 2 x 2 stakes driven 12 inches into the ground. You could build a portable screen that isn't secured to anything, but don't expect it to survive a gust of wind. Cap the panels and posts with a rail.

Joe stained his screen gray to match the color of his house, though he also considered letting it weather gradually in order to blend in with its rustic surroundings.

Finally, before installing a structure that significantly changes the way your home looks, check for any local ordinances or neighborhood covenants that may limit what you can build. Plus, it's always common courtesy to let your neighbors know what you're doing—though chances are they'll appreciate the upgrade. "Every one of our neighbors has stopped by to thank us for putting our screen up," Joe says. "They couldn't be happier."



GOT A HOME-MAINTENANCE OR REPAIR PROBLEM? ASK THE EDITORS.

Send your questions to pmhomeclinic@hearst.com or to Home Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



TOOL OF THE MONTH

SKILSAW MAG77LT (\$219)

Skil's worm-drive saw has changed little in its 75 years as "the saw that built America." But its near-infallible design and beefy 15-amp motor is not without heft: The standard model weighs 17 pounds. That's like cutting lumber with three house bricks strapped to your arm. The MAG77LT, however, uses magnesium parts to help shave 4 pounds off the aluminum-and-steel original and 2 pounds off previous magnesium editions.

WHY WE LIKE IT

It's lighter, sure, but the MAG77LT is still more saw than we'll ever need. Its high-torque motor is everything we'd expect from a Skilsaw, and on a recent demolition job it tore through two layers of subfloor without a whimper. The rubberized handle is comfy, and the redesigned one-piece foot plate feels sturdier than its predecessor's.

Broken Nosing

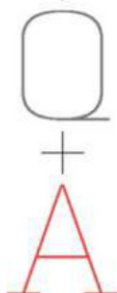
I fell on my butt while walking downstairs and broke off a stair tread's nosing. Can I fix it?

It's easy. Hold the nosing in place, and bore a series of pilot holes through it and into the tread. Apply a thin film of carpenter's glue to the nosing and the tread, and use 6d or 8d finishing nails to reattach the parts. Set the nailheads, and when the excess glue has turned rubbery, skim it off with a sharp chisel. Don't wait until the glue has hardened—by then it will be too difficult to remove. Hide the fix with color-matched putty over the nailheads.

Ant Invasion

We finally got rid of our ant infestation this winter, but now they're back. Any suggestions that don't involve toxic insecticides?

Ants invade houses to forage for food, especially during cold, rainy winters and again during hot, dry summers. Without insecticides you'll have to make life difficult for them so they'll eventually move on. First, figure out how they're getting in, and then try to block their access. Apply weather stripping to windows and exterior doors, and caulk cracks in foundations and walls. If you can't seal these entry points, use a nontoxic insect repellent there instead. We've heard of people using everything from mint tea to artificial sweeteners to commercial products such as Orange Guard—all with varying results. Do some Internet research and brew your own; you might be surprised how effective it is. Or isn't. Finally, your ants are probably workers scouting for food, so keep your countertops and floors clean, especially near doors, windows, and anywhere else you think they're getting in. **PopMech**



W

WEEKEND

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diy

Tech

- AUTOMATING A/C
- STREAMING VIDEO FROM OVERSEAS
- CREATING PERSONALIZED KEYBOARD SHORTCUTS



TECH MYTHS, DEBUNKED

PM DISPELS THE MOST FRUSTRATING FALSEHOODS OF THE DIGITAL AGE.

BY MELANIE PINOLA



Sorry, Minotaur, five bars of signal and your text to King Minos still won't go through.



Tech lore has it that Macs never get viruses, PCs are terribly fragmented, and if you jailbreak your phone, you're going to jail. Though many common tech myths are harmless, others can waste your time and even leave you dealing with digital snafus. Here, we explore some of the most prevalent untruths to finally put them to rest.



