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PM FEATURES
VOLUME 187 NO. 2

Popular
Mechanics

Feb.

54 Can Robots Be Trusted?

Humanoid machines have long been a sci-fi staple—but soon we'll be meeting them face to face. As social robots enter our lives, should we be wary of liking them too much?

BY ERIK SOFGE

62 Panama Digs a Bigger Ditch

With supersize ships plying the oceans, the undersize Panama Canal risked becoming a backwater. A massive upgrade, now underway, will ensure the waterway remains a global crossroads.

BY DAVID DUNBAR

66 Taking a Fall

Tumbling out of an airplane at cruising altitude and living to tell about it may seem impossible—but it does happen. Here's how to increase your chances of walking away from a free-fall landing.

BY DAN KOEPEL

70 Like a Rolling Home

With sophisticated hydraulics and old-fashioned muscle, movers can pick up a house, transport it down the street (or across the state) and settle it into a new address—without so much as a cracked piece of plaster. Here's how it's done.

BY JIM GORMAN

74 WHAT WENT WRONG: Disaster on the Yenisei

On Aug. 17, 2009, an explosion at Russia's largest hydroelectric power plant killed 75 workers and caused \$1.3 billion in damages. Why did it happen? And could the same disaster strike here?

BY JOE P. HASLER

It's no Terminator—in fact, humanoid social robots like Sarcos, seen here, could soon be fixtures in our daily lives.

ON THE
COVER

Gregg Segal photographed Sarcos exclusively for the POPULAR MECHANICS feature story "Can Robots Be Trusted?" (page 54) in Salt Lake City on Nov. 18, 2009. The social robot, owned by Sterling Research, a spinoff of the University of Utah, also appears courtesy of Raytheon Sarcos.

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Tyler Sand, Summit Group Software, www.summitgroupsoftware.com

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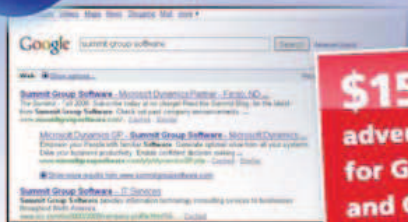
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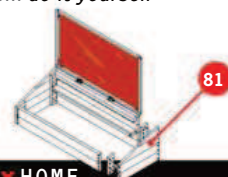
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WHAT THEY'RE DOING



★ GAVIN A. SCHMIDT

Climatologist, NASA Goddard Institute for Space Studies
Gavin Schmidt is developing models for the 2014 IPCC report. He hopes his recent research on emissions, which reveals greater combined effects of methane and aerosols on the atmosphere than previously thought, will encourage policymakers to enforce the capture and reuse of methane at sites such as landfills, farms and sewage treatment facilities.



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PM LETTERS

Aviation Safety

I read with interest your analysis of the crash of Air France 447 in December's "Anatomy of a Plane Crash." Failing to recover that plane's black box indirectly threatens the lives of all overseas plane passengers for years to come, since we don't have specific data on the cause of the crash.

I believe engineers could help prevent untraceable black boxes in future crashes by designing a mechanism that would eject the box and float it to the surface in the case of a crash over water. The black box would be positioned closer to the aircraft's skin, under a hatch controlled by a simple depth gauge. The hatch would be programmed to be released at a specific water-depth reading by compressed air, which would also inflate a small balloon or flotation device attached to the box.

MICHAEL SCRIVEN
POINT REYES, CA

EDITOR'S NOTE: *The National Transportation Safety Board, the Federal Aviation Administration and the Department of Homeland Security are*



ISSUE

12/09

✕
Readers responded to an analysis of aviation safety, a netbook buyer's guide, gonzo shop tips and tool tests.

conducting a feasibility study on the use of deployable data recorders for airplanes.

Netbook OS Wars

I read with great interest "So You Want to Buy a Netbook." I love the teardown of the computer and the look inside. One comment about operating systems: You say there's no Mac netbook yet. Though technically true, there are several websites where Apple fans describe hacking into a netbook and installing working versions of OS X Leopard. Apparently it's very easy to do if one has the proper knowledge.

LUKE RADEMACHER
NOVI, MI

Shop Guerrillas

Mike Allen's "The Guerrilla Mechanic," about DIY solutions around the shop, suggested using a quart-size freezer bag to refill a transmission case. I'd also suggest an oil-suction gun, which holds about a pint of oil.

It's intended to remove oil, but it works equally well in reverse.

PHILIP HEINE
SPOKANE, WA

Cordless Showdown

I have always enjoyed the DIY Home section in your magazine, and December's "Bantam-weight Slugfest" did not disappoint. The cordless drill critiques provided me with an excellent view on which drill to buy, since your tests represent an average person's use. Plus, the author also commented about how the drills felt, their ease of use and their performance. Keep up the good work.

OLIVER STRINGHAM
NORTH ARLINGTON, NJ

→ CALLING ALL HOMETOWN HEROES

Do you know someone who has contributed in a positive way to your community? Maybe a handyman who volunteered to rebuild a storm-damaged school, or a tech-savvy citizen who rigged up a Wi-Fi network for the local library. **POPULAR MECHANICS** is currently accepting nominations for our 2010 Hometown Hero Awards. If you know someone who fits the bill, he or she could be honored in the magazine. For more details and to submit your nomination, visit popularmechanics.com/hometownhero.

CORRECTION: *In the December issue, "Anatomy of a Plane Crash" should have stated that there was one survivor from the crash of Northwest 255. "Run Silent, Run Sleek" should have stated that pilot Steve Fossett plummeted from the skies over California.*

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do you
think?

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Digital Hollywood



VISUAL EFFECTS As technology continues to blur the line between computer-generated and live-shot movies, PM is there to explain what's real (the gigantic explosion in Michael Bay's *Transformers: Revenge of the Fallen*) and what's not (the human army attacking the elf-like characters in *Avatar*, directed by James Cameron, seen above).

HOLLYWOOD FACT CHECK When a shadowy, radioactive monster that can turn people into dust makes a prime-time television cameo, it's obviously a fiction—but PM's Digital Hollywood asks, is there a basis in reality? Whether it's debunking lightsabers in *Star Wars* or explaining the modern-day reality of brain puppetry in *Surrogates*, PM goes to real-life scientists to get the skinny on fringe research and out-there sci-fi concepts.

3D TECHNOLOGY Will the NFL ever broadcast in 3D? Will you notice the difference between a movie that was shot for 3D and one that was converted? How can someone set up a theater at home without buying an expensive new television? If you have 3D tech questions, look no further. PM provides the inside scoop on DIY 3D rigs and how to best enjoy 3D in the theater and at home.

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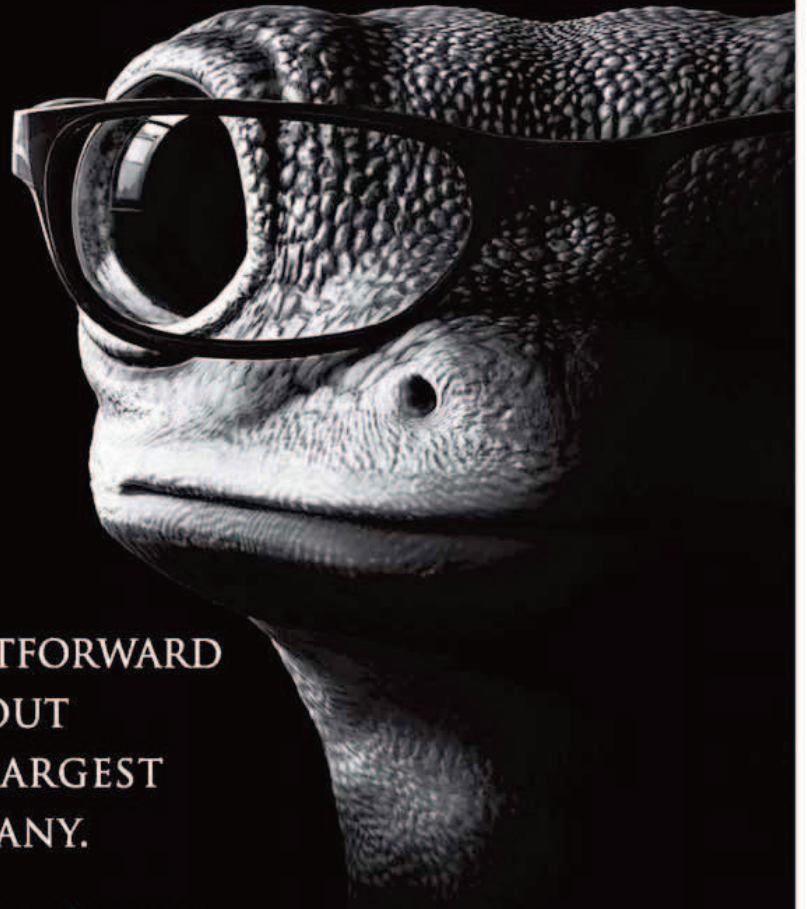
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FROM A SPOKESMAN WHO'S NOT
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Quite frankly, there's nothing I enjoy more than rolling up my sleeves and getting to work (though it should be noted I'm not in the habit of wearing shirts, either). After all, GEICO has been around for over 70 years — and that isn't simply a matter of luck. It takes dedication and skill to help people save hundreds of dollars on their car insurance. Of course, it also helps to be owned by Warren Buffett's Berkshire Hathaway Inc. So it should come as no surprise that when it comes to financial security, GEICO is consistently rated "excellent" or better by independent experts. Or that over 3 million drivers switched to GEICO last year. Clearly, when it comes to car insurance, I mean business. Even if the same can't be said of my attire.

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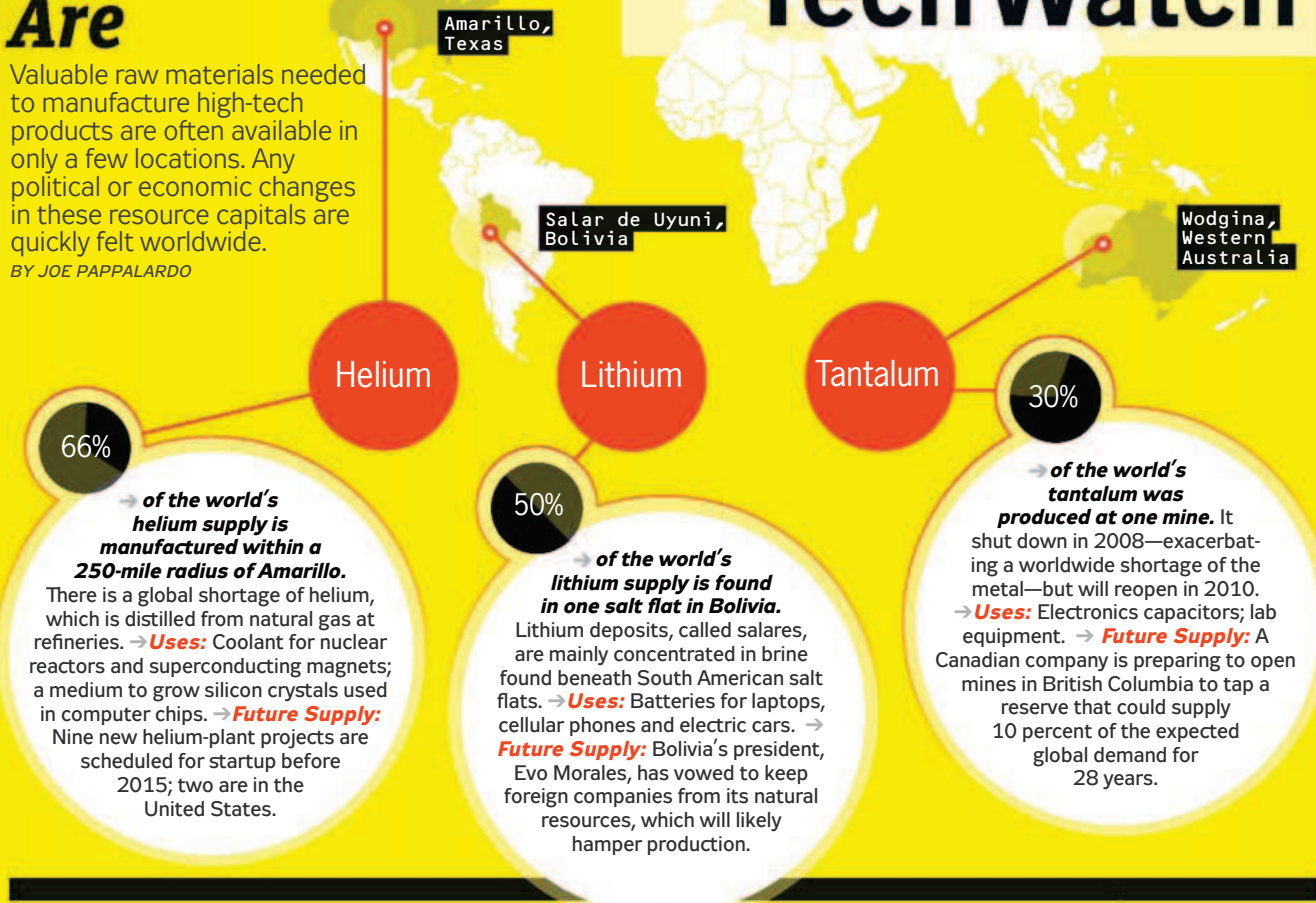
Where the Commodities Are

Valuable raw materials needed to manufacture high-tech products are often available in only a few locations. Any political or economic changes in these resource capitals are quickly felt worldwide.

BY JOE PAPPALARDO

NEWS + TRENDS + BREAKTHROUGHS

Tech Watch



RADAR-FRIENDLY WINDMILLS

By Alex Hutchinson

Thousands of megawatts' worth of proposed wind farms in the U.S. have been blocked because aviation radar confuses the spinning turbines with aircraft. British defense firm QinetiQ and Danish turbine-maker Vestas have produced a turbine that minimizes radar returns by coating the turbine's tower with radar-absorbent material and integrating stealthy composites into the blades.



BENEFICIARIES OF THE DEATH OF ANALOG TV

High-speed wireless Internet has arrived in Claudville, Va. (population 916). Under an experimental license from the FCC, Florida-based Spectrum Bridge is using "white space" in the television spectrum left vacant by analog TV broadcasts to provide wireless service to homes, hospitals and schools that were too remote to receive it previously.

MAKING SOUND SEE BETTER

Sound waves can create images of the things they bounce off of but can't reveal any details smaller than their wavelength—a barrier known as the diffraction limit.

Researchers at the University of California—Berkeley created an acoustic hyperlens that produces images of objects 6.7 times smaller than the sound's wavelength. The system uses 36 brass fins to

magnify a detailed but short-lived portion of the sound wave to create an image; such detailed resolution could revolutionize the use of medical ultrasound and naval sonar systems.

ONE WING IS ALL YOU NEED

Aerospace grad students at the University of Maryland have copied nature's design of maple seeds by developing a single-wing unmanned aerial

vehicle. A propeller causes the main wing to rotate fast enough for the aircraft to hover. These UAVs could be deployed from airplanes or from the ground to provide quick, covert surveillance.



TECHWATCH

Hubble's 3D Closeup

ASTRONAUTS ON A MISSION TO RESCUE A SPACE TELESCOPE MOONLIGHT AS CINEMATOGRAPHERS. BY ERIN MCCARTHY

➤ Astronauts repairing Hubble in May 2009.

➔ During the past 20 years, the Hubble Space Telescope revealed the age of the universe (about 14 billion years), shed light on dark energy and captured galaxies in all stages of evolution. Few pieces of scientific equipment rise to Hubble's level of celebrity, and film director Toni Myers felt the telescope's final upgrade in May 2009 was worthy of full Hollywood treatment. The result is *Hubble 3D*, to be released in April. A remote-control camera, operated by astronauts in space, filmed the *Atlantis* crew as they captured Hubble with a robotic arm and conducted spacewalks to repair and refurbish it. The crew were quick studies. "I've never met an astronaut who wasn't brilliant," Myers says. "They're the best learners in the world." IMAX technicians modified their stereoscopic camera so it could survive in space and fit inside the shuttle's cargo bay. The cameras typically employ two strips of 65-mm film recording at 24 frames per second—one for the left eye, one for the right—but filmmakers opted to shoot on a single strip of film that held both views and recorded twice as fast; technicians separated the left and right eye images on Earth.



q + a

GREG C. JOHNSON NASA Astronaut

Greg Johnson has served as a Navy fighter jock, a test pilot and an aerospace engineer. On his latest mission, he also served as a documentary cameraman in space.

“I don't normally get nervous, but when filming some scenes, I would rather have been in a head-to-head dogfight in an F-18.”

PM: Does operating the IMAX 3D camera have a steep learning curve?

When I went into this, I was thinking, this'll be fairly straightforward—I'll just hit a button and it'll take a scene. But it was far more complicated than I thought. The camera was in the payload bay, aimed at Hubble, and it had three lenses. I had to select the lens, the focal length and

the f-stop using a laptop inside of *Atlantis*.

PM: What were some of the challenges of shooting?

Lighting was a big one, because as you orbit around the Earth, you have a sunrise and sunset every 90 minutes. Usually we were getting earthshine—light that went to the Earth and came back up to the telescope. Another

challenge was deciding when the scene would actually start. We had limited film, but we didn't direct the spacewalker to change out a sensor—they do it per their timeline. Many things in space happen slowly, so you didn't want to start only to shoot 10 seconds of nothing happening.

PM: Did the astronauts fixing Hubble outside the

space station communicate with you guys?

No. Our agreement with IMAX was that this couldn't interrupt our primary job. There is one scene where [astronaut] Drew Feustel is parallel to the Earth on the end of the robotic arm, and he knew we were trying to get that on film. If we moved the arm in a way that wasn't obvious to him, he knew that would be okay. He wouldn't say, "Why are you taking me down? I need to get going here!"

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A Geo-Engineered World

SCIENTISTS ENVISION RADICAL IDEAS TO RID THE PLANET OF GLOBAL WARMING ILLS, BUT THE CURES WON'T COME WITHOUT RISKS. BY ERIK SOFGE

→ **The term geo-engineering**—direct technological interventions to reshape the planet—calls to mind the dark laughter of a science-fiction villain. But researchers are pondering ways to use geo-engineering to counter the effects of global warming. This past year, three European institutions released reports on the benefits and risks of “climate engineering.” Recommendations vary, but the reports each conclude that the most promising technologies should be tested on small scales. Scientists worry that some nation’s future unilateral geo-engineering project could cause frightening side effects that cross national boundaries. “If a country’s leaders feel some existential threat, they might resort to desperate measures,” says Ken Caldeira, a senior scientist at the Carnegie Institution at Stanford University. “What if Greenland is sliding into the ocean? And what if you could stop it?”