JAILBREAKING AND ROOTING ARE ILLEGAL

Smartphone owners can jailbreak their iOS devices and root their Android phones to get around the restrictions of manufacturers and carriers. But is this ominous-sounding practice legal? The word itself—jailbreaking—makes it sound like the process is illegal. In actuality, it's more complicated: The technique both is and isn't illegal under U.S. copyright law. Last fall, when the Library of Congress updated the rules for 2013 through late 2015, it decided that you can legally jailbreak your smartphone (though you'll void your Apple warranty) but not necessarily your tablet, because, the Library says, "tablets" is an ill-defined category. What is definitely *not* legal is unlocking your phone. The Library's ruling prohibits tinkering with your device so it works on different cellular networks without your wireless carrier's permission, which is subject to as much as \$2500 in fines, or even jail time.

Legal questions aside, is jailbreaking worth the trouble? Nearly 7 million iOS users who cracked their devices using the latest jailbreak since it became available in February say yes. And as for the riskiness of jailbreaking an iPad, just consider: Despite the law, absolutely no one has (yet) been prosecuted or fined.



MORE BARS EQUALS BETTER MOBILE SERVICE

If your phone has five bars, you'll get the best wireless service performance, right? Well, no. Those bars indicate your signal strength to the nearest cellular tower, but if many other people are also connected to that tower, you can still experience dropped calls and poor speed due to the congestion caused by networks' limited capacities. For instance, it might take about a square block of people in Manhattan to overload a single cell tower, whereas in Wyoming, it would take a population spread over 15 square miles.

And even if you capture some of that service, speed varies by network provider. According to wireless-coverage mapper RootMetrics, AT&T has the fastest LTE data network, followed by Verizon and then Sprint.



LED AND LCD ARE DIFFERENT SCREEN TECHNOLOGIES

This is more of a technicality, but "LED" screen is a bit of a misnomer. It is not a new kind of display, as some retailers might assert, but rather a type of LCD television. The only difference between a so-called LED TV and a regular LCD TV is the type of backlighting: Though both rely on LEDs to form the picture, LED displays also use light-emitting diodes (LEDs) to illuminate

the display, whereas non-LED sets use fluorescent backlights.

So which is better? That depends. LED-backlit LCDs come in two configurations: Some have a full array of LEDs behind the LCD, others have LEDs just on the edges. Edge-lit TVs tend to be thinner,

while full LED-backlit screens can do tricks such as "local dimming" to increase contrast in dark sections of an image. Regardless, all LED sets have two distinct advantages over conventional fluorescent LCDs and plasmas: They are more energy-efficient, and they last longer. If you plan to keep your set for a while, go with LED.



IT DOESN'T MATTER IF YOU KEEP YOUR LAPTOP ALWAYS PLUGGED IN

Speaking of life spans, you might also have come across advice

saying that if you have a lithium-ion battery in your laptop, you don't ever have to completely drain it the way you needed to with older nickel-metal-hydrate laptop batteries. This is false if you want to get the most out of your battery. For one thing, if your plugged-in laptop gets hot while you use it and the battery is charged fully, all you're doing is exposing the battery to heat, which will make it age more quickly. Besides heat, the other extreme that shortens Li-ion battery life is high voltage—like the high voltage maintained by a charger after the battery is full. Keep the battery just below a full charge by keeping it active, and when you do charge it for a long time, do it when the computer is off to avoid blasting it with extra heat.

You need to be careful about charging only if your computer doesn't include battery-management software, as many made by Lenovo,



Sony, and Samsung do. For computers that don't automatically optimize charging, the advice on how often to charge and discharge their batteries varies. Apple recommends getting battery juices flowing by using the computer unplugged from time to time—though not too many times, since Li-ion batteries have limited charge cycles (each cycle is from complete charge to complete discharge). No matter what, though, Li-ion batteries will eventually lose capacity; expect to get about two to three years of good charges.



MACS DON'T GET VIRUSES

In the raging Mac-versus-PC debate you'll usually find at least one Apple loyalist claiming Macs are immune to viruses. Apple itself has contributed to this myth (remember that "I'm a Mac" ad in which the poor PC guy gets sick with a virus while Mac is unconcerned?), but after the Flash-back virus crisis last summer, which affected around 250,000 Macs, Apple quietly changed its "virus-free" sales pitch on its Mac page from "It doesn't get PC viruses" to "It helps keep you safe." It's a subtle but significant change. While it's true PCs get more viruses and malware than Macs, that's mostly because attackers target the more widely used Windows operating system. Now that Apple computers are growing rapidly in market share, however, Mac users may need to be more cautious.

So, do you need an antivirus program for OS X? Probably, though don't assume it will keep you entirely safe. No antivirus program will catch 100 percent of all viruses, and some antivirus software can cripple your system's performance. The first and foremost defense against malware is safe browsing habits. Still, unobtrusive software such as the free Sophos Anti-Virus for Mac Home Edition can give you peace of mind by protecting your not-so-invincible system.



THE MORE MEGAPIXELS A CAMERA HAS, THE BETTER THE PICTURES



The camera on the **NOKIA 808 PUREVIEW** captures 33.6 million pixels—almost eight times more than can be displayed on the **GOOGLE CHROMEBOOK PIXEL**, which has the highest-resolution computer screen available.



New 18-megapixel cameras might make your 6-megapixel seem obsolete, but the emphasis on megapixels in the camera world reflects marketing spin as much as technological superiority. It's true that more megapixels means more detail in larger photos. That detail, though, depends not just on pixel count but also on the camera's sensor: The larger it is, the more light data it can pick up, and the more detailed your images will be. If you add megapixels without increasing the overall size of the sensor, you reduce the amount of light reaching each pixel. Your point-and-shoot camera may have 20 megapixels, but if its sensor is the size of a pinhead, your photos won't look so great.

According to camera reviewer and self-proclaimed "Forrest Gump of photography" Ken Rockwell, "10 megapixels is more than enough for anything," and even just 6 will probably be good enough (most new cameras tend to come with at least 12). The goal, Rockwell says, is a sharp photo, not tons of pixels.



TO GET THE BEST HD EXPERIENCE, YOU NEED EXPENSIVE CABLES

You can spend \$3 on an HDMI cable, or you can spend \$2000. But when it comes to these cables, the you-get-what-you-pay-for maxim doesn't apply. Premium-cable manufacturers would have you believe gold-plated connectors and "high-density triple-layer metal-to-metal shielding" give you a better signal and, therefore, the ultimate picture and audio performance. But generic—and cheaper—cables will deliver the same picture and audio quality. Signal over an HDMI cable is digital; it either comes through or it doesn't.

There are, however, some cases in which spending more is a good idea. For example, if you need a very long cable (more than 6 feet), skip the cheapest ones, since poorly made cables are more likely to impede the signal at longer distances. For the record, unless you don't care at all where your money goes, no one should spend two grand on a cable.



EMPTYING THE TRASH OR RECYCLE BIN PERMANENTLY DELETES FILES

It would make sense that deleting a file would actually delete it. But when you empty the Recycle Bin (Windows) or Trash (Mac), the data aren't erased, only the links to the complete files are. A computer told to delete a file won't actually remove it but will instead deallocate the space it takes up on the hard drive, opening that space up to be written again. That means bits of information still remain, and any snooping hacker could piece them together to rebuild what you thought was gone forever.

To truly and permanently delete files, you have to instruct your computer to go a step beyond emptying the Trash or Recycle Bin. On a Mac, choose "secure empty Trash"; on a PC, you have to work in the command-line interface of Sdelete, a free program that allows you to totally wipe either

W

WEEKEND

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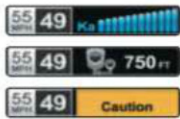


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all free space or only specific files.

There is an upside: If you accidentally delete something and must get it back, in theory, you can.



PRIVATE/INCOGNITO BROWSING PROTECTS YOUR PRIVACY

Here's one last downer. The "private browsing" feature of your browser

isn't as private as it suggests. The setting tells your browser not to do its usual job of saving information about which pages you've visited or about what you've typed into forms. It does not, however, keep you anonymous. Websites, ad trackers, and your ISP can still record your visits, and files you download will still remain on your computer or mobile device. Even worse, a 2010 study by Stanford University found that some browser add-ons store information about your browsing even while in private mode.

If you're wondering what you can do to stay anonymous online, you'll need to use a proxy server, such as Tor, so you appear to be somewhere and someone else as you surf, or a VPN, which can secure and encrypt your information. Also, get in the habit of clearing your browser's cookies cache and history every week or so.