IS EARTH READY FOR THESE GLOBAL WARMING FIXES?

DIM THE SKY

Objective: Block solar radiation to drop Earth’s surface temperature.

Proposal: Unmanned airships or air-bursting artillery rounds inject sulfur-dioxide particles into the stratosphere. A former Microsoft executive proposes lofting a hose with helium balloons to pump liquefied sulfur dioxide into the sky.

Blowback: Global temperatures could spike as soon as treatments stop. Seeded areas may see redder, hazier skies.

Proposed by: Copenhagen Consensus Center

SOAK THE CLOUDS

Objective: Decrease the amount of sunlight—and heat—absorbed by cloud cover.

Proposal: Funnel salt water into the air with robotic ships, brightening clouds to cool specific areas, such as the Arctic.

Blowback: The tactic is likely to alter weather patterns, nudging rainfall from one region to another in unpredictable ways. The good news is that seawater droplets cycle out of clouds within a few days.

Proposed by: Copenhagen Consensus Center

GROW ALGAE EVERYWHERE

Objective: Suck carbon dioxide out of the atmosphere, reducing greenhouse gases that contribute to warming.

Proposal: Deploy vast algae farms on land and at sea. Strips of algae could be built onto buildings, and miles of algae-filled plastic bags could stretch across an ocean’s surface.

Blowback: To work well, a continent of algae is needed, and that’s more pricey than other carbon-capture schemes.

Proposed by: NASA (algae farms); Institution of Mechanical Engineers, U.K. (buildings)

WHITEWASH EVERYTHING

Objective: Deflect solar radiation to cool the surface of the planet.

Proposal: Installing white or otherwise reflective roofs on buildings and replacing less reflective crops with ones engineered to be glossier could lower summer temperatures in the U.S. by nearly 2 F.

Blowback: Large-scale genetic modification of crops could face stiff resistance, and there might not be enough rooftops to make a difference.

Proposed by: University of Bristol, U.K. (crops); U.S. Secretary of Energy Steven Chu (roofs)

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NEW POWER FROM HOT AIR
SHAPE-MEMORY METAL COULD
BE THE SECRET TO TURNING
CAR EXHAUST INTO ENERGY.
By Larry Webster

It's hard to look at a car's tailpipe and not be depressed. After all, even the most efficient internal-combustion engines use only 30 percent of the fuel's energy to propel the vehicle. Much of the rest exits out the rear as waste heat. Now, researchers at

General Motors are working on an energy-scavenging device that could convert that exhaust heat into electricity.

The key is the use of a shape-memory alloy (SMA), explains Jan Aase, director of GM's Vehicle Development Research Lab. "When you heat it up, it shrinks to its original length and gets stiffer," he says. "When you cool it, you can stretch it out. So if you wrap shape-memory-alloy wire around two pulleys—one hot, one cold—the material will actually

cycle the pulleys."

Imagine a pack of cigars wrapped around the exhaust pipe, and you have a good idea of what the proposed generator will look like. The "cigars" are actually tubular pulleys arranged in two sets. The hot set is next to the pipe, while the cold one is offset and cooled by fresh air. The SMA wire coils around the pulleys. As the material expands and contracts, it causes the pulleys to spin, which drives a generator. GM is working with California-based Dynalloy, a company that recently developed a process to produce a nickel-titanium SMA capable of repeating

millions of heat/cool cycles. "Now we can get the material in large quantities and with predictable shape-changing characteristics," Aase says.

The researchers hope that the unit will produce enough juice to power all of a car's electrical accessories—including electric power-steering pumps—allowing the engine to burn less fuel. GM R&D last year received a \$2.7 million government grant to pursue the technology, which could potentially harness energy from factory smokestacks and house furnaces, as well as from automotive tailpipes. GM hopes to have a prototype ready by late 2010.

Perfect Car Key Copier



LOCKSMITHS COULD REALLY BENEFIT FROM THE KEY IMPRESSIONER. UNFORTUNATELY, SO COULD THIEVES.

Inventor Steve Randall spent a college summer working for his father's locksmith shop, watching the pros make replacements for lost car keys. Lacking the identification codes, called bittings, that tell them which patterns to cut into blanks, locksmiths must rely on trial and error to make a perfect fit. Late last year, Randall unveiled a solution: the Electronic Key Impressioner. The Impressioner has a sensor that finds the tumblers' locations inside the lock; the information is then matched with a vehicle's make and model to glean a correct key pattern. Yes, the device could make reselling stolen cars easier—but Randall says that only licensed locksmiths would be able to buy one, and adds that he could shut down any rogue systems remotely. Despite this, the crowd at a recent tech conference tittered when Randall introduced his device. The inventor says the technology might be accepted if it served another purpose. "We've been trying to figure out what else to use it for," he says. "If you've got any ideas, let us know." —S.E. KRAMER

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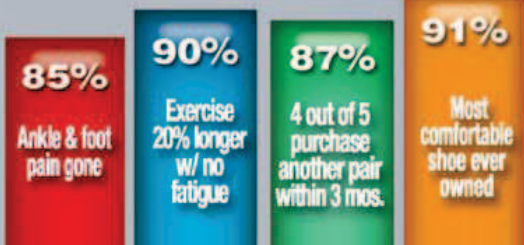
Extra weight puts an added toll on your bones and joints. Running isn't an option, and walking can become difficult. G-Defy Shoes will take the pressure from your large frame body, make you more active and change your life forever!

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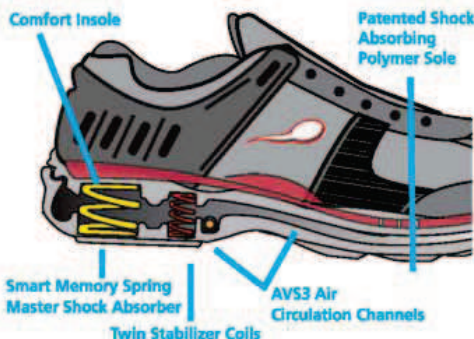
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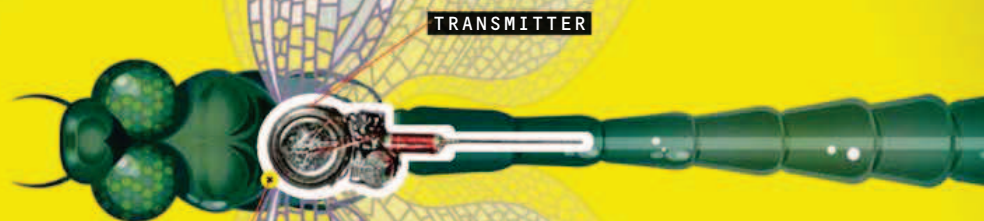
→ Atlantic Salmon Federation biologist Fred Whoriskey is tracking fish migration using arrays of receivers moored to the seafloor to tally passing fish implanted with "sonic pingers." He found a salmon superhighway between Newfoundland and Labrador where fish gather en route to foraging grounds near Greenland. "I think this research is showing us that there's a social dynamic to fish populations that we've been underplaying," Whoriskey says.

Sleepy
Snakes

→ Biologist Jonathan Mays surgically implanted radio transmitters into black racer snakes in Maine. He discovered that females travel up to 3 miles to lay eggs and that the snakes hibernate beneath open grasslands, not in wooded ravines as previously thought.

Social
Sparrows

→ A team of scientists at the University of Washington is outfitting song sparrows with tiny microprocessors and transceivers. As these Encounternet tags interact with one another, they document the social interactions between the birds.



Biologist Martin Wikelski glues lightweight tracking devices [1] onto the thoraxes of migrating insects [2] and then tracks them with receivers [3].

Unraveling
Nature's Social
Networks

BIOLOGISTS USE TINY TRACKING DEVICES TO TRACE PATTERNS IN UNSEEN ANIMAL INTERACTIONS.
BY MURRAY CARPENTER

→ Chasing insects in airplanes is just part of Martin Wikelski's job description as director of migration research at the Max Planck Institute for Ornithology. In an attempt to discover migration strategies shared by various flying creatures, the German researcher glued 0.3-gram radio transmitters onto the thoraxes of 14 dragonflies and followed them in a single-engine Cessna. The bugs' survival techniques became clear as he observed individual insects day after day: They refuse to fly

when conditions are too windy; they schedule rest days and travel only during warm daylight hours. Hanging a battery-powered transmitter on the ear of a 500-pound grizzly bear is one thing; installing a similar rig on a lightweight bird or insect is harder. In recent years, electronic transmitters have become miniaturized enough to fit on even the most diminutive creatures. Researchers can assign a frequency or identification number to each tag so that individual animals can be identified. Scientists are using more advanced tracking devices to gather other kinds of data. Proximity tags the size of a quarter, created by a team at the University of Washington, exchange their unique codes when they come within a preset range, then store the event as an "encounter." The data is stored on the base station until a field assistant retrieves it. The information is then used to create models of which animals are hanging out with each other. This is especially useful in charting the movements of sick animals or discerning how offspring learn behavior from their elders.

“I was originally too embarrassed to have ‘the talk’ with my doctor, but now I wish I’d done it sooner.”



Your Doctor Talks to Men About ED Every Day

Your doctor will tell you that erectile dysfunction (ED) isn't something to keep to yourself, or to be embarrassed about. It's a common medical condition he can treat.



Doctor portrayal.

Running the Numbers

Did you know half of all guys over 40 have some form of ED? Here are some numbers to keep in mind from a recent survey of men with ED:



of men were anxious about talking to their doctor about ED.



of men felt relieved after talking to their doctor.



Tell Me More

To learn more about VIAGRA for the treatment of ED, and ED in general, visit viagra.com today. You'll find an online sexual health quiz, videos of guys with ED who've had the VIAGRA Talk and other helpful information.

Over 20 million men have already had their VIAGRA Talk. Isn't it time you had yours?

Don't Keep Your Questions Bottled Up

The hardest part about having 'the talk' is getting those first few words out.

Here are some ideas to help you break the ice when your doctor asks how everything's going:

The Direct Approach:

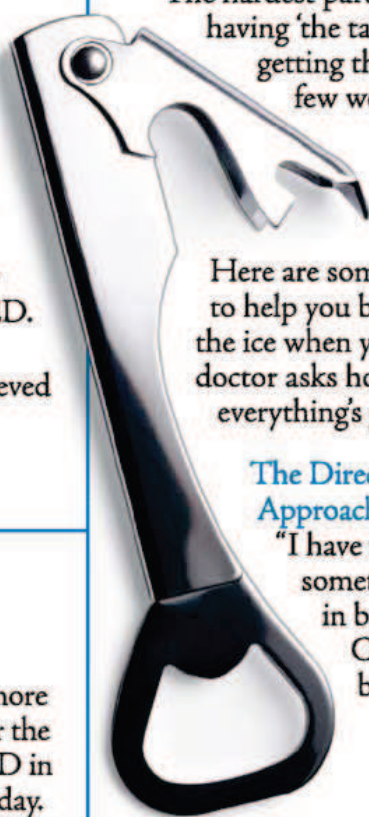
"I have trouble sometimes in bed. Could it be ED?"

The Indirect Approach:

"Is it true age affects sexual performance?"

The Silent Approach:

Just hand this ad to your doctor, he'll take it from there.



Important Safety Information

We know that no medicine is for everyone. Don't take VIAGRA if you take nitrates, often prescribed for chest pain, as this may cause a sudden unsafe drop in blood pressure.

Talk with your doctor first. Make sure your heart is healthy enough to have sex. If you have chest pain, nausea, or other discomforts during sex, seek medical help right away.

In the rare event of an erection lasting more than four hours, seek immediate medical help to avoid long-term injury.

In rare instances, men who take PDE5 inhibitors (oral erectile dysfunction medicines, including VIAGRA) reported a sudden decrease or loss of vision, or sudden decrease or loss of hearing. It is not possible to determine whether these events are related directly to these medicines or to other factors. If you experience any of these symptoms, stop taking PDE5 inhibitors, including VIAGRA, and call a doctor right away.

The most common side effects of VIAGRA are headache, facial flushing, and upset stomach. Less common are bluish or blurred vision, or being sensitive to light. These may occur for a brief time.

VIAGRA does not protect against sexually transmitted diseases including HIV.

Please see Important Facts for VIAGRA on the following page or visit viagra.com for full prescribing information.

For free information, including questions to ask your doctor, call 1-888-4VIAGRA (1-888-484-2472).

VIAGRA®
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IMPORTANT FACTS

VIAGRA®
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(vi-AG-rah)

IMPORTANT SAFETY INFORMATION ABOUT VIAGRA

Never take VIAGRA if you take any medicines with nitrates. This includes nitroglycerin. Your blood pressure could drop quickly. It could fall to an unsafe or life-threatening level.

ABOUT ERECTILE DYSFUNCTION (ED)

Erectile dysfunction means a man cannot get or keep an erection. Health problems, injury, or side effects of drugs may cause ED. The cause may not be known.

ABOUT VIAGRA

VIAGRA is used to treat ED in men. When you want to have sex, VIAGRA can help you get and keep an erection when you are sexually excited. You cannot get an erection just by taking the pill. Only your doctor can prescribe VIAGRA.

VIAGRA does not cure ED.

VIAGRA does not protect you or your partner from STDs (sexually transmitted diseases) or HIV. You will need to use a condom.

VIAGRA is not a hormone or an aphrodisiac.

WHO IS VIAGRA FOR?

Who should take VIAGRA?

Men who have ED and whose heart is healthy enough for sex.

Who should NOT take VIAGRA?

- If you ever take medicines with nitrates:
 - Medicines that treat chest pain (angina), such as nitroglycerin or isosorbide mononitrate or dinitrate
- If you use some street drugs, such as "poppers" (amyl nitrate or nitrite)
- If you are allergic to anything in the VIAGRA tablet.

BEFORE YOU START VIAGRA

Tell your doctor if you have or ever had:

- Heart attack, abnormal heartbeats, or stroke
- Heart problems, such as heart failure, chest pain, or aortic valve narrowing
- Low or high blood pressure
- Severe vision loss
- An eye condition called retinitis pigmentosa
- Kidney or liver problems
- Blood problems, such as sickle cell anemia or leukemia
- A deformed penis, Peyronie's disease, or an erection that lasted more than 4 hours
- Stomach ulcers or any kind of bleeding problems

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal products. Tell your doctor if you take or use:

- Medicines called alpha-blockers to treat high blood pressure or prostate problems. Your blood pressure could suddenly get too low. You could get dizzy or faint. Your doctor may start you on a lower dose of VIAGRA.
- Medicines called protease inhibitors for HIV. Your doctor may prescribe a 25 mg dose. Your doctor may limit VIAGRA to 25 mg in a 48-hour period.
- Other methods to cause erections. These include pills, injections, implants, or pumps.

POSSIBLE SIDE EFFECTS OF VIAGRA

Side effects are mostly mild to moderate. They usually go away after a few hours. Some of these are more likely to happen with higher doses.

The most common side effects are:

- Headache
- Feeling flushed
- Upset stomach

Less common side effects are:

- Trouble telling blue and green apart or seeing a blue tinge on things
- Eyes being more sensitive to light
- Blurred vision

Rarely, a small number of men taking VIAGRA have reported these serious events:

- Having an erection that lasts more than 4 hours. If the erection is not treated right away, long-term loss of potency could occur.
- Sudden decrease or loss of sight in one or both eyes. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. They may be caused by conditions like high blood pressure or diabetes. If you have sudden vision changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Sudden decrease or loss of hearing. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. If you have sudden hearing changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Heart attack, stroke, irregular heartbeats, and death. We do not know whether these events are caused by VIAGRA or caused by other factors. Most of these happened in men who already had heart problems.

If you have any of these problems, stop VIAGRA. Call your doctor right away.

HOW TO TAKE VIAGRA

Do:

- Take VIAGRA only the way your doctor tells you. VIAGRA comes in 25 mg, 50 mg, and 100 mg tablets. Your doctor will tell you how much to take.
- If you are over 65 or have serious liver or kidney problems, your doctor may start you at the lowest dose (25 mg).
- Take VIAGRA about 1 hour before you want to have sex. VIAGRA starts to work in about 30 minutes when you are sexually excited. VIAGRA lasts up to 4 hours.

Don't:

- Do not take VIAGRA more than once a day.
- Do not take more VIAGRA than your doctor tells you. If you think you need more VIAGRA, talk with your doctor.
- Do not start or stop any other medicines before checking with your doctor.

NEED MORE INFORMATION?

- This is only a summary of important information. Ask your doctor or pharmacist for complete product information OR
- Go to www.viagra.com or call (888) 4-VIAGRA (484-2472).

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Goopy Robots Slip Through the Cracks

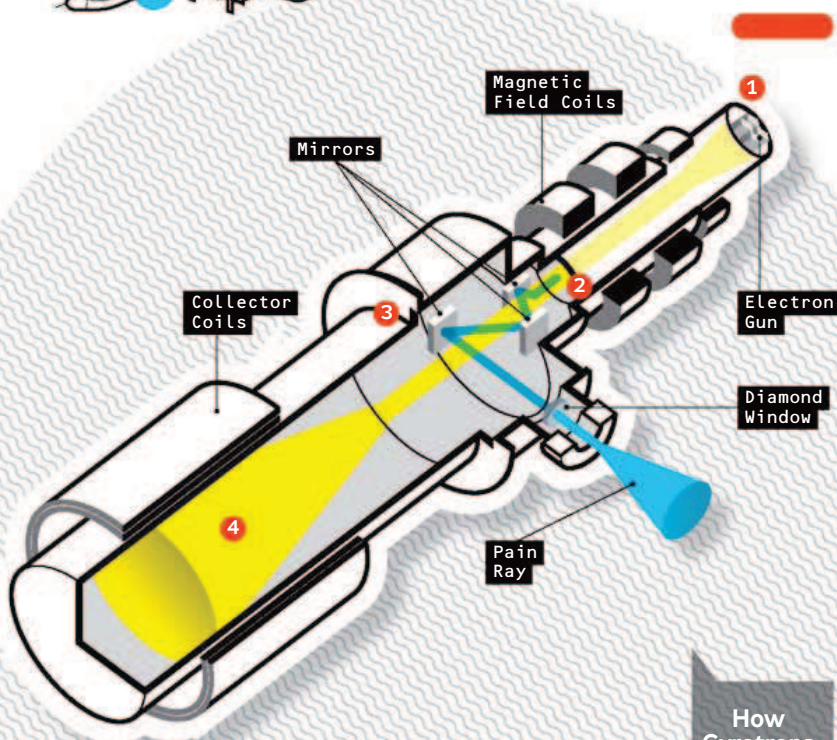
Researchers at iRobot Corporation and the University of Chicago, working on a Defense Department program to develop robots that can squeeze through small holes, offered a glimpse of their progress at a recent robotics conference in St. Louis. The team created a technique called “jamming skin-enabled locomotion,” in which a robot that looks like a semi-inflated volleyball expands and contracts a flexible silicone shell to push itself around. That shell contains air pockets packed with particles. When the air is removed, the air pressure equalizes and the particles inside the pockets shift, changing the blob’s shape. Ultimately, the researchers hope to produce a robot that can fit through openings smaller than its own dimensions—a useful trait for discreet reconnaissance missions. —ALEX HUTCHINSON



Bringing the Hurt

NONLETHAL ENERGY-BEAM BLASTERS COULD FINALLY FIND A HOME—INSIDE SPECIAL OPERATIONS GUNSHIPS.

BY DAVID HAMBLING

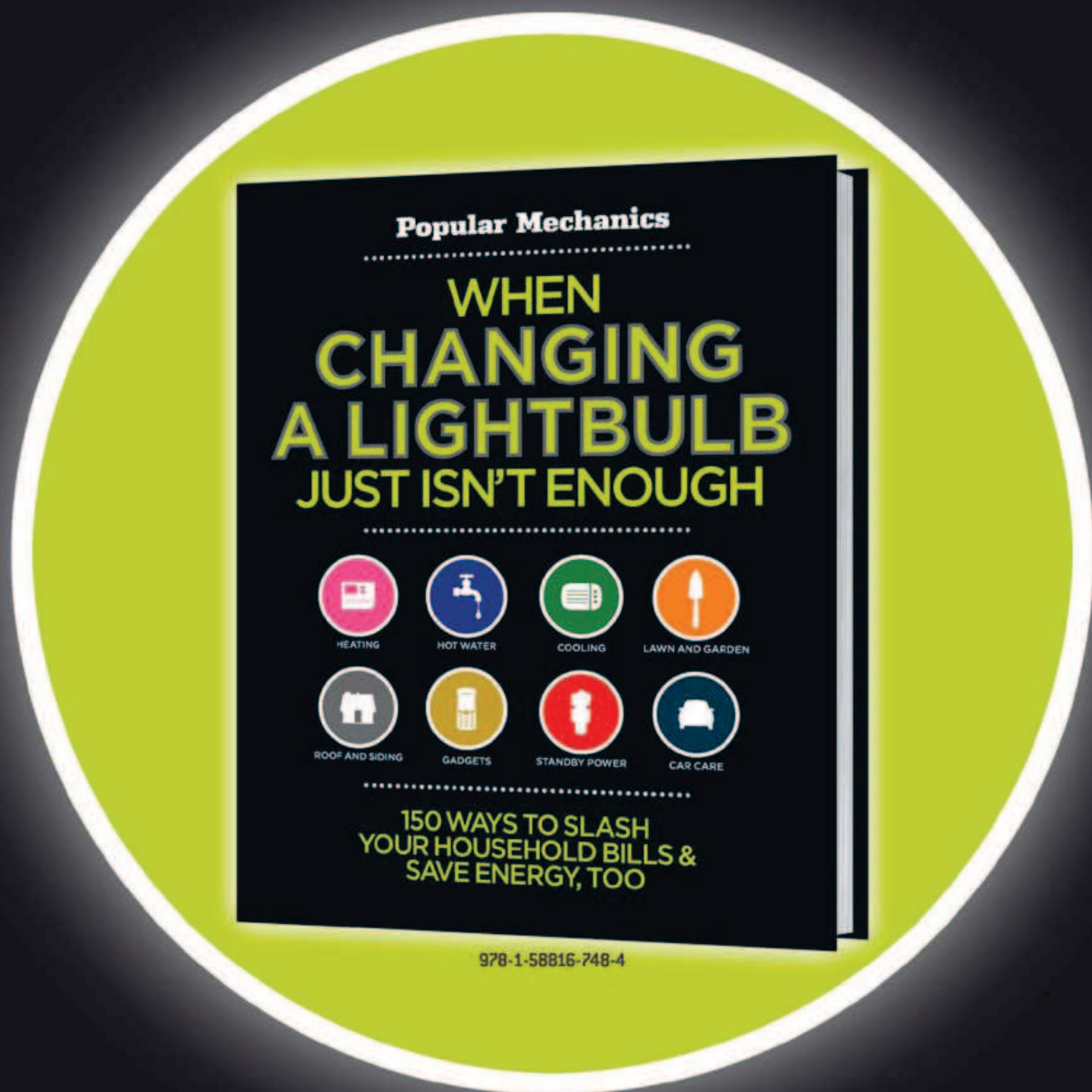


How Gyrotrons Work

→ 1	→ 2	→ 3	→ 4
An electron gun fires a particle beam through a vacuum tube wrapped with strong magnets.	As the beam meets the magnetic field, the electrons bunch up and gyrate, producing high-power microwaves at set frequencies.	Mirrors steer the microwaves through a window made of diamond. The gem is used for its resistance to heat and for its clarity.	The electron beam's excess energy is deposited in the coils of a collector.

→ The Pentagon has been researching nonlethal pain rays since the mid-'90s, but finding a vehicle to carry them has proven to be a challenge. Researchers have mounted these microwave weapons—which repel people by heating water molecules just under the skin, reportedly without damaging tissue—on trucks, guard towers and Humvees, but the U.S. military has never deployed them for real-world use. (Using such weapons on civilians in Iraq or Afghanistan is not seen as a good way to win hearts and minds.) Undaunted, the Air Force is now trying to install pain rays on Special Operations gunships, which are 98-foot-long AC-130 aircraft originally designed to haul cargo. The Airborne Active Denial System would require a beam generator of unprecedented size, says Diana Loree, manager of the program at the Air Force Research Lab. Megawatt microwave generators (called gyrotrons) already exist, producing intense heat in plasma-research laboratories and factories that need to melt glass or composite materials, but the military program requires a generator twice as large as any existing model. AFRL staff hope to demonstrate a giant gyrotron during ground tests in 2014, Loree says. Special Ops forces might welcome an overhead nonlethal weapon that disperses mobs or stops people from advancing on downed aircraft. Also, the use of an energy weapon during a clandestine mission would be less prone to public outcry.

MARKETING DISCOMFORT Active Denial System (ADS) microwave weapons work well in tests but don't get used much. The U.S. Army's **Project Sheriff** mounted ADS on a light armored vehicle, along with dazzling lights and sonic blasters; the hardware was ready in 2005 but was never fielded. In October, Raytheon said it sold a lower-power version of ADS called **Silent Guardian** to a foreign buyer and to a U.S. law-enforcement agency, but will not identify the customers.



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BY SETH PORGES

A spring-loaded starting mechanism allows you to start the chain saw without rapidly jerking the recoil handle.



the
vacs



Black & Decker FHV1200 Flex (\$70)



Dyson DC31 (\$220)



Makita BCL180W (\$150)

Abusive Lab Test

HANDHELD
VACUUMS

➔ When Black & Decker released the original Dustbuster 30 years ago, the company essentially created the mass-market hand-held vacuum cleaner. Today, cordless hand vacs use advanced batteries and motors to pull with more power than ever. We took three new models—including Black & Decker's latest Dustbuster successor, and one that uses a power-tool battery—and pitted them against a gantlet of spilled snacks and workshop detritus. *BY HARRY SAWYERS*



the
tests

IN THE HOUSE

We vacuumed up after a staged Super Bowl bash—popcorn and Doritos crushed into 20 square inches of carpet.

IN THE SHOP

To simulate a workshop cleanup, we pitted the vacs against a mound of sawdust, screws, tacks and flat washers.

BATTERY LIFE

To test the tools' stamina, we measured charge time and total chamber loads per charge.

➤ **BLACK & DECKER:** Crushed food clogged the hose, which had a tendency to regurgitate crumbs out the nozzle. Gross. **DYSON:** Smaller crumbs were no problem, but some larger kernels got jammed in the nozzle (it was nothing a pencil poke couldn't clear out). **MAKITA:** No jams, and no problems. The Makita gulped down whole kernels and large chip shards with ease. It filled, dumped and did it again as fast as we could twist off the 650-milliliter container. **WINNER:** Makita, by a mile

➤ **BLACK & DECKER:** Smaller particles swept through the hose easily, but an odd static-cling effect made it difficult to dump the sawdust. **DYSON:** The cyclonic sucking hit its prime when swirling up the dust and hardware. Even the heaviest screws shot straight up the hatch. **MAKITA:** The vac ingested our nuts and bolts with ease, but its opaque plastic shell made it difficult to tell when the canister was full. **WINNER:** Dyson

➤ **BLACK & DECKER:** Although the Nickel-Cd battery pack took 21 hours to charge, it sucked just four fills of its 503-ml tank. **DYSON:** A 3.5-hour charge on its 22.2-volt lithium-ion battery sucked and dumped 341 ml's worth of gunk an impressive 52 times. **MAKITA:** Use of a standard Makita power-tool battery and charger ensured long life (59 loads) and a quick charge (just 15 minutes). **WINNER:** Makita

BOTTOM LINE

➔ The Makita's long-lasting battery and imperviousness to clogs helped it pull off a first-place finish. And while the Dyson came in a close second, the B&D's clog-prone hose made it a distant third.

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by Tempur-Pedic™



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The AdvantageBed makes it possible to enjoy all the benefits of **better sleep** and **better health** at an unmatched value! Unlike traditional spring mattresses that push against you causing painful pressure points, Tempur-Pedic beds are made of our proprietary TEMPUR® material.

TEMPUR material absorbs pressure, cradling your body with customized support and providing deep, rejuvenating sleep giving you **renewed daytime energy**.

Tempur-Pedic delivers all the life-improving benefits of body conforming support. Invest in more than simply a new mattress, make an investment in your health with guaranteed better sleep night after night! Rest assured...**Every Tempur-Pedic bed is backed by our 20 year Limited Warranty!**

You spend 1/3 of your life sleeping, you deserve the highest level of comfort available...**you deserve a Tempur-Pedic!**



Which would you rather sleep on?



Traditional Steel Spring
Mattress



Pressure-Absorbing
TEMPUR® Material



Value a Tempur-Pedic...

"Because of the stress that people feel you're not getting enough sleep. If you're not **resting and feeling good** you're going to have a harder time during your day. The person that values sleep, they'll **value a Tempur-Pedic.**"

Luci & Barry
Tempur-Pedic owners since January 2005

Call today for your **FREE** Information Kit with
FREE DVD / FREE Tryout Certificate / FREE Catalog

888-359-8492

or visit us online at www.TempurPedic.com
to find a retail location near you!





Hitting the Hardwood

➔ Installing a nail-down floor is equal parts whacking and dragging—when you're not whacking the pneumatic nailer with a hammer, you're dragging its 11-pound off-kilter mass to the next spot. So at only 9 pounds, the Hitachi NT50AF 2-inch Flooring Nailer (\$450) lightens the load by a welcome margin, allowing you to focus exclusively on firing off its 150 rounds of 2-inch, 16-gauge cleats—because laying in ½-inch to ¾-inch solid hardwood should be, if anything, all about the whacking.

E-Booking It

➔ Amazon's Kindle has barely changed in the two years since it was first released. The **Barnes & Noble Nook E-Book Reader (\$260)** represents a massive upgrade in terms of what an e-book reader can do. Like the Kindle, it has a 6-inch E Ink screen and the ability to wirelessly download books over a 3G network. Unlike the Kindle, it tosses in the ability to wirelessly beam books to friends for borrowing, and a small color touchscreen for navigating menus—a dash of color that makes the device far more fun. In the future, things could get even better. The Nook is based on Google's Android operating system, meaning Barnes & Noble could easily open it up to third-party developers who want to add apps.



File this one under "so good, it should be banned." If you haven't heard of Spotify yet, just know that it could soon change the way you listen to music. The gist: It's a free and legal music-streaming service that plays virtually any song you can think of, on demand and so

quickly that you'd swear it was stored on your computer's hard drive. It even has a mobile app for on-the-go listening. The six-million-song-and-growing catalog is awe-inspiring. (We did manage to stump it with a few of our more obscure favorites, and some major artists, such as the Beatles, have opted out of streaming their entire catalog.) The service was launched

in Europe in 2008, but as of press time, the company was still in negotiations with record labels for a U.S. debut. That should take place soon, and when it does, we expect millions of people's musical horizons to expand, and the music industry to be transformed—again.



NAS and Quiet

→ Network-attached storage (or NAS) drives allow users to easily back up their data and access media files from multiple computers across a home network. But most of them have a serious flaw: Their spinning platters and churning fans are too loud for a device that's supposed to sit unnoticed in the background. The **Omega Stor-Center ix2-200 NAS Drive (\$270 for 1 terabyte, \$370 for 2 TB, \$700 for 4 TB)** brings the screech down to a whisper—it may be the quietest NAS drive we've ever used. One way it knocks off decibels: Unlike most NAS drives, which have perpetually spinning fans, this drive's fans turn off when they aren't needed.



Droid Rage

→ After riding the success of hit phones such as the StarTAC and the Razr to market dominance, Motorola has struggled to find its footing in a post-iPhone world. Well, the company's slide is officially over. The **Motorola Droid (\$200 w/contract)** is the best phone the manufacturer has ever made—and a godsend for Verizon customers who love their network's blazing speeds but loathe its weak lineup of touchscreen superphones. The phone, which runs on Google's Android operating system, has both a touchscreen and a slide-out keyboard, and it roared through our lab tests. Best of all? Free turn-by-turn auto navigation built right in.



Mobile Melter

→ Typically, welders are corded, and so bulky that they need to be stationed in carts or car trunks. But not the new **Hobart Welders Trek 180 Battery-Powered MIG Welding Package (\$1800)**. It's portable and battery-operated. In fact, the entire wire-feeding welder rig weighs just over 50 pounds, including batteries, and comes packed in a luggable suitcase. Sure, the size of your job is limited by the life of its lead-acid batteries, but that's more than enough juice for 90 percent of a homeowner's welding needs.



2010 Digital Preview

→ When gadget manufacturers want to make a blockbuster announcement, they usually do it in one place: the Consumer Electronics Show in Las Vegas. This annual gathering of geekery gives us a sneak peek at

what the year has in store for tech fiends. Here's a first look at some of the show's standouts, which we can expect to trickle into stores over the coming months. **BY SETH PORGES**

First Look



1. Canon Vixia HF S21 Camcorder (\$1300)

During closeups, even image-stabilized camcorders have a hard time telling the difference between accidental hand jitters and intentional panning. This camcorder has a new powered image-stabilization mode that tells it that all movements are mistakes, allowing the lens to lock up to tripod-like levels of steadiness.

2. Regen ReVerb Solar iPod Speaker (\$2230)

This 3-foot-tall iPod speaker dock features built-in solar panels that power its 60-watt speakers—even when it's indoors. Just be patient;



4. Garmin ecoRoute HD (\$150)

Pulling info from a car's diagnostic port usually involves plugging in a scan tool and matching obscure problem codes with listings in a book. This small, hidden box plugs into the diagnostic port and beams the info, presented as a visual readout, directly to a Bluetooth device such as a GPS or phone.



the 20-hour outdoor charge time (good for up to 12 hours of tunes) is doubled when the device is charged inside. But that cash could also buy an exceptional flat screen.

3. Intel i5 and i7 Computer Chips

Intel's new chips automatically monitor activity across all their cores. When certain cores are idle, the chips act like automatic overclockers, reallocating available power to boost the speed of the remaining active cores.



5. LG eXpo Phone
(price not set)

Nearly two years after the first microprojector was released, manufacturers are finally beginning to build the technology directly into other devices such as cameras and phones. But even the smallest microprojector adds bulk—never a good thing when you're dealing with pocket-based gadgets. This phone's solution: a microprojector that's offered as a snap-on accessory, allowing you to shave off the extra mass when it's not needed.

6. Logitech Speaker Lapdesk N700 (\$70)

Two of our biggest gripes with laptops: They get too hot, and their

speakers never have enough juice. This padded USB-powered lapdesk is the first one that has both a built-in cooling fan and built-in (and surprisingly powerful) speakers.

7. Kodak Pulse Digital Frame (\$130)

Uploading new photos to digital frames is a nuisance. Stashing shots on this

7-inch display is as easy as sending an e-mail—the Wi-Fi-connected frame has its own address. Send a picture to it from a PC or phone, and the shot pops up on the screen.

8. Lenovo IdeaPad S10-3t (starts at \$500)

All signs suggest that 2010 will be the year of the touchscreen tablet PC, with multiple

manufacturers planning their own takes on the tech. This convertible tablet (it has a keyboard that can be completely covered by the swiveling 10-inch touchscreen) is part of a new breed of machines that take advantage of Windows 7's built-in multitouch capabilities.



The (New) Home Theater Setup Guide



JUST WHEN YOU THOUGHT YOU'D MASTERED THE MESS OF WIRES, PLUGS AND PORTS REQUIRED FOR HDTV AND MULTICHANNEL SOUND, THE NEW ERA OF NETWORKED HOME ENTERTAINMENT IS CHANGING EVERYTHING—AGAIN. HERE'S WHAT YOU NEED TO KNOW TO HOOK UP THE ULTIMATE HOME THEATER.