Digital Clinic

Cool Automation

Is there a way to turn on my window air-conditioning units from my office, so my house isn't hot when I get home?

BY RACHEL Z. ARNDT

PHOTOGRAPH BY BEN GOLDSTEIN

W

WEEKEND



If you had central air, the answer would be easy: Install a smart thermostat such as the Nest or Honeywell Wi-Fi Smart Thermostat. But even if you don't have central HVAC, you can still control window air conditioners from afar, so you always arrive home at the end of a sweltering summer day to a comfortable and cool house.

To pull it off, you'll need to plug your air conditioner into a smart outlet, which, in turn, plugs into your regular outlet. These can be controlled over the Internet via your smartphone or from Web portals. We like Belkin's Wemo Switch (in spite of its name) for its compatibility with If This Then That (IFTTT), an automating service, and ThinkEco's Modlet, which is used by some utility companies for demand-response programs. As long as your a/c unit isn't an industrial-size behemoth that requires 220 to 250 volts, and as long as it has either a manual control knob or, if it has digital controls, can restart after

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DIY TECH / DIGITAL CLINIC

tip

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SEARCH

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finds PowerPoint files that include airplanes

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SEARCH

finds recipes that don't include the word bananas

`recursion`

SEARCH

finds one of Google's many Easter eggs

a power outage, it should work fine. Both Belkin and Modlet have smartphone apps that pair with their respective switches and let you flip them on and off from anywhere. Keep in mind that you must leave your a/c on for either smart switch to work, since it turns the entire outlet on and off—stopping and starting the flow of electricity—not the specific device. (The same is true for other appliances, such as lights, that you plug into the Wemo.)

If remembering to remotely turn on the a/c ahead of time is too much for you, opt for the Modlet, which comes with scheduling capabilities, or turn to prewritten Wemo scripts from IFTTT (ifttt.com), such as one that turns on the Wemo every time the outside temperature reaches a predetermined threshold, and another that puts the Wemo on a set daily schedule. Next thing you know, you'll never have to lift a finger to an on/off switch again.

Shortcut Solutions

I use the keyboard shortcuts for cut, paste, and copy all the time on my computer. They're real timesavers, and I'd love to have a lot more of them. Is there any way to make my own shortcuts with my operating system?

Windows makes the process a bit tricky. But, with some free software, it's possible to give nearly any menu-item command in any program a keyboard shortcut. If you're keen on learning a niche scripting language that applies to only one program, use AutoHotkey, a powerful application that allows you to write a ton of shortcuts—for keyboard commands, for mouse buttons, and for shortened text inputs, among others. But if you're just looking to assign a quick window-close shortcut or two, try HotKeyz. The program comes with some hot keys already written, which serve as good reference for your own shortcuts based on, for example, if a window title includes the text *Microsoft* (you might want a specific command to close a Microsoft Word document).



On a Mac, keyboard shortcuts are included in the Keyboard section of System Preferences. There, find the application in which you want to use the shortcut, and enter the to-be-shortcut menu-item text *exactly* as it appears. Simultaneously press the keys you want to assign and, voilà, you're spared some mouse movement. So, for instance, if you want to make a shortcut to insert a page break in a Microsoft Word document, you'd choose Word as the application and then type Page Break, which is the exact menu text.

Video Without Borders

I've recently gotten into British soccer, but I can rarely catch the games on TV, and British sports websites' live streams don't work. Is there any way I can access them? Yes, by convincing them that you're in Great Britain, not the U.S. Before you start, you should realize that you're heading into murky legal waters. That's because doing this skirts video-streaming sites' region blocking, a practice they employ to protect copyrights (Hulu and Netflix, for instance, make it nearly impossible to watch their videos from abroad). If you thwart region blocking by making your computer appear to be in a different geographical area than it really is, you also thwart copyright law. You should, however, be safe in terms of hacking and the Digital Millennium Copyright Act, says Derek Bambauer, a professor of Internet law and intellectual property at the University of Arizona. But, he concedes, "we don't yet fully know the rules—we can guess from existing law, but it's an uncertain exercise."