BY GLENN DERENE

THE CONNECTED HOME THEATER

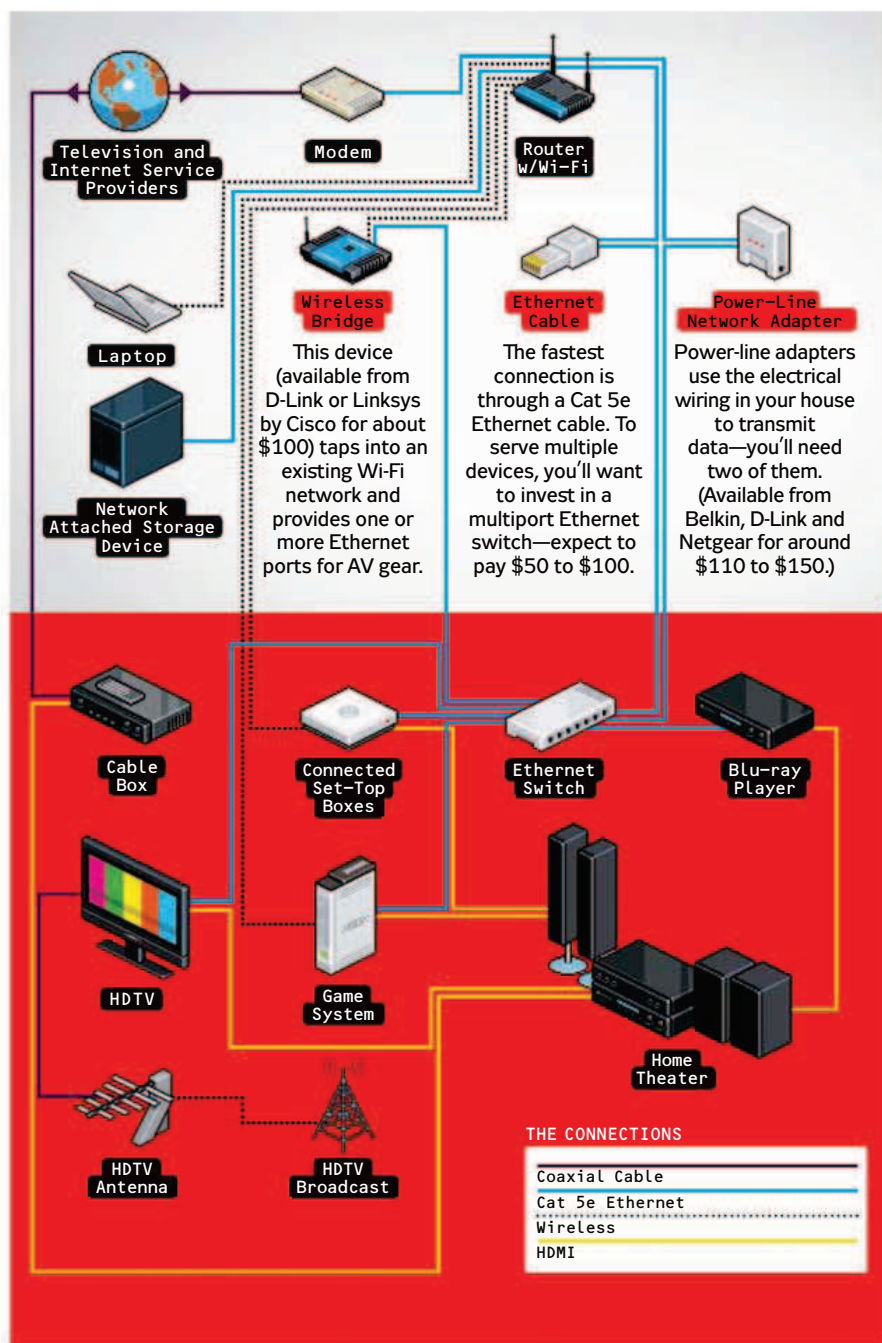
A modern home theater is part of a home network. The ideal setup uses both wireless and wired connections. And there are several ways to bridge the gap between computer and AV equipment.

THE PRODUCTS

1. *Vizio's 55-inch TruLED LCD HDTV* (\$2200) can dim sectors of the screen for increased contrast.
2. The *AppleTV* (\$230) syncs with computers running iTunes on a local network and can be used to purchase content from the iTunes store.
3. *Sony's HT-SS360 5.1-Channel Home Theater System* (\$350) has 1000 watts of power and three HDMI inputs.
4. Both a game console and an AV streaming device, the *Xbox 360* (starting at \$200) acts as a hub between a home theater and a network.
5. The *Roku HD-XR Digital Video Player* (\$130) can stream HD movies from Netflix and Amazon.
6. The *Samsung BD-P3600 Blu-ray Player* (\$300) can stream movies from the Internet or networked PCs.

One of the engineering challenges of the digital age is that even though most homeowners get their TV and Internet from the same provider, the two services are usually set up in different parts of the house. The cable box is in the living room or den, while the broadband Internet modem is stationed in the home office.

Increasingly, though, home theater gear wants in on that broadband connection. Gaming systems such as the Xbox 360 and PlayStation 3, as well as Blu-ray players and HDTVs from Samsung, LG, Sony, Panasonic and Vizio, can tap into online services for content. What's more, many of these devices



INSIDE

→ THE PRODUCTS → THE CONNECTED HOME THEATER → HOW TO MOUNT A FLAT-PANEL TV
→ CALIBRATING YOUR TV → WHAT'S A WIDGET? → CABLE GUIDE

depend on connectivity for software updates and patches. For better or worse, the new model of basic electronics maintenance requires a direct Internet link.

The tough news is that it can be a mind-bending exercise to hook it all together. Look at the diagram on page 35 and you'll see just how complex a fully networked system can get. Some of your home theater equipment can natively tap into a Wi-Fi network, but most modern AV gear is strictly an Ethernet plug-in proposition. So to make all of your computer gear cooperate with your home theater, you need to explore the tools (wireless bridges, power-line networking or long throws

of Cat 5e cable) that allow these devices to shake hands.

The good news here is that patching AV gear into a computer network opens up a whole new set of options in terms of content. Pictures and audio and video files can be accessed from computers or networked drives in any room in the house and viewed on your TV, and online content can be streamed directly to your living room using a more TV-friendly interface.

Internet movie and music services such as Netflix, Amazon Video On Demand and Apple's iTunes Store are pretty sophisticated and user-friendly. Most of these services allow you to rent, buy or stream audio and video directly to a variety of AV equipment.

Things get a bit trickier when you try to collect and manage video files among computers and networked drives on your home network. There is no standard format for HD video—the confusing file extensions include .avi, .mov, .mkv, .m4v, etc. The best advice we can provide is to make sure all of your equipment is certified by the Digital Living Network Alliance (DLNA), which will ensure that all the devices can see one another. Then acquire a transcoding software package, such as Badaboom (\$30) from Elemental Technologies, which translates uncooperative files to formats that your equipment can understand.

MOUNTING A FLAT-PANEL TV

TV

Most TVs have standard mounting points on the back. The bolts used to attach the TV's stand are usually the same as those for the mount. Still, check the compatibility of your TV before you buy a mount.

Most HDTV manufacturers suggest that customers leave wall-mounting to pro installers, but PM believes that a careful DIYer can do just as good a job. Hardware from companies such as Sanus and OmniMount can articulate along any axis. Regardless of how you want your set to tilt or swivel, pick a mount to fit your TV's size and weight—for anything over 50 pounds, attach the hardware to two studs. Most important: Before adding the weight of your TV, give the mount a good tug. If anything feels loose, start over.

MOUNT

Mounts generally come in two pieces: a bracket that attaches to the wall, and a mounting plate that bolts to the back of your TV. The two pieces are installed separately. Then the TV is locked onto the mounting plate.

WALL

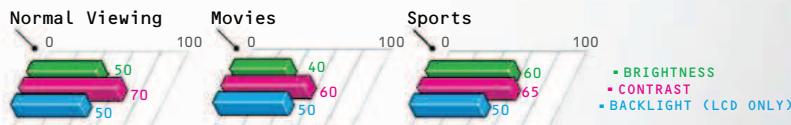
Depending on the size and weight of your television, the mounting plate should be anchored to either one or two studs. Use a digital stud finder to mark the edges of each stud, then drive lag screws into the center for a firm anchor. Trust us, you don't want to anchor to the edge of the stud.

TOOLS

Screwdriver / Socket Wrench / Stud Finder / Cordless Drill Driver / Measuring Tape

CALIBRATING YOUR HDTV

TV calibration is a complex art that is best left to the professionals. But if you don't feel like paying a pro, you'll get 90 percent of the benefit by just setting your TV's levels according to this chart.

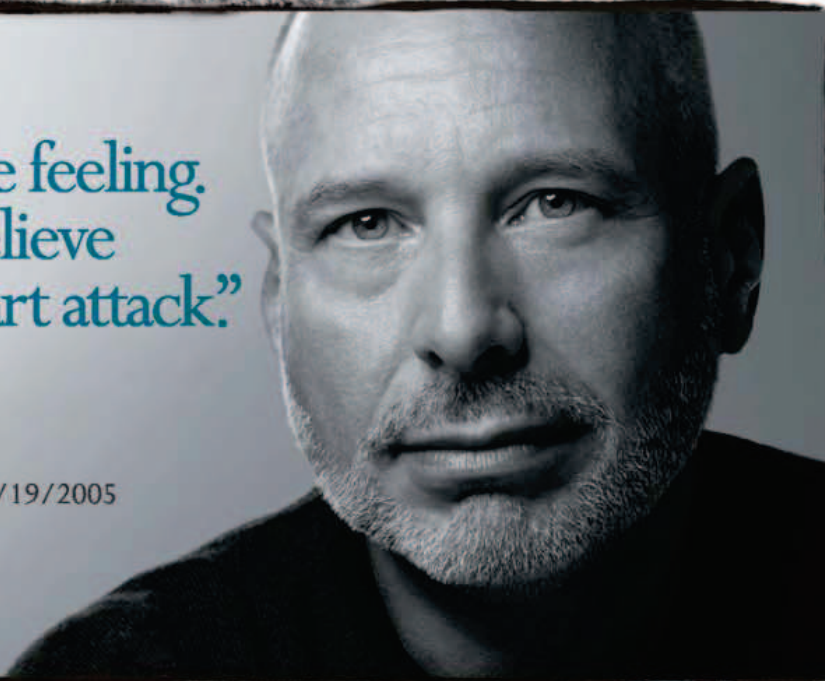


WHAT'S A WIDGET AND WHAT DOES IT DO?

Many new TVs come with Internet connectivity built in. The most widespread system, Yahoo TV Widgets, is now found on Sony, Samsung, LG and Vizio TVs. The widget interface is still evolving, but currently you can set up multiple accounts on a single set, letting each member of the family tap into his or her own Twitter feed, Flickr photos and Facebook account or get real-time info from sources such as *USA Today* and CBS Sports.

**"It was a horrible feeling.
I couldn't believe
I was having a heart attack."**

~Dean K.
Airmont, NY
Heart attack: 12/19/2005



**"I should've done more to take care of myself.
Now I'm exercising, watching my diet, and I trust my heart to Lipitor."
Talk to your doctor about your risk and about Lipitor.**

- Adding Lipitor may help, when diet and exercise are not enough. Unlike some other cholesterol-lowering medications, Lipitor is FDA-approved to reduce the risk of heart attack and stroke in patients with several common risk factors, including family history of early heart disease, high blood pressure, low good cholesterol, age and smoking.
- Lipitor has been extensively studied with over 17 years of research. And Lipitor is backed by 400 ongoing or completed clinical studies.

IMPORTANT SAFETY INFORMATION:

LIPITOR is not for everyone. It is not for those with liver problems. And it is not for women who are nursing, pregnant or may become pregnant.

If you take LIPITOR, tell your doctor if you feel any new muscle pain or weakness. This could be a sign of rare but serious muscle side effects. Tell your doctor about all medications you take. This may help avoid serious drug interactions. Your doctor should do blood tests to check your liver function before and during treatment and may adjust your dose.

Common side effects are diarrhea, upset stomach, muscle and joint pain, and changes in some blood tests.

INDICATION:

LIPITOR is a prescription medicine that is used along with a low-fat diet. It lowers the LDL ("bad" cholesterol) and triglycerides in your blood. It can raise your HDL ("good" cholesterol) as well. LIPITOR can lower the risk for heart attack, stroke, certain types of heart surgery, and chest pain in patients who have heart disease or risk factors for heart disease such as age, smoking, high blood pressure, low HDL, or family history of early heart disease.

LIPITOR can lower the risk for heart attack or stroke in patients with diabetes and risk factors such as diabetic eye or kidney problems, smoking, or high blood pressure.

Please see additional important information on next page.



Have a heart to heart with your doctor about your risk. And about Lipitor.

Call 1-888-LIPITOR (1-888-547-4867) or visit www.lipitor.com/dean

*You are encouraged to report negative side effects of prescription drugs to the FDA.
Visit www.fda.gov/medwatch or call 1-800-FDA-1088.*

IMPORTANT FACTS



LIPITOR
atorvastatin calcium
tablets

(LIP-ih-tore)

LOWERING YOUR HIGH CHOLESTEROL

High cholesterol is more than just a number, it's a risk factor that should not be ignored. If your doctor said you have high cholesterol, you may be at an increased risk for heart attack and stroke. But the good news is, you can take steps to lower your cholesterol.

With the help of your doctor and a cholesterol-lowering medicine like LIPITOR, along with diet and exercise, you could be on your way to lowering your cholesterol.

Ready to start eating right and exercising more? Talk to your doctor and visit the American Heart Association at www.americanheart.org.

WHO IS LIPITOR FOR?

Who can take LIPITOR:

- People who cannot lower their cholesterol enough with diet and exercise
- Adults and children over 10

Who should NOT take LIPITOR:

- Women who are pregnant, may be pregnant, or may become pregnant. LIPITOR may harm your unborn baby. If you become pregnant, stop LIPITOR and call your doctor right away.
- Women who are breast-feeding. LIPITOR can pass into your breast milk and may harm your baby.
- People with liver problems
- People allergic to anything in LIPITOR

BEFORE YOU START LIPITOR

Tell your doctor:

- About all medications you take, including prescriptions, over-the-counter medications, vitamins, and herbal supplements
- If you have muscle aches or weakness
- If you drink more than 2 alcoholic drinks a day
- If you have diabetes or kidney problems
- If you have a thyroid problem

ABOUT LIPITOR

LIPITOR is a prescription medicine. Along with diet and exercise, it lowers "bad" cholesterol in your blood. It can also raise "good" cholesterol (HDL-C).

LIPITOR can lower the risk of heart attack, stroke, certain types of heart surgery, and chest pain in patients who have heart disease or risk factors for heart disease such as:

- age, smoking, high blood pressure, low HDL-C, family history of early heart disease

LIPITOR can lower the risk of heart attack or stroke in patients with diabetes and risk factors such as diabetic eye or kidney problems, smoking, or high blood pressure.

POSSIBLE SIDE EFFECTS OF LIPITOR

Serious side effects in a small number of people:

- **Muscle problems** that can lead to kidney problems, including kidney failure. Your chance for muscle problems is higher if you take certain other medicines with LIPITOR.
- **Liver problems.** Your doctor may do blood tests to check your liver before you start LIPITOR and while you are taking it.

Call your doctor right away if you have:

- Unexplained muscle weakness or pain, especially if you have a fever or feel very tired
- Allergic reactions including swelling of the face, lips, tongue, and/or throat that may cause difficulty in breathing or swallowing which may require treatment right away
- Nausea, vomiting, or stomach pain
- Brown or dark-colored urine
- Feeling more tired than usual
- Your skin and the whites of your eyes turn yellow
- Allergic skin reactions

Common side effects of LIPITOR are:

- Diarrhea
- Muscle and joint pain
- Upset stomach
- Changes in some blood tests

HOW TO TAKE LIPITOR

Do:

- Take LIPITOR as prescribed by your doctor.
- Try to eat heart-healthy foods while you take LIPITOR.
- Take LIPITOR at any time of day, with or without food.
- If you miss a dose, take it as soon as you remember. But if it has been more than 12 hours since your missed dose, wait. Take the next dose at your regular time.

Don't:

- Do not change or stop your dose before talking to your doctor.
- Do not start new medicines before talking to your doctor.
- Do not give your LIPITOR to other people. It may harm them even if your problems are the same.
- Do not break the tablet.

NEED MORE INFORMATION?

- Ask your doctor or health care provider.
- Talk to your pharmacist.
- Go to www.lipitor.com or call 1-888-LIPITOR.

Uninsured? Need help paying for Pfizer medicines? Pfizer has programs that can help. Call 1-866-706-2400 or visit www.PfizerHelpfulAnswers.com.

 **helpful
answers**



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June 2009

Rx only

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CABLE
GUIDE

THE LINES BETWEEN DATA, AUDIO AND VIDEO CABLES ARE NOW COMPLETELY BLURRED, BUT THAT DOESN'T MEAN THE WORLD OF WIRING IS SIMPLER. THERE ARE MORE CABLES THAN EVER—HERE'S HOW TO USE THEM.

CAT 5e

This cable connects every device to your home network, allowing you to distribute movies, music and photos from PCs to HDTVs.

USB

The standard wire for connecting PC peripherals is also used for game-console controllers.

iPOD**CONNECTOR**

Many home theater receivers integrate iPod docks or USB inputs that interface directly with iPods.

DVI

Some PCs now have built-in AV connectors, but DVI, a video-only screen output, is still the most common way to get HD images out of a computer.

SPDIF

This optical cable transmits a purely digital audio signal from components and computers to receivers.

MINIJACK

Most commonly used for headphones, this analog stereo audio connection is also the default audio output for portable devices.

**COAXIAL
AUDIO**

Like optical SPDIF audio cables, coaxial audio cables carry pure digital audio signals from components to AV receivers.

HDMI

The current king of AV cables, HDMI carries an uncompressed 1080p video signal and up to eight channels of digital audio.

COMPONENT

This three-plug analog technology can carry HD video up to 1080p, but cannot handle audio.

S-VIDEO

Back in the days of DVDs, S-video was the highest quality video connector you could get, but it is limited to an analog signal of 480i.

COMPOSITE

This video cable can only carry a standard-def image, but it is common on older equipment.

RCA AUDIO

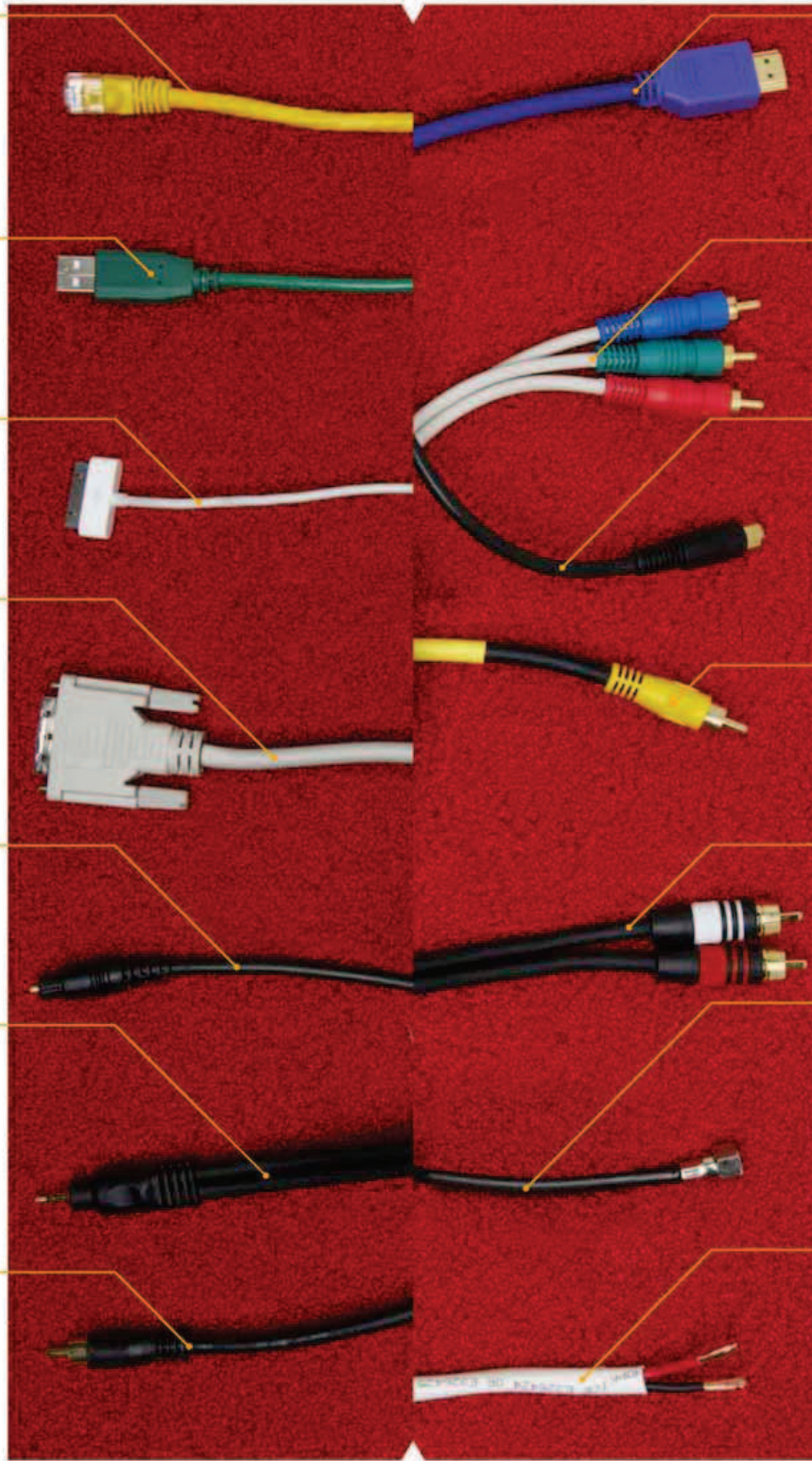
Two-plug analog RCA jacks are still the most common way to connect audio components.

COAXIAL

Not to be confused with coaxial audio, this is the "cable" behind the cable industry. It carries both multichannel video and Internet into your home.

SPEAKER WIRE

Great big spools of this traditional wire need to be run throughout a room to carry sound from an AV receiver to surround-sound speakers.



GREAT PRODUCTS AND PROMOTIONAL OFFERS FROM PM ADVERTISERS

THE LAST "CAN OF AIR" YOU'LL EVER HAVE TO BUY!

New **DataVac® Electric Duster®**, the high-performance "green" alternative to throwaway "canned-air" computer dusting products. Features an all-steel body built to last and a full range of high-quality computer cleaning attachments. Made in USA...Costs less than 5 "cans of air"!



Visit DataVacElectricDuster.com for more information.

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The all-new **MRT® (Mechanix Racing Technology) 0.5 M-Pact®**

Glove continues our tradition of cutting edge, race developed products. It offers both high dexterity and protection. A honeycomb exoskeleton integrates with a specially-designed rubber knuckle ribbing for top-of-hand protection. It has a 2-stage palm of thinner 0.5mm dimpled Clarino

Septon in the fingers and dual-layer EVA foam palm panels for impact protection. The fingertips and partial palm are also overprinted for an ultra grip. This glove has it all. Mechanix Gloves. The Tool That Fits Like A Glove.®



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2010
**honda
accord
crosstour**

2010

Segment Buster

The Honda Accord Crosstour doesn't fit neatly into any one vehicle segment. Yet it's several notches closer to "car" than most crossovers. The Crosstour uses most of the components of the V6 Honda Accord, so it drives more like a family sedan than a utility wagon. In fact, this might be one of the most rewarding crossovers to drive. The 271-hp V6 is powerful and smooth, the rev-matching five-speed automatic performs supple shifts, and the suspension and steering are surprisingly well-suited to spirited driving. But when it comes to real hauling, the Crosstour doesn't offer quite as much room inside as some of its rivals, nor can it tow quite as much weight. Still, if driving passion is more important to you than hauling, the Crosstour is a comfortable—and even fun to drive—family wagon. — BEN STEWART

Base Price: \$34,900





Efficiently Enjoyable

If the sixth-generation VW Golf were a piece of software, odds are it would be called the Golf 5.2. That's because the visible changes between the fifth and sixth generations are so slight that some might have a hard time distinguishing the two. Still, the news under the hood is quite significant. For the first time, the Golf is available with VW's 140-hp 2.0-liter turbodiesel—the same one we've been enjoying in the Jetta for over a year. This torquey diesel delivers 30 mpg city, 41 mpg highway and a relentless surge when the right pedal is pressed firmly to the carpet. A 2.5-liter gasoline engine is available too, but we'd opt for the more pricey \$21,990 diesel model. Though the new Golf may be one or two genes off from last year's model, the car retains all the traits we dug the last time around: a spacious, finely crafted interior, efficient motoring and buckets of driving fun. — JAMES TATE

Purebred

The traditional midsize SUV may have been the definitive vehicle of the 1990s, but now it's an endangered species. Whistling right past that SUV graveyard is the new Toyota 4Runner—a full-frame rock crawler. In fact, the 4Runner drives a lot like a Land Cruiser. Buy one in white, throw some U.N. stickers on the front doors, and you're ready for a mission in Africa. Even though the new 4Runner hasn't changed much dimensionally from its predecessor, it feels heftier and more planted. A 157-hp 2.7-liter four-cylinder engine is available on 2WD models, but most 4Runners will use a 270-hp 4.0-liter V6. Sorry, V8 fans, the Six is the largest engine in the lineup. That's okay—the V6 is never strained by the 4Runner's heft, the unobtrusive transmission doesn't have to hunt for the right gear, and shifts are creamy smooth. But off-road is where the 4Runner is a stunner. Tug the lever into low range, and experienced off-roaders will have the 4Runner floating over the Rubicon Trail. — JOHN PEARLEY HUFFMAN

A panel above the rearview mirror on 4Runner Trail models houses the controls for two new off-road technologies. Crawl Control manages the throttle and brakes over difficult terrain so the driver can focus on steering. Multi-Terrain Select allows the driver to dial in wheel-slip control to match the trail—more slip for sand and mud, less when driving on rocky terrain.

HONDA ACCORD | CROSS TOUR | VW GOLF | TOYOTA 4RUNNER | KIA SORENTO | SUZUKI TU250X | BENTLEY CONTINENTAL SUPERSPORTS | DODGE RAM HEAVY DUTY | LEXUS LFA | SUZUKI KIZASHI | ACURA ZDX

URGENT MESSAGE

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When you order your FREE Dynamo Emergency World Band Radio, you'll also receive four free issues of Newsmax magazine — a \$20 value — yours FREE.

Newsmax magazine brings you exclusive stories the major media won't report. Even they can't ignore



Emergency LED Flashlight

Built-in hand crank generator means radio operates even if the batteries fail!

Important Features of the Emergency World Radio:

- 8-Band World Receiver
- Long-Range AM Receiver
- 6 Shortwave Bands
- High Sensitivity FM Band
- High Quality 2" Speaker
- Emergency LED Flashlight
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1

2011
Kia Sorento

2

2009
Suzuki TU250X

3

2010
Bentley Continental
Supersports

Secrets of Success

Other automotive brands have been hit hard by the recession, but Kia has actually increased its market share. Its surge has been fueled, at least in part, by striking design. And while the new Sorento doesn't stand out as much as the boxy Soul, it's certainly handsome. Besides the unibody chassis, the \$20,000 (est.) 2011 Sorento now offers full-time all-wheel drive. In other words, this is Kia's first midsize crossover. The ride is smooth, and the cabin provides a quiet, relaxing environment for road trips. The 273-hp V6 has plenty of power and offers 28 mpg highway. Four-cylinder models deliver 1 mpg better. The suspension won't inspire you to seek twisty two-laners, but it's perfect for the daily commute. The optional third-row seat is handy, but think "kid-zone only." With the second row folded, there are almost 73 cubic feet of storage space—nearly best in class. —KEVIN A. WILSON

RETRO BARGAIN

Every now and then, a motorcycle manufacturer decides to keep it simple. The \$3799 retro-style Suzuki TU250X (available in every state but California) is a hip bike for beginners or those who simply yearn to get a taste of the past without a huge outlay of cash. Swing a leg over the TU250X, and you'll be welcomed by a nice, low seat. The TU250X isn't quick, but at speed the Suzuki's mild acceleration couples with quick, nimble direction changes. It's actually fun to ride, thanks to the bike's feathery 328-pound curb weight. It's tossable, and a joy to fling around the tight curves. However, this is a small bike, so larger riders might find the ergonomics a bit too compact for their frame.

—BASEM WASEF

Recession-Proof

The new Bentley Continental Supersports pounds out an astonishing 622 hp and comes with equipment you'd never expect to see in a Bentley—like racing bucket seats and carbon-ceramic brakes. And although a 204-mph Bentley is no recipe for eco-motoring, the new flex-fuel Continental Supersports can run on E85. To create the Supersports, Bentley trimmed 243 pounds from the Continental GT Speed by nixing unnecessary equipment like, say, back seats. It's hard to wrap your mind around the fact that a car this huge can be so fast. Power from that big W12 is boundless, pouring through the drivetrain to all four of the very fat tires. And as impressive as the straight-line launches are, Bentley's work on the car's suspension is absolutely remarkable. Body roll is all but nonexistent, and the handling is incredibly precise. But before you say, "Well, it should be, in a \$270,000 car," remember that the Supersports still weighs 4939 pounds. It drives as though it weighs exactly 1 ton less. —J.T.

HONDA ACCORD | CROSSOVER | VW GOLF | TOYOTA 4RUNNER | KIA SORENTO | SUZUKI TU250X | BENTLEY CONTINENTAL SUPERSPORTS | DODGE RAM HEAVY DUTY | LEXUS LFA | SUZUKI KIZASHI | ACURA ZDX

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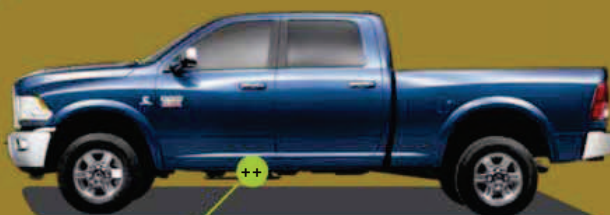


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2010
Dodge Ram Heavy Duty

1



2011
Lexus LFA

Hardcore Hauler

As part of Fiat-Chrysler's turn-around plan, CEO Sergio Marchionne has made Ram its own brand going forward. We can't think of a more fitting line of rigs to sit atop the division than the new Ram HD pickups. They may look new from the outside, but much of the big truck's foundation remains the same. Underhood, there's a 380-hp 5.7-liter V8 or the 350-hp Cummins diesel with a mountain-moving 650 lb-ft of torque. Over the course of our 120-mile two-lane highway romp through central Texas, we saw an average of 16.2 mpg in a 2WD 3500 dually—not too bad. But our favorite was the Power Wagon. This special off-road package comes with better gearing, a monster winch, locking differentials and a front sway-bar disconnect that allows the suspension to flex like a contortionist over obstacles. Oh, and we dig those flat black graphics on the bodywork too. — MARK WILLIAMS

Stealthy Supercar

Ten years ago, Toyota instructed its Lexus luxury division to start bottling up enough tech to build the ultimate sports machine. One glance at the spec sheet is enough to confirm that much blood and treasure have been expended on the LFA (short for Lexus Future Advance). The 552-hp 4.8-liter V10 peaks at an ear-splitting 9000 rpm. That V10 bursts into life and whines into an absurdly high idle speed like an industrial fan heater. Pull the right-hand shift paddle into first and the car pulls away reluctantly, as if the single-plate clutch were sparing you the full force of the engine. Speed up a whole lot more, however, and you start to realize just how super the LFA actually is. That V10 dominates the experience, with a hammering, band-saw engine note that feeds back directly into the cabin and your synapses. Power delivery is as flat as a sportbike. Out on the new Nürburgring grand prix track, we saw 170 mph and it was still pulling incredibly hard, that V10 howling away. We want one—quite badly. — ANDREW ENGLISH

The LFA will run to 60 mph in 3.6 seconds and hit a top speed of 202 mph. Only 500 of the \$375,000 supercars will be built globally. At least part of that price can be blamed on the carbon-fiber construction that helps the LFA weigh just 3263 pounds. From the chassis to the body panels, all the carbon fiber was developed and produced in-house at Toyota. Impressive.

HONDA ACCORD CROSS TOUR | VW GOLF | TOYOTA 4RUNNER | KIA SORENTO | SUZUKI TU250X | BENTLEY CONTINENTAL SUPERSPORTS | DODGE RAM HEAVY DUTY | LEXUS LFA | SUZUKI KIZASHI | ACURA ZDX



Bold Mover

The new Suzuki Kizashi may be the best car the automaker has ever produced. The company undertook a rigorous design and development program targeting the best midsize sedans, and its engineers left no fastener unturned in their quest for class-leading dynamics. All of Suzuki's painstaking chassis work has produced a seriously competent sedan. In slalom and lane-change tests set up by Suzuki at Portland International Raceway, we compared the Kizashi to several models. And the \$19,000 Kizashi turned in with more crispness, resisted roll with more determination and exhibited way less understeer than most of its competitors. Some of its secrets were revealed by a sectioned body shell, with numerous gussets and welded-in bridges. This is one stiff structure. Though the Kizashi's 185-hp four-cylinder provides only modest thrust, a big V6 is on the way. If the Kizashi is indicative of Suzuki's future cars, we can't wait to see what's next.

—BARRY WINFIELD

The new Kizashi's optional all-wheel-drive system isn't just for snowy-weather security. The i-AWD, as Suzuki calls it, is integrated with the stability control and has strategies that combine with the usual brake operation to stabilize a wayward Kizashi. For example, it can transfer torque to the front wheels in the event of a rear-wheel slide.

Defying Classification

The crossover vehicle class has splintered into yet another subset—the sporty, all-wheel-drive four-door coupe. Though capable of hauling five passengers, the \$46,305 Acura ZDX's layout lends more space to the front passengers, with cargo capacity reaching 55.8 cubic feet when the rear seats are folded down. The 300-hp 3.7-liter V6 provides only modest boost off the line, but the surge gets more forceful when the V6 stretches past the 5000-rpm mark, offering a heightened punch. Low steering effort and sharp throttle response enable the ZDX to feel lighter than its 4424 pounds, and that sensation of nimbleness was evident as we hit Malibu's tight canyon roads. The ZDX's driving dynamics offer a reasonable balance between luxury and sportiness. Other crossovers may offer more practicality, but few will turn as many heads. —BASEM WASEF

FIRST
LOOK1. 2010
LEXUS GX 460

Crossovers might dominate the suburban landscape, but Lexus believes that some buyers still want a strong ladder frame and the V8 power of an SUV for serious towing. The GX 460 may offer all the usual Lexus luxuries, but it can also handle a whopping 6500-pound trailer-towing capacity, thanks to its new 301-hp V8 and six-speed automatic.

2. 2011
TOYOTA SIENNA

Toyota's new Sienna retains the current 3.5-liter V6, while adding a 2.7-liter four-cylinder that boosts value and economy. Both are paired to six-speed automatics and should beat the current Sienna's 24-mpg highway. The new Sienna is hipper and more luxurious than its forebears. And Limited models include lounge seating—with an ottoman.

3. 2011
FORD MUSTANG

Next year, Ford's legendary Mustang muscles up. The car's ancient 210-hp 4.0-liter V6 will be replaced by a tech-heavy 305-hp 3.7-liter V6 paired to six-speed manual and automatic transmissions. The company says the V6 Mustang will hit 30 mpg highway. A new 5.0-liter V8 will also debut in the Mustang GT, packing right around 400 hp.

4. 2011
HYUNDAI SONATA

Hyundai is on a roll these days. The all-new Sonata promises to take a larger bite from Camry and Accord sales, with a look that suggests designers performed a mind meld with Lexus. A new direct-injected 198-hp 2.4-liter four-cylinder will deliver 35 mpg. The top engine will be a turbocharged Four that will debut later in the year along with a hybrid model.



MERCEDES-BENZ / SPLITVIEW

In a nation of distracted drivers, there's good reason for restrictions on in-dash navigation screens. Currently, the U.S. doesn't allow front-seat passengers to view video media unless the car is parked. But the new Mercedes-Benz SplitView screen, debuting on the S400 Hybrid, provides a novel work-around. The 8-inch Bosch-developed screen can show two pictures simultaneously by using a filter to mask the display, allowing driver and passenger to view different images at the same time.

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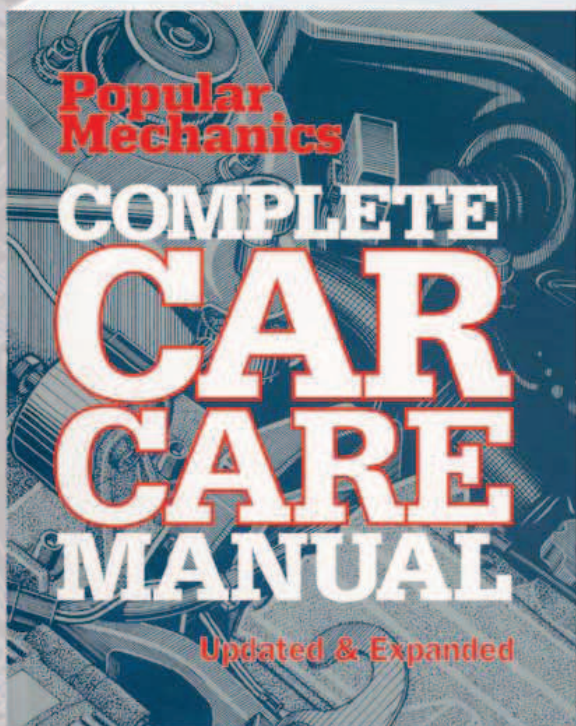
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WILL COAL
BECOME THE
CLEAN, GREEN
FUEL OF
THE FUTURE?
NOT SO FAST.