The first step to this uncertain

process is downloading either a browser extension to reroute your Internet traffic or a VPN client. The simplest method is a browser extension such as Hola (hola.org), a peer-to-peer network through which your browsing travels, opening up region-blocked sites.

A VPN gives you more choices, such as where you want your Internet traffic to look like it's coming from. VPN programs encrypt your browsing, and once you're linked to another computer via VPN, your outgoing traffic will appear to come from that computer's IP address. Some sites block access through VPNs, but in general, using a VPN client such as StrongVPN or WiTopia lets you instruct your computer to show up as if it were in the U.K., and then you can watch as much *football* as you please. **PopMech**

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SUPER COUPON!

HaulMaster

SUPER-WIDE TRI-FOLD LOADING RAMP

LOT NO. 90018/69595/60334

Item 90018 shown

\$79⁹⁹ REG. PRICE \$144.99

64548102

SAVE \$65

1500 LB. CAPACITY

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SUPER COUPON!

CENTRALPNEUMATIC

17 PIECE AIR TOOL ACCESSORY KIT

LOT NO. 68236/61449

Item 68236 shown

\$4⁹⁹ REG. PRICE \$9.99

52648921

SAVE 50%

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SUPER COUPON!

Gordon

27 LED PORTABLE WORKLIGHT/FLASHLIGHT

LOT NO. 67227/60566/69567

Item 67227 shown

\$2⁵⁹ REG. PRICE \$5.99

67199917

SAVE 56%

Requires three AAA batteries (included).

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SUPER COUPON!

MECHANIC'S GLOVES

LARGE LOT NO. 93640/60447

X-LARGE LOT NO. 93641/60448

Item 93640 shown

\$3⁵⁹ REG. PRICE \$9.99

645908152

SAVE 64%

YOUR CHOICE!

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SUPER COUPON!

300 LB. CAPACITY

17 FT. TYPE 1A MULTI-TASK LADDER

LOT NO. 67646

Item 67646 shown

\$114⁹⁹ REG. PRICE \$169.99

65776133

SAVE \$55

23 CONFIGURATIONS

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SUPER COUPON!

PITTSBURGH

16 OZ. HAMMERS WITH FIBERGLASS HANDLE

CLAW LOT NO. 47872/69006/60715/60714

RIP LOT NO. 47873/69005/61262

Item 47872 shown

\$2⁹⁹ REG. PRICE \$7.99

17108822

SAVE 62%

YOUR CHOICE!

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SUPER COUPON!

HaulMaster

500 LB. CAPACITY ALUMINUM CARGO CARRIER

LOT NO. 92655/69688/60771

Item 92655 shown

\$69⁹⁹ REG. PRICE \$129.99

87715294

SAVE \$60

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SUPER COUPON!

PITTSBURGH PRO

TORQUE WRENCHES

1/4" DRIVE LOT NO. 2696/61277

3/8" DRIVE LOT NO. 807/61276

1/2" DRIVE LOT NO. 239

Item 239 shown

\$9⁹⁹ REG. PRICE \$34.99

34833625

SAVE 71%

ACCURACY WITHIN ±4%

YOUR CHOICE!

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SUPER COUPON!

PORTABLE GARAGE

LOT NO. 69039/68217/60727

Item 69039 shown

\$174⁹⁹ REG. PRICE \$299.99

14500060

SAVE \$125

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SUPER COUPON!

PITTSBURGH PRO

7 PIECE RATCHETING COMBINATION WRENCH SETS

SAE LOT NO. 96654

METRIC LOT NO. 95552

Item 96654 shown

\$17⁹⁹ REG. PRICE \$39.99

96753945

SAVE 55%

YOUR CHOICE!

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SUPER COUPON!

drillmaster

18 VOLT CORDLESS 3/8" DRILL/DRIVER AND FLASHLIGHT KIT

LOT NO. 68287/69652

Item 68287 shown

\$19⁹⁹ REG. PRICE \$44.99

93693262

SAVE 55%

Includes one 18V NiCd battery and charger.

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SUPER COUPON!

WINDSOR DESIGN

60" WORKBENCH WITH FOUR DRAWERS

LOT NO. 93454/69054

Item 93454 shown

\$139⁹⁹ REG. PRICE \$229.99

76450945

SAVE \$90

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BY AMANDA GREEN

Prototype of Lonnie Johnson's Power Drencher, later renamed the Super Soaker.