THE MYTH OF CLEAN COAL

> BY JAMES B. MEIGS
> ILLUSTRATION BY PAUL BLOW

C

oal is pretty amazing stuff. A single fist-size lump of bituminous coal contains about 12,000 Btu—enough energy to power a 75-watt bulb for two days. It's relatively easy to dig out of the ground and dirt-cheap: about one-sixth the cost of oil or natural gas per Btu. Most of the modern industrial world we see around us was built with coal power.

But coal has issues. Each lump can contain large amounts of sooty particulates, sulfur and nitrogen compounds (which cause acid rain), and traces of mercury and other toxic metals. Although coal-fired power plants are cleaner than they used to be, they are still bad news for the environment and human health. A recent study concluded that coal emissions contribute to 10,000 premature deaths in the United States each year. And coal is by far the largest single source of greenhouse gases in the U.S. So it is no surprise that coal has long been the primary

target of proposals to cut air pollution and carbon-dioxide emissions.

Until now. Just in time to skirt the various plans to cap or tax CO₂, coal is getting rebranded. The new buzzword is “clean coal”—and it's being portrayed as the high-tech, low-emissions fuel of the future. Senators John Kerry, D-Mass., and Lindsey Graham, R-S.C., recently wrote a *New York Times* op-ed piece calling for the United States to become the “Saudi Arabia of clean coal.” U.S. energy secretary Steven Chu has called on his counterparts around the world to promote the “widespread affordable deployment” of clean-coal technology. A current climate bill in the U.S. Senate proposes a complex regime of taxes and subsidies intended to cut America's greenhouse gas emissions by 20 percent by 2020. But the bill effectively gives the coal industry a pass on cutting emissions until “sufficient commercial-scale” clean-coal technology has been deployed. Why try to reduce our dependence on coal today, the reasoning seems to be, when fabulous, guilt-free clean coal is just around the corner?

There's just one problem with this scenario: Coal will never be clean. It is possible to make coal emissions *cleaner*. In fact, we've come a long way since the '70s in finding ways to reduce sulfur-dioxide and nitrogen-oxide emissions, and more progress can be made. But the nut of the clean-coal sales pitch is that we can also bottle up the CO₂ produced when coal

is burned, most likely by burying it deep in the earth. That may be possible in theory, but it's devilishly difficult in practice.

Carbon dioxide is not some minor byproduct of coal combustion. Remember your high school chemistry: When coal burns, oxygen from the air combines with the carbon in the coal in an exothermic (heat-releasing) reaction. Because of the addition of oxygen, the resulting CO₂ weighs more than the carbon alone—which means that each pound of coal produces about 2.5 pounds of CO₂.

Keeping that CO₂ out of the atmosphere requires a process known as carbon capture and sequestration (CCS). It works by forcing the exhaust from a power plant through a liquid solvent that absorbs the carbon dioxide. Later, the solvent is heated to liberate the gas, much the way a bottle of soda releases its dissolved CO₂ when opened. The CO₂ is then compressed to about 100 times normal atmospheric pressure and sent away for storage.

So far, so good. But CCS has two major hurdles. First, it consumes energy—a lot of it. While estimates vary, a coal-fired power plant would have to burn roughly 25 percent more coal to handle carbon sequestration while producing the same amount of electricity. That would mean a vast expansion in mining, transportation costs and byproducts such as fly ash.

But that's the easy part. The harder challenge would be transporting and burying all of this high-pressure CO₂. American Electric Power recently began a CCS project at its Mountaineer Plant in West Virginia. The operation captures a few hundred tons of CO₂ a day. That's a start—but a typical 500-megawatt power plant produces about 10,000 tons daily. Collectively, America's coal-fired power plants generate 1.5 billion tons per year. Capturing that would mean filling 30 million barrels with liquid CO₂ every single day—about one and a half times the volume of crude oil the country consumes. It took roughly a century to build the infrastructure we use to distribute petroleum products. Could we build an even bigger CCS

infrastructure of pumps, pipelines and wells quickly enough to hit the ambitious targets the climate bill envisions? Serious plans to engineer—much less finance—such a vast project aren't even on the table.

Here's a final problem: We don't know if the gas will stay buried. We could easily spend hundreds of billions injecting CO₂ into the earth only to have it start leaking out again in a few decades. None of this means that CCS is impossible to achieve. But it is a dangerous gamble to assume that it will become technically and economically feasible any time soon.

At the moment, the Senate's climate bill is on the back burner. And many Americans remain dubious about both the causes of and the appropriate solutions for global warming. (Recent revelations that several climate scientists apparently tried to

a politically favored constituency—while actually worsening the problem it seeks to solve.

The focus on mythical clean coal is particularly frustrating because practical, cost-effective alternatives do exist—and I don't mean just wind and solar power. Natural gas is plentiful in the U.S., and gas-fired power plants produce only about half as much CO₂ as coal. Not only that, but once it's ready, the CCS technology envisioned for coal plants would be even more effective if used with natural gas. Tiny gas-fired cogeneration plants in individual homes could also help. Because these mini electrical generating systems use their waste heat to drive the homes' climate control systems, they avoid the huge energy losses involved in making power at distant facilities. This technology exists today. Nuclear power is another proven, low-CO₂-

RUNNING TODAY'S POWER PLANTS ON SO-CALLED CLEAN-COAL TECH WOULD MEAN FILLING 30 MILLION BARRELS WITH LIQUID CO₂ EVERY DAY.



quelch legitimate debate certainly don't inspire confidence.) But concern over greenhouse gas emissions will continue, and the pressure to regulate them is growing. Wouldn't it be a shame if we created a policy that burdens American consumers with higher energy prices and yet does virtually nothing to reduce our CO₂ emissions? By embracing the clean-coal myth, that lose-lose scenario may be exactly what we stand to achieve.

Sadly, although it might make little economic or scientific sense, the political logic behind clean coal is overwhelming. Coal is mined in some politically potent states—Illinois, Montana, West Virginia, Wyoming—and the coal industry spends millions on lobbying. The end result of the debate is all too likely to resemble Congress's corn-based ethanol mandates: legislation that employs appealing buzzwords to justify subsidies to

emitting option—and despite public fears, U.S. nuclear plants have been paragons of safety compared with the harm done by coal-fired plants.

The cleanest energy option of all is also the closest at hand: conservation. As clean-energy guru Amory Lovins has shown, it's almost always cheaper to save energy than to mine or drill for it. And there are still massive efficiencies to be found almost everywhere energy is used. Boosting incentives for insulation, next-gen LED lights and ultraefficient smart appliances could do more than carbon sequestration to reduce CO₂ emissions in the coming decades.

Let's be clear. We should continue research into making coal cleaner—that fuel will be a vital part of our energy mix for decades. But let's not allow clean-coal myths to divert us from real-world energy alternatives that work today.

PM



THE GYROPLANE DILEMMA

> BY JEFF WISE

Helicopters and gyroplanes:

It's a contentious family rivalry. Both have spinning rotors and are highly maneuverable at low speed. Gyros were invented in the early 1920s, but ever since helos were introduced in the 1940s, they've upstaged their older cousins. The main difference is that gyroplanes are unable to take off and land vertically. But fans say gyros have many other admirable qualities—they're mechanically simple and cheap to operate, for example. It's time, they argue, for a new appreciation of this long-overlooked form of flight. Detractors, however, are having none of it. They say gyroplanes are deathtraps.

In order to find out which of these diametrically opposed views is correct, I travel to Fond du Lac, Wis., to meet with Dofin Fritts, one of only about

ARE GYROPLANES
AIRBORNE DEATHTRAPS
OR FLYING FUN
MACHINES? THERE'S
ONLY ONE WAY
TO FIND OUT.

← PM contributing editor Jeff Wise in the Rotary Air Force 2000. The gyroplane kit costs \$45,105.

35 gyroplane instructors in the United States. He has been teaching for 17 years, and I figure that if he's survived that long, he can make it through a few more gyro flights with me. We meet at the town's sleepy, rural airport, where Fritts introduces me to his vehicle of choice, the Rotary Air Force 2000. Like all of today's gyroplanes, it's available in the U.S. only as a kit. Yet for a homebuilt craft, the RAF looks reassuringly snazzy, with shiny purple pushrods and a doorless bubble canopy. Anyone with a rotorcraft sport pilot's license can operate the two-seater, which has a 130-hp Subaru automotive engine that powers a three-blade pusher propeller.

Like a helicopter, a gyroplane generates lift with a set of spinning rotor blades. But in a helicopter, the engine spins the rotor. In a gyro, the engine is connected to a propeller, which pushes the craft forward. That forward motion spins the rotor blades like a pinwheel. The outer edge of the blades generates lift, and that keeps the gyro in the air.

We strap in and Fritts starts the engine. Pushed by the blast from the prop, we taxi to the edge of the runway, where Fritts talks me through a procedure called pre-rotation, which

gets the rotor blades spinning by temporarily connecting them to the engine. With the engine at idle, I squeeze a lever to engage the clutch. *Whoosh ... whoosh ... whoosh.* I squeeze tighter to increase power. The blades spin faster. *Whoosh. Whoosh. Whoosh.* I let go of the clutch, release the wheel brakes and add power to the propeller. We roll out onto the runway. Throttle to full! *Whooshwhoosh-whoosh.* Now the only thing driving the rotor is the flow of air from our forward motion. The blades accelerate to a blur. Rolling along at 50 mph, the gyroplane abruptly lifts into the sky, climbing much more steeply than I'm used to in the small fixed-wing planes that I normally fly.

We level off at 1000 feet. The cockpit swings beneath the rotor blades as we bump along in the afternoon ther-

mals. Fritts asks me to take my hands off the controls. I do, and the RAF putters along straight and level all by itself. Next I try some gentle turns, left and right. Although it looks like a helicopter, the gyro flies like a supernaturally agile plane. Fritts takes the controls and pushes the stick hard to the left. As we shoulder into a steep bank, it feels like we're not so much turning as pivoting in place.

The crucial task in flying a gyroplane is managing the energy of the rotor. If you fail to keep air flowing through it, its speed drops, and so does the rotor's ability to provide lift. Careless pilots sometimes find themselves in this situation when they climb too steeply, lose airspeed and try to gain velocity by pushing the stick forward. This can result in something called a power pushover, in which the aircraft lurches violently forward and plunges into the ground. Hence the deathtrap reputation.

But in other ways gyroplanes are actually safer than airplanes. They can't stall—that is, undergo the catastrophic loss of lift that results from flying too slowly. To demonstrate, Fritts asks me to fly straight ahead,

then gradually reduce engine power as I pull back on the stick as if to climb. The airspeed indicator slides down past 40 mph, 30, 20, all the way to zero. The landscape is frozen in the windshield, then starts to move in reverse. We're being carried backward by a headwind as we sink through the air, our spinning rotor acting like a parachute. We could ride all the way to the ground like this. We'd hit hard, but the impact would be survivable.

To restore lift, Fritts takes the controls and adds power, gently pushing the stick forward. Then we head back to the airfield to practice landings. The approach is steep, but at the last minute Fritts pulls the nose up; the gyro touches down like a bird settling on a perch. Compared to airplanes, gyros can make ridiculously short landings. With the right wind, you can stop within the width of the runway.

Which brings us back to the original question: Are gyroplanes deathtraps or overlooked marvels of the air? True, gyroplanes have a relatively high accident rate. But with proper training, the risk can be minimized. Brian Pagán, a graduate student in engineering at the Eindhoven University of Technology in the Netherlands, has analyzed 20 years of gyroplane crash statistics. "There was nothing in my findings to indicate that gyroplanes are particularly dangerous," he says, "as long as you follow the rules."

During our second flight together, Fritts heads west of the airport, then eases us down to low altitude to follow a winding stream that cuts across the rural patchwork of farm fields. We bank left and right, following a corridor through a canyon of trees. We ease down lower and zoom along at stepladder height, dodging and weaving around bushes, then crank around in a steep turn and head straight for a gap between two stands of trees that's barely wider than we are. I only have an instant to think—impossible!—before we're through, the green whipping by so close I could reach out and grab a branch. Then we're climbing, banking to the left, veering downward again. "Want the stick?" Fritts asks. And that's when I know I'm hooked.

PM



- ← Gyroplane pilot Dofin Fritts demonstrates how the machine's control stick works.
- ↘ The author at the controls, banking into a steep turn to the left, high over central Wisconsin farms.
- ↓ Fritts comes in for a short landing at Fond du Lac.





Can Robots Be Trusted?

Humans have feared a robotic uprising since the machines first appeared in science fiction. Today, experts caution against a more insidious threat: We might like living with them too much.

by erik sofge

photographs by gregg segal

Being hacked by a robot requires much less hardware than I expected. There's no need for virtual-reality goggles or 3D holograms. There are no skullcaps studded with electrodes, no bulky cables or hair-thin nanowires snaking into my brain. Here's what it takes: one pair of alert, blinking eyeballs.

I'm in the Media Lab, part of MIT's sprawling campus in Cambridge, Mass. Like most designated research areas, the one belonging to the Personal Robots Group looks more like a teenage boy's bedroom than some pristine laboratory—it bursts with knotted cables, old pizza boxes and what are either dissected toys or autopsied robots. Amid the clutter, a 5-foot-tall, three-wheeled humanoid robot boots up and starts looking around the room. It's really looking, the oversize blue eyes tracking first, and the white, swollen, doll-like head following, moving and stopping as though focusing on each researcher's face. Nexi turns, looks at me. The eyes blink. I stop talking, midsentence, and look back. It's as instinctive as meeting a newborn's roving eyes. *What do you want?* I feel like asking. *What do you need?* If I was hoping for dispassionate, journalistic distance—and I was—I never had a chance.

"Right now it's doing a really basic look-around," researcher Matt Berlin says. "I think it's happy, because it has a face to look at." In another kind of robotics lab, a



Capable of gesturing and speaking, Sarcos was built in 1997 to talk about technology with children at the Carnegie Science Center in Pittsburgh. Social robots like it are expected to be a \$15 billion industry by 2015.

humanoid bot might be motivated by a specific physical goal—cross the room without falling, find the appropriate colored ball and give it a swift little kick. Nexi's functionality is more ineffable. This is a social robot. Its sole purpose is to interact with people. Its mission is to be accepted.

That's a mission any truly self-aware robot would probably turn down. To gain widespread acceptance could mean fighting decades of robot-related fear and loathing. Such stigmas range from doomsday predictions of machines that inevitably wage war on mankind to the belief that humanoid robots will always be hopelessly unnerving and unsuitable companions.

For Nexi, arguably the biggest star of the human-robot interaction (HRI) research field, fame is already synonymous with fear. Before visiting the Media Lab, I watched a video of Nexi that's been seen by thousands of people on YouTube. Nexi rolls into view, pivots stiffly to face the camera and introduces itself in a perfectly pleasant female voice. If the goal was to make Nexi endearing, the clip is a disaster. The eyes are big and expressive, the face is childish and cute, but everything is just slightly off, like a possessed doll masquerading as a giant toddler. Or, for the existentially minded, something more deeply disturbing—a robot with real emotions, equally capable of loving and despising you. Viewers dubbed its performance “creepy.”

Now, staring back at Nexi, I'm an instant robot apologist. I want to shower those clips with embarrassingly positive comments, to tell the haters and the doubters that the future of HRI is bright. There's no way seniors will reject the meds handed to them by chattering, winking live-in-nurse bots. Children, no doubt, will love day-care robots, even if the bots sometimes fail to console them, or grind to an unresponsive halt because of buggy software or faulty battery packs. To turn today's faceless Roombas into tomorrow's active, autonomous machine companions, social robots need only to follow Nexi's example, tapping into powerful, even uncontrollable human instincts.

That's why Nexi's metallic arms and hands are drifting around in small, lifelike movements. It's why Nexi searches for faces and seems to look you in the eye. When it blinks again, with a little motorized buzz, I realize I'm smiling at this thing. I'm responding to it as one social, living creature to another. Nexi hasn't said a word, and I already want to be its friend.

As it turns out, knowing your brain is being hacked by a robot doesn't make it any easier to resist. And perhaps that's the real danger of social robots. While humans have been busy hypothesizing about malevolent computers and the limits of rubber flesh, robotists may have stumbled onto a more genuine threat. When face to face with actual robots, people may become *too* attached. And like human relationships, those attachments can be fraught with pitfalls: How will grandma feel, for example, when her companion bot is packed off for an upgrade and comes back a complete stranger?

When a machine can push our Darwinian buttons so easily, dismissing our deep-seated reservations with a well-timed flutter of its artificial eyelids, maybe fear isn't such a stupid reaction after all. Maybe we've just been afraid of the wrong thing.

Robots began scaring us long before they existed. In 1921, the Czech play *R.U.R.*, or *Rossum's Universal Robots*, simultaneously introduced the word “robot” and the threat of a robot apocalypse. In a proclamation issued in the play's first act, the robots, built as cheap, disposable laborers, make their intentions clear: “Robots of the world, we enjoin you to exterminate mankind. Don't spare the men. Don't spare the women.” The origins of the evil robot can be traced back even further (see page 59), but *R.U.R.*'s new species of bogeyman was all the rage in the pulp sci-fi of the '40s and '50s—well before the actual research field of robotics. In fact, *I, Robot* author Isaac Asimov coined the term “robotics” at the same time that he began developing ethical laws for robots in his short stories.

By the time Arnold Schwarzenegger's T-800 gunned down an entire police precinct in the 1984 movie *The Terminator*, the robot insurgency had become one of pop culture's most entrenched clichés. The film has since become shorthand for a specific fear: that artificial intelligence (AI) will become too intelligent, too obsessed with self-preservation. *The Terminator* colors the way we think about robots, AI and even the booming business of unmanned warfare. The Office of Naval Research, among others, has studied whether ethical guidelines will be needed for military robots, and in a 2008 preliminary report the authors tackle the bleakest possible endgame: “*Terminator* scenarios where machines turn against us lesser humans.”