1896: The cast-iron USA Liquid Pistol—said to “stop the most vicious dog (or man), without permanent injury”—is patented. A menacing rubber squeeze bulb and tube load the ammo.

1906: Soren Sorensen Adams founds the Cachoo Sneeze Powder Company. The prettiest prank in his bag of tricks: the water-streaming lapel flower.

1936: Space hero Buck Rogers fired ray guns. His earthbound fans settle for the XZ-44 Liquid Helium Toy Water Pistol, which is now on display at the National Air and Space Museum in Washington, D.C.

1940s: Abbott and Costello spray each other with seltzer bottles while becoming a favorite comic duo.

1977: The Cosmic Liquidator sounds like a businessman's worst nightmare, but it's actually the name of the first air-pressurized water gun.

1985: The first battery-powered automatic water guns, invented by Alan Amron, employ an electric motor instead of an index finger.

1987: Long before *Twilight*, a group of teenage boys fight vampires with guns loaded with holy water in *The Lost Boys*.

1989: Engineer Lonnie Johnson perfects the Power Drencher, positioning the air-pressurized water chamber on top of the barrel. Rebranded in 1991 as the Super Soaker, it triggers a water-gun craze.

1994: Alan Amron strikes again with the Shout 'N' Shoot, a voice-activated, multidirectional water-spouting headset.

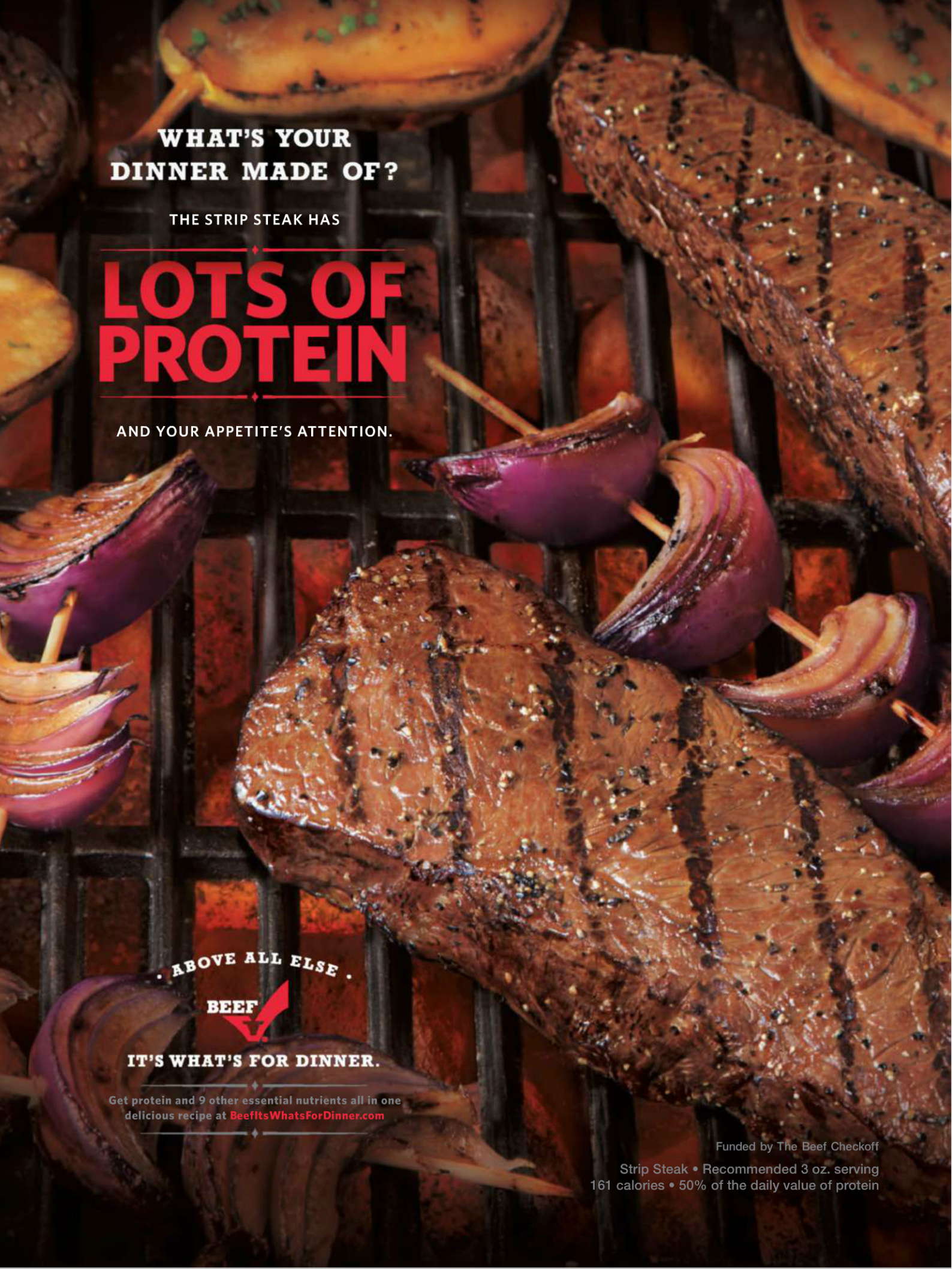
2009: With H₂O grenades and rocket launchers, Wii's Water Warfare “first-person soaker” is the perfect game for water-fight enthusiasts who don't want to go outside or get wet. What?

2011: The H2Grow ammo in Xploderz toy weapons—pellets that become gelatinous when soaked—are a safer alternative to paintballs and a more painful alternative to water.

2012: Water guns are banned—but actual guns are allowed—at the Democratic and Republican national conventions.

2013: Nerf Super Soaker's Arctic Shock may not be the biggest gun in the arsenal, but its 25-ounce Ice Drum makes it the coldest. Only the *brrrr*ave need apply.

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A close-up photograph of a grill with several pieces of food. In the foreground, a large, thick strip steak is being grilled, showing prominent dark char marks and a glistening surface. To its left and right are several red onions, cut in half and threaded with wooden skewers, also showing grill marks. In the background, there are more onions and a long, thin piece of meat, possibly a brisket or another steak, also on the grill. The grill's metal grate is visible, and the overall lighting is warm, emphasizing the textures and colors of the food.

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Introducing a smarter, greener, techier Honda Civic Hybrid. Smarter, with sophisticated Lane Departure¹ and Forward Collision Warning² systems. Greener, with 44 mpg highway³ and some of the lowest emissions⁴ on the road. Techier, with SMS texting⁵ and Pandora[®] compatibility.⁶ And with standard features like *Bluetooth*[®],⁷ USB integration⁸ and rearview camera, it's basically everything...er.



¹LDW only alerts drivers when lane drift is detected without a turn signal. LDW may not detect all lane markings or departures; accuracy varies based on weather, speed or road condition; operation affected by extreme interior heat. Driver is responsible for safely operating vehicle. ²FCW cannot or may not detect all objects ahead; accuracy varies based on weather, speed and other factors; operation affected by extreme interior heat and other factors. FCW does not include a braking function. Driver remains responsible for safely operating vehicle. ³Based on 2013 EPA mileage ratings. Use for comparison purposes only. Actual mileage will vary depending on how you drive and maintain your vehicle. ⁴Advanced Technology Partial Zero-Emission Vehicle models as certified by the California Air Resources Board are available in CA and states that have adopted California Zero-Emission Vehicle regulations. ⁵Compatible with select phones with *Bluetooth*[®]. Wireless carrier's rate plans apply. Only use texting feature when state and local laws permit and conditions allow you to do so safely. ⁶Pandora, logo and trade dress are owned by Pandora Media, Inc., and used with permission. Compatible with select smartphones. Wireless carrier's rates apply. ⁷The *Bluetooth*[®] word mark and logos are owned by the Bluetooth SIG, Inc., and any use of such marks by Honda Motor Co., Ltd., is under license. ⁸USB Audio Interface is used for direct connection to and control of some USB devices that contain MP3, WMA or AAC files. Some USB devices and files may not work. See Honda dealer for details. Hybrid model shown. ©2013 American Honda Motor Co., Inc.