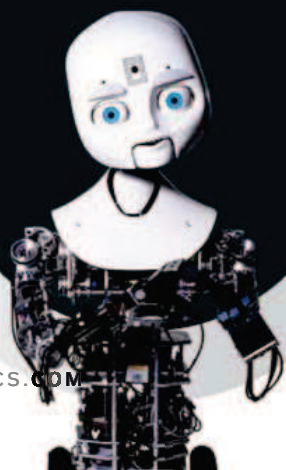
But according to Patrick Lin, an assistant professor of philosophy at California Polytechnic State University and an ethics fellow at the U.S. Naval Academy, the need for ethical bots isn't restricted to the battlefield. “Social robots probably pose a greater risk to the average person than a military robot,” Lin says. “They won't be armed, but we will be coming face to face with them, quite soon.”

That, of course, is precisely the kind of quote reporters work hard to publish. The media homes in on juicy details about the hypothetical danger of self-organizing AI, and the prospect of amoral robots gunning down civilians. But the real threats posed by robots may have nothing to do with the *Terminator* scenario. Because compared to even the dumbest armed insurgent, robots are practically brain-dead.

Take Nexi, for example. Considered to be one of the most advanced social robots in the world, Nexi can understand only the most basic vocal instructions. During my visit, it couldn't even do that—it was in the process of being loaded with behavioral software developed for another MIT robot, the fuzzy, big-eared Leonardo. Now in semi-retirement—its motors have gone rickety—Leonardo learns

Nexi

The first in a proposed class of MDS, or Mobile Dexterous Social, robots, Nexi is the most high-profile project in MIT's Personal Robots Group. It is part of an approach, pioneered at MIT, called embodied AI—artificial intelligence that, like human intelligence, is tied to the workings and limitations of its own body.



“Social robots probably pose a greater risk to the average person than a military robot,” Lin says. “They won’t be armed, but we will be coming face to face with them, quite soon.”



from humans such lessons as which blocks fit into a given puzzle, or which stuffed animal is “good” and which it should be afraid of. The implications are of the mind-blowing variety: a robot that listens to what we say and learns to crave or fear what we tell it to. Programmed with Leonardo’s smarts, “maybe in a year Nexi will be able to have a conversation with you that’s very boring,” MIT’s Berlin says. “But it may be pretty interesting if you’re trying to escape a burning building.”

If David Hanson, the founder of Hanson Robotics, has his way, the Texas-based company’s latest social robot, Zeno, could be talking circles around Nexi by the end of this year. At \$2500, the 23-inch-tall humanoid robot would be a bargain, not because of its hardware but because of the code crammed into its cartoonish head. “The intelligent software can be aware of multiple people in a room,” Hanson says. “It builds a mental model of who you are, what you like and what you said. We’re getting to the point where it can hold an open-ended, open-domain conversation.” Hanson plans to roll out a \$250 mass-market version in 2011 or 2012, with the same facial- and vocal-recognition capabilities. His goal is to provide a powerful testbed for researchers, while also harnessing AI algorithms to make a robot toy that’s actually fun for more than 15 minutes.

But for all of Nexi’s and Zeno’s social skills and painstaking simulation of emotional life, the bots are creatures of instinct, not introspection. Tracking software finds the human who’s speaking, a keyword triggers a scripted response, and when you leave the room, they don’t imagine where you’ve gone, whether the conversation helped or hurt you, or how to overthrow your government. “It’s very difficult for an artificial intelligence to project in a physical sense,” says Kevin Warwick, a professor of cybernetics at the University of Reading in England. “A robot can think about eventualities, but it can’t think even one step ahead about the consequences of its decisions.”

There are, of course, researchers who foresee rapid progress in computational neuroscience leading to inevitable “strong AI,” or artificial intelligence that’s not simply finishing your sentence in a Google search box, but mimicking human thought. IBM’s Blue Brain Project, for one, is energizing doomsayers with its goal of creating a virtual brain, potentially as soon as 2019. Still, without a neurological map of our own sense of consequence or morality, the breakthroughs that would allow for a truly power-hungry or evil robot are nowhere in sight. Contemplating them is a little like debating the ethical pitfalls of unregulated teleportation. Until someone builds the Enterprise, why worry if Scotty is going to drunk-dial himself into your house?

Robots will not rise up en masse anytime soon. Nexi won’t be e-mailing Zeno the “exterminate all humans” flier from *R.U.R.* to distribute among the world’s Roombas, Predators and assembly-line welding machines. It’s a fantasy, or, at best, a debate for another century. And like many robot

fears, it threatens to drown out a more rational debate, one that stems from the fact that robots fall through nearly every legal and ethical crack. “If an autistic patient charges a robot and tries to damage it, how should the robot respond?” asks Lin, who is also planning to develop ethical guidelines for social healthcare bots. “Should it shut down? It’s an expensive piece of equipment—should it push back?” When the robots arrive in force, are we prepared for the collateral damage, both physical and psychological, they could inflict?

When our eyes see a robot, one that we think is autonomous—moving, acting, functioning under its own power—our mirror neurons fire. These same neurons activate when we watch another animal move, and neuroscientists suspect they’re associated with learning, by way of imitation. Mirror neurons could care less about a wax statue, or a remote-control drone. It’s the autonomous robot that lights the fuse, tricking the mind into treating a mechanical device as a living thing.

And yet, like many aspects of human-robot interaction, the full repercussions are unknown. Science-fiction writers may have spent a half-century theorizing about the long-term effects of living with robots, but science is only getting started. While the field of HRI goes about the business of collecting data and sorting out its methodologies, drawing solid conclusions can be impossible, or at least irresponsible. Take those mirror neurons, for example. Neuroscientists can watch them flip on, but the exact purpose of those neurons is still up for debate.

Another, more common example of the brain’s mysterious response to robots is often referred to as the uncanny valley—a poetic way of saying, “robots are creepy.” Proposed in a 1970 paper by roboticist Masahiro Mori, the uncanny valley describes a graph showing that humans feel more familiar with, and possibly more comfortable toward, humanoid machines. Until, that is, the machine becomes too human-like, tripping the same psychological alarms associated with seeing a dead or unhealthy human. At that point the graph collapses, and then rises again with the response to a real human being, or, theoretically, a perfect android.

Whether this is a distortion of our fight-or-flight instincts or something more complex, Mori’s word choice was important—the uncanny is not naked fear, but a mix of familiarity and fear, attraction and repulsion. It’s a moment of cognitive dissonance that the brain can’t reconcile, like encountering a talking Christmas tree, or a laughing corpse.

By academic standards, it’s evocative, exciting stuff, describing what appears to be a widespread phenomenon. Nexi’s unnerving YouTube clips seem like textbook examples, and the robot has plenty of unsettling company. The Japanese social bot CB2 (Child-robot with Biomimetic Body), with its realistic eyes, child-like proportions and gray skin, evokes near-universal horror among

Zeno

Zeno is more of a business plan than a stand-alone humanoid, an attempt by Hanson Robotics to channel the company’s breakthroughs in artificial skin and social-learning algorithms into a hybrid robot toy and dirt-cheap research testbed. If Zeno catches on with kids, it could be the world’s biggest—and least controlled—experiment in human-robot interaction.



Fear of a Bot Planet

It's not the hardware that makes the evil robot one of Western culture's most powerful myths. It's the software, the artificial intelligence (AI) that turns machines into monsters. Here are the most iconic examples of malevolent AI with the fears each inspired.

1600s

Golem of Prague

Taught us to fear: unstable artificial intelligence

In folk tales, the Golem of Prague was sculpted from river mud and animated with magic, but its design is robotic to the core—big, impossibly strong and emotionless. Its AI is also familiar in its limitations: The Golem floods a house when no one tells it to stop fetching water. In later versions of the myth, it loses its mind.

1818

Frankenstein's Monster

Taught us to fear: artificial genius

A doomed, romantic sociopath, the monster in *Frankenstein* had a whip-smart mind that was his own undoing. He learns to speak and read in months and to resent his creator just as quickly. Critics call this the world's most influential evil-robot story. Frankenstein refuses to build a mate, fearing a superior, malevolent race that would destroy mankind.

1921

Radius

Taught us to fear: organized robotic insurrection

Like Frankenstein's monster, the robots in the play *R.U.R.* are flesh-and-blood murderers. The difference is scale: These robots are mass-produced from factory-grown organs, and they succeed in wiping out the human race. The robot leader, Radius, doesn't mince words, saying, "I wish to be the master of people."

1950

The Machines

Taught us to fear: a less deadly but more secret insurrection

In his short story "The Evident Conflict," science-fiction writer Isaac Asimov granted the machines control of the world economy. They proved overzealous. Hollywood eventually supplied the melodrama, turning AI's quiet financial coup into the mass house-arrest of mankind in the movie *I, Robot*.

1968

HAL 9000

Taught us to fear: AI-controlled systems

The singsong condescension in HAL 9000's voice should have been a warning sign. But by the time *2001: A Space Odyssey* leaps from sci-fi to horror, it's too late—the AI jettisons the human crew members it considers to be a liability to the spacecraft's mission. Like Asimov's machines, HAL isn't malicious, just a little too smart for our own good.

1984

T-800/Skynet

Taught us to fear: networked, self-organizing AI

Skynet never appears on camera in *The Terminator*, but the movie's eponymous enforcer bears its message: The planet's not big enough for biological and artificial intelligence. We also don't see the advanced defense computer becoming self-aware. Instead, the movie shows the smoldering aftermath of war, giving an old myth its most powerful update.

1987

ED-209

Taught us to fear: armed, autonomous robots

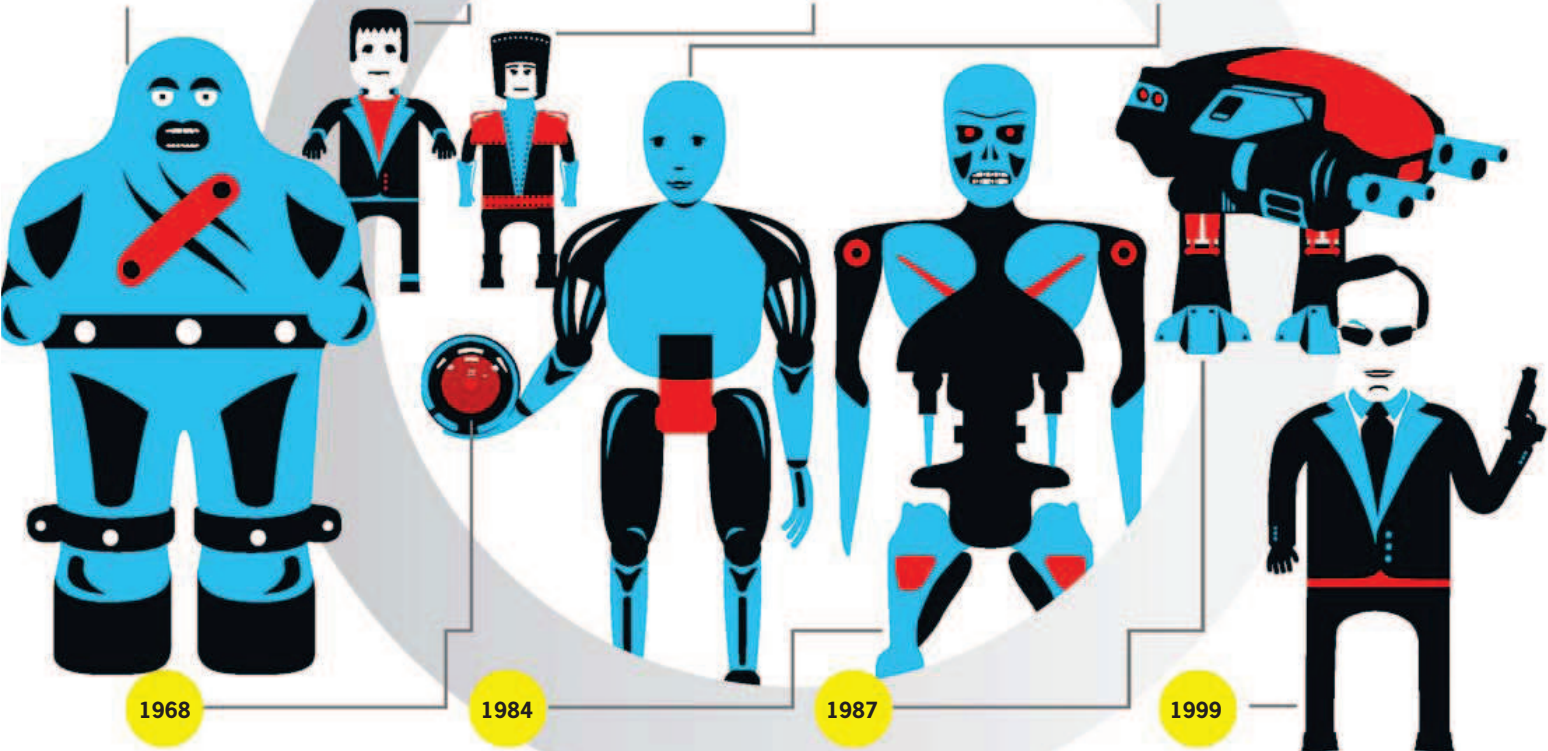
In *RoboCop*, ED-209 has the cognitive powers of a very smart police dog and the firepower of an attack chopper. And, like dogs trained for violence, ED-209 sometimes bites the wrong person: In one of the movie's most memorable scenes, the security bot botches its own sales demo by gunning down an unarmed civilian.

1999

The Machines

Taught us to fear: everything in *The Terminator*, and robot slavers

The machines of *The Matrix* are a deliriously twisted race of AIs. They turn prisoners into battery packs, craft vast virtual worlds to keep us occupied and, as evidenced by Agent Smith, are capable of abject hatred. The real horror of *The Matrix* (sequels aside) is the prospect of machines not only conquering mankind, but toying with our defeated species.



bloggers and reporters. Another Japanese robot, KOBIAN, features a wildly expressive face, with prominent eyebrows and a set of fully formed, ruby-red lips. It, too, was instantly branded creepy by the Western press. The designers of those social bots were actually trying to avoid the uncanny—Asian labs are packed with photorealistic androids that leap headlong into the twitching, undead depths of Mori's valley.

But just as the *Terminator* scenario withers under scrutiny, the uncanny valley theory is nowhere near as tidy as it sounds. Based on those YouTube clips, I had expected my meeting with Nexi to be hair-curling. Instead, I can see my grin scattered across computer monitors in the Media Lab. Nexi's forehead-mounted, depth-sensing infrared camera shows my face as a black and gray blur, and the camera in its right eye portrays me in color. I watch as I slip from the monitors, Nexi's head and eyes smoothly tracking to the next face. I am not creeped out—I'm a little jealous. I want Nexi to look at me again.

"There are some very practical things that we do to make our robots not creepy," Berlin says. The secret to Nexi's success, apparently, is within arm's reach of the robot: a slightly battered hardcover book titled *The Illusion of Life: Disney Animation*—required reading for the Personal Robots Group. "We're making an animation, in real time," Berlin says. Like many animated characters, Nexi's features and movements are those of exaggerated humanity. When it reaches for an object, its arm doesn't shoot forward with eerie precision. It wastes time and resources, orienting its eyes, head and body, and lazily arcing its hand toward the target. Nexi is physically inefficient, but socially proficient.

How proficient? In interactions with hundreds of human subjects, including residents of three Boston-area senior centers, researchers claim that no one has run screaming from Nexi. Quite the opposite: Many seniors tried to shake the robot's hand, or hug it. At least one of them planted a kiss on it. "It interacts with people in this very social way, so people treat it as a social entity in an interpersonal way, rather than a machine-like way," Cynthia Breazeal, director of the Personal Robots Group, says. "In studies with Nexi, we've shown that if you have the robot behave and move in ways that are known to enhance trust and engagement, the reaction is the same as it is with people. You're pushing the same buttons."

That principle has proven true for CB2 and KOBIAN as well. The research leaders of both projects claim that the apprehension directed at their robots online and in the media never materializes in person. With the exception of one Thai princess, everyone who encountered CB2 liked it, according to Osaka University's Minoru Asada. A Japanese newspaper brought a group of elderly to visit KOBIAN. They were "deeply pleased and moved," Atsuo Takanishi, a professor of mechanical engineering at Waseda University, says, "as if the robot really had emotion."

Even if the uncanny valley ends up being more of a shallow trench, one that's easily leveled by actually meeting an android, the success of Nexi and company only raises a more profound question: Why do we fall so hard for robots?

"It turns out that we're vulnerable to attaching, emotionally, to objects. We are extremely cheap dates," says Sherry Turkle, director of the MIT Initiative on Technology and Self. "Do we really want to exploit that?" Turkle has studied the powerful bond that can form between humans and robots such as Paro, an almost painfully cute Japanese baby-seal-shaped therapy bot that squirms in your arms, coos when caressed and recharges by sucking on a cabled pacifier. She has also documented assumptions of intelligence and even emotion reported by children playing with robotic dolls. The effect that Paro, a therapy bot that's little more than an animatronic stuffed animal, had on senior citizens only reinforced her concerns. "Tell me again why I need a robot baby sitter?" Turkle asks. "What are we saying to the child? What are we saying to the older person? That we're too busy with e-mail to care for those in need?"

To researchers like Turkle, the widespread deployment of social robots is as risky as it is inevitable. With some analysts estimating a \$15 billion market for personal robots by 2015, the demand for expressive machines is expected to be voracious. At the heart of Turkle's argument—a call for caution, essentially—is the fear of outsourcing human interaction to autonomous machines. Even more alarming are the potential beneficiaries of robotic companionship, from children in understaffed schools to seniors suffering from Alzheimer's. Enlisting an army of robots to monitor the young and the elderly could be a bargain compared to the cost of hiring thousands of teachers and live-in nurses. But how will the first generation to grow up with robotic authority figures and friends handle unpredictable human relationships? Without more data, a well-intended response to manpower shortage could take on the ethical and legal dimensions of distributing a new and untested antidepressant.

One possible solution is to scale back the autonomy and use social bots as puppets. Huggable, another robot from MIT's Personal Robots Group, is a teddy bear whose movements can be controlled through a Web browser. The researchers plan to use it to comfort hospitalized children; family members or doctors would operate it remotely. When I see Huggable, it's actually a teddy bear skeleton. The furry coat, which will eventually be replaced with one that includes pressure- and touch-sensitive sensors, sits in a heap next to the bot as it fidgets. An open laptop shows the operator's view through Huggable's camera and a menu of simple commands, such as raising and lowering its arms, or aiming its head at my face.

For now, Huggable has no identity of its own. It's a high-tech ventriloquist's dummy channeling the voice of its operator, not a full-fledged social creature. In a recent paper

Kobian

This Japanese invention is the intellectual love child of a pair of earlier Waseda University robots—one was an expressive head, the other a humanoid body. The result is what its creators call "an emotional humanoid," able to express emotions with its entire body, potentially allowing personal robots to better communicate with humans.



describing the dangers of “parent” modes in Japanese robotic toys and the temptation to use robots as nannies, Noel Sharkey, a professor of artificial intelligence and robotics at the University of Sheffield in England, cited Huggable’s lack of autonomy as a selling point. “Such robots do not give rise to the same ethical concerns as exclusive or near-exclusive care by autonomous robots,” he wrote with a co-author. Semi-autonomy might not cut payrolls, but it could be a safer way to roll out the first wave of social bots.

Sharkey’s and Turkle’s ominous point of view overlaps uncomfortably with the climate of fear that has always surrounded robots. And yet, nearly every researcher I spoke with agreed on a single point: We need ethical guidelines for robots, and we need them now. Not because robots lack a moral compass, but because their creators are operating in an ethical and legal vacuum. “When a bridge falls down, we have a rough-and-ready set of guidelines for apportioning out accountability,” says P.W. Singer, a senior fellow at the Brookings Institution and author of *Wired for War*. “Now we have the equivalent of a bridge that can get up and move and operate in the world, and we don’t have a way of figuring out who’s responsible for it when it falls down.”

In a debate steeped in speculation and short on empirical data, a set of smart ethical guidelines could act as an insurance policy. “My concern is not about the immediate yuck factor: What if this robot goes wrong?” says Chris Elliott, a systems engineer and trial lawyer who contributed to a recent Royal Academy report on autonomous systems. “It’s that people will go wrong.” Even if the large-scale psychological impact of social robots turns out to be zero, Elliott worries that a single mishap, and the corresponding backlash, could reverse years of progress. Imagine the media coverage of the first patient killed by a robotic surgeon, an autonomous car that T-bones a school bus or a video clip of a robotic orderly wrestling with a dementia patient. “The law is way behind. We could reach a point where we’re afraid to deploy new beneficial robots because of the legal uncertainty,” Elliott says.

The exact nature of those guidelines is still anyone’s guess. One option would be to restrict the use of each robotic class or model to a specific mission—nurse bots that can visit with patients within a certain age range, or elder-care bots that watch for dangerous falls but aren’t built for small talk and snuggling. In the long run, David Hanson believes AI should be explicitly programmed to cooperate with humans, so that when robots self-evolve they have what he calls the “wisdom” not to harm us. Cynthia Breazeal’s take is more hard-nosed. “Now is certainly the time to start hammering things out,” she says. “People should have a serious dialogue before these robots are in contact with vulnerable populations.”

Philosophers, ethicists, lawyers and roboticists have only begun the hard work of fleshing out Asimov’s early code of robo-ethics. In the meantime, if there’s a way to dismantle our



Cynthia Breazeal, the director of MIT’s Personal Robots Group, says social robots require systems that are “savvy and intelligent in their interactions with people,” not simply compatible with objects.

long-standing, irrational fear of robots and head off any risk of a Luddite backlash, it might be up to robots such as Nexi.

While I’m eyeing the gears and servos along Nexi’s exposed back, a tour group shows up in the Media Lab unannounced. A crowd of kids, maybe fifth or sixth graders, approaches the robot. Nexi is tracking their faces when one of the boys gets a little too close. The robot’s eyebrows swivel inward. The eyelids narrow as the head tilts down. And the worm motors that control Nexi’s fingers whine like electric drills as its fists clench.

“Whoa!” the kid in the lead says, and they all backpedal.

“Is it getting mad?” one girl asks the researchers.

Then Nexi’s face softens and, instantly, they’re laughing.

“So do you give robots emotions?” another girl asks.

I remember something Breazeal told me earlier: that for kids who grow up around robots, the uncanny valley could be irrelevant and *The Terminator* little more than a quaint story. Vulnerable or not, children interact with these machines differently. Understanding the limits and strange potential of robotics might be as simple as letting them meet the models most like them—the ones built to live at their sides. Maybe Nexi could act as that first, limited exposure, a vaccine against the wild fears and warped perceptions the rest of us have grown up with.

The kids provoke Nexi’s anger response again, laughing more this time. When its eyebrows level, the lead boy jabs his friend and points at the robot’s impassive face.

“It’s smiling at you! It’s smiling!”

PM

PANAMA DIGS A BIGGER

THE PANAMA CANAL'S NEW THIRD LANE WILL
HANDLE THE WORLD'S BIGGEST SHIPS, DOU-
BLING TRAFFIC ON THE HISTORIC WATERWAY.

+++++

BY DAVID DUNBAR

PHOTOGRAPHS BY ANDREW KAUFMAN



DITCH

SINCE ITS COMPLETION IN 1914, the Panama Canal has been the crossroads of the Western Hemisphere. But the growing dominance of megaships threatened to turn the 50-mile-long passage between the Pacific and the Atlantic into a regional backwater. Hence the current \$5.25 billion expansion program designed to keep the canal relevant in future maritime trade. The existing three sets of locks handle vessels up to 965 feet long and 106 feet wide (so-called Panamax ships). When the seven-year modernization plan is completed during the canal's centennial, those facilities will be complemented by a slightly longer third lane of traffic with two new sets of locks and approach channels that can accommodate post-Panamax ships up to 1200 feet long and 160 feet wide.

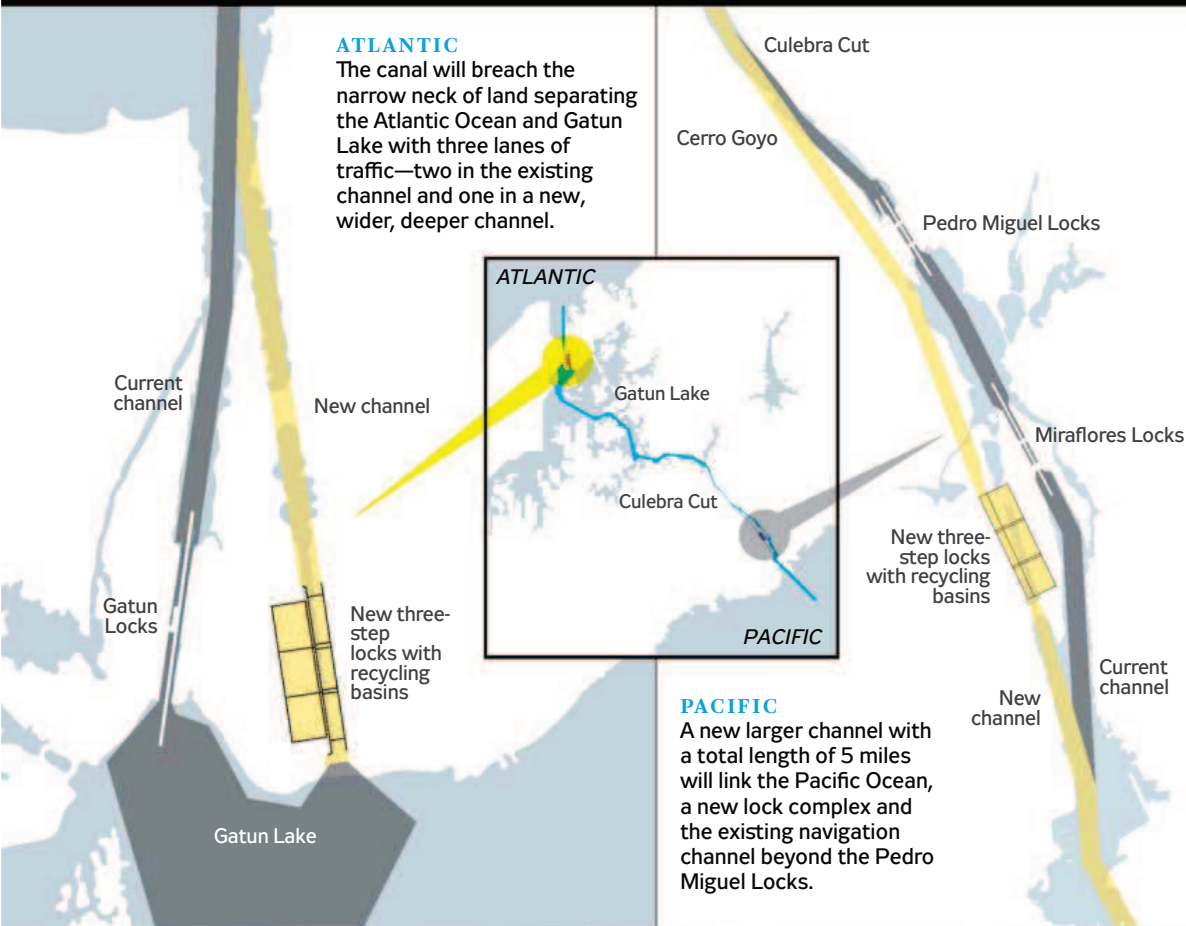
Here's how the upgrade will work. A post-Panamax freighter from Asia bound for, say, Norfolk, Va., will nose into the canal west of the existing Pacific entrance and head up a new mile-long channel to

At Cerro Goyo, northwest of the Pedro Miguel Locks on the Panama Canal, a 1400-hp hydraulic shovel claws 22 cubic yards per swipe. Part of a \$5.25 billion expansion, this excavation will connect a new set of locks to the existing waterway.



three-step locks. (Excavation crews will use 85 percent of an earlier dig that was halted by World War II.) The lock will lift the vessel 85 feet to another new channel that parallels the current Miraflores and Pedro Miguel Locks. Beyond Pedro Miguel, old and new waterways will merge in a widened, deepened channel that will knife through the Continental Divide at the Culebra Cut. Five miles on, the supersize ship will enter man-made Gatun Lake, which it will cross in a 45-mile-long expanded navigation channel to reach a new three-step lock complex and water lane east of the existing Gatun Locks and channel. (Crews will use all of the World War II-era excavation here.) Two miles later—and, depending on traffic, 8 to 10 hours after entering the canal—the freighter will reach the Atlantic, with Norfolk less than a week away to the north. **PM**

PANAMA CANAL EXPANSION 2007–2014



Opposite: This vehicular bridge is part of a diversion project that now sends the Cocoli River down to the Pacific. The river used to flow through the site of a new access channel that will carry post-Panamax vessels between the ocean and new three-step locks near the existing Miraflores Locks. Three basins at each lock chamber will recycle 60 percent of the water used for transiting ships.

An Atlantic-bound Panamax container ship (below, far left) that has cleared the Pedro Miguel Locks eases past the Cerro Goyo excavation en route to Gatun Lake. Panamax refers to the current maximum size of a vessel that the canal can accommodate: 965 feet long, with a beam of 106 feet and a draft of 39 feet. Expansion will boost post-Panamax dimensions to 1200 feet, 160 feet and 50 feet.

Uncovered during excavations at Cerro Goyo, a dredge bucket and iron railroad wheels date from early-20th-century American excavations. Prior to the U.S. dig, a French company attempted a sea-level canal—that is, a lockless waterway—across the isthmus. Some 20,000 workers died in the failed effort. In 1904 the U.S. paid France \$40 million for its equipment and excavations and, in 1914, completed a canal with dams and locks. In 1999, the U.S. transferred control of the canal to Panama.





TAKING A FALL

*the 120-mph
35,000-foot
3-minutes-to-impact
survival guide*





6:59:00 AM

35,000 feet

YOU HAVE A LATE NIGHT AND AN EARLY FLIGHT. NOT long after takeoff, you drift to sleep. Suddenly, you're wide awake. There's cold air rushing everywhere, and sound. Intense, horrible sound. *Where am I?*, you think. *Where's the plane?*

You're 6 miles up. You're alone. You're falling.

Things are bad. But now's the time to focus on the good news. (Yes, it goes beyond surviving the destruction of your aircraft.) Although gravity is against you, another force is working in your favor: time. Believe it or not, you're better off up here than if you'd slipped from the balcony of your high-rise hotel room after one too many drinks last night.

Or at least you will be. Oxygen is scarce at these heights. By now, hypoxia is starting to set in. You'll be unconscious soon, and you'll cannonball at least a mile before waking up again. When that happens, remember what you are about to read. The ground, after all, is your next destination.

Granted, the odds of surviving a 6-mile plummet are extraordinarily slim, but at this point you've got nothing

By Dan Koeppel
Illustrations by Nanospore

to lose by understanding your situation. There are two ways to fall out of a plane. The first is to free-fall, or drop from the sky with absolutely no protection or means of slowing your descent. The second is to become a wreckage rider, a term coined by Massachusetts-based

amateur historian Jim Hamilton, who developed the Free Fall Research Page—an online database of nearly every imaginable human plummet. That classification means you have the advantage of being attached to a chunk of the plane. In 1972, Serbian flight attendant Vesna Vulovic was traveling in a DC-9 over Czechoslovakia when it blew up. She fell 33,000 feet, wedged between her seat, a catering trolley, a section of aircraft and the body of another crew member, landing on—then sliding down—a snowy incline before coming to a stop, severely injured but alive.

Surviving a plunge surrounded by a semiprotective cocoon of debris is more common than surviving a pure free-fall, according to Hamilton's statistics; 31 such confirmed or "plausible" incidents have occurred since the 1940s. Free-fallers constitute a much more exclusive club, with just 13 confirmed or plausible incidents, including perennial Ripley's Believe It or Not superstar Alan Magee—blown from his B-17 on a 1943 mission over France. The New Jersey airman, more recently the subject of a *MythBusters* episode, fell 20,000 feet and crashed into a train station; he was subsequently captured by German troops, who were astonished at his survival.

Whether you're attached to crumpled fuselage or just plain falling, the concept you'll be most interested in is *terminal velocity*. As gravity pulls you toward earth, you go faster. But like any moving object, you create drag—more as your speed increases. When downward force equals upward resistance, acceleration stops. You max out.

Depending on your size and weight, and factors such as air density, your speed at that moment will be about 120 mph—and you'll get there after a surprisingly brief bit of falling: just 1500 feet, about the same height as Chicago's Sears (now Willis) Tower. Equal speed means you hit the ground with equal force. The difference is the clock. Body meets Windy City sidewalk in 12 seconds. From an airplane's cruising altitude, you'll have almost enough time to read this entire article.

7:00:20 AM

22,000 feet

BY NOW, YOU'VE DESCENDED INTO BREATHABLE AIR. YOU sputter into consciousness. At this altitude, you've got roughly 2 minutes until impact. Your plan is simple. You will enter a Zen state and decide to live. You will understand, as Hamilton notes, "that it isn't the fall that kills you—it's the landing."

Keeping your wits about you, you take aim.

But at what? Magee's landing on the stone floor of that French train station was softened by the skylight he crashed through a moment earlier. Glass hurts, but it gives. So does

To slow your descent, emulate a sky diver. Spread your arms and legs, present your chest to the ground,

and arch your back and head upward ...

But don't relax. This is not your landing pose.

grass. Haystacks and bushes have cushioned surprised-to-be-alive free-fallers. Trees aren't bad, though they tend to skewer. Snow? Absolutely. Swamps? With their mucky, plant-covered surface, even more awesome. Hamilton documents one case of a sky diver who, upon total parachute failure, was saved by bouncing off high-tension wires. Contrary to popular belief, water is an awful choice. Like concrete, liquid doesn't compress. Hitting the ocean is essentially the same as colliding with a sidewalk, Hamilton explains, except that pavement (perhaps unfortunately) won't "open up and swallow your shattered body."

With a target in mind, the next consideration is body position. To slow your descent, emulate a sky diver. Spread your arms and legs, present your chest to the ground, and arch your back and head upward. This adds friction and helps you maneuver. But don't relax. This is not your landing pose.

The question of how to achieve ground contact remains, regrettably, given your predicament, a subject of debate. A 1942 study in the journal *War Medicine* noted "distribution and compensation of pressure play large parts in the defeat of injury." Recommendation: wide-body impact. But a 1963 report by the Federal Aviation Agency argued that shifting into the classic sky diver's landing stance—feet together, heels up, flexed knees and hips—best increases survivability. The same study noted that training in wrestling and acrobatics would help people survive falls. Martial arts were deemed especially useful for hard-surface impacts: "A 'black belt' expert can reportedly crack solid wood with a single blow," the authors wrote, speculating that such skills might be transferable.

The ultimate learn-by-doing experience might be a lesson from Japanese parachutist Yasuhiro Kubo, who holds the world record in the activity's *banzai* category. The sky diver tosses his chute from the plane and then jumps out after it, waiting as long as possible to retrieve it, put it on and pull the ripcord. In 2000, Kubo—starting from 9842 feet—fell for 50 seconds before recovering his gear. A safer way to practice your technique would be at one of the wind-tunnel simulators found at about a dozen U.S. theme parks and malls. But neither will help with the toughest part: sticking the landing. For that you might consider—though it's not exactly advisable—a leap off the world's highest bridge, France's Millau Viaduct; its platform towers 891 feet over mostly spongy farmland.

Water landings—if you must—require quick decision-making. Studies of bridge-jump survivors indicate that a feet-first, knife-like entry (aka “the pencil”) best optimizes your odds of resurfacing. The famed cliff divers of Acapulco, however, tend to assume a head-down position, with the fingers of each hand locked together, arms outstretched, protecting the head. Whichever you choose, first assume the free-fall position for as long as you can. Then, if a feet-first entry is inevitable, the most important piece of advice, for reasons both unmentionable and easily understood, is to *clench your butt*.

No matter the surface, definitely don't land on your head. In a 1977 “Study of Impact Tolerance Through Free-Fall Investigations,” researchers at the Highway Safety Research Institute found that the major cause of death in falls—they examined drops from buildings, bridges and the occasional elevator shaft (oops!)—was cranial contact. If you have to arrive top-down, sacrifice your good looks and land on your face, rather than the back or top of your head. You might also consider flying with a pair of goggles in your pocket, Hamilton says, since you're likely to get watery eyes—impairing accuracy—on the way down.

7:02:19 AM

1000 feet

GIVEN YOUR STARTING ALTITUDE, YOU'LL BE JUST ABOUT ready to hit the ground as you reach this section of instruction (based on the average adult reading speed of 250 words per minute). The basics have been covered, so feel free to concentrate on the task at hand. But if you're so inclined, here's some supplemental information—though be warned that none of it will help you much at this point.

Statistically speaking, it's best to be a flight crew member, a child, or traveling in a military aircraft. Over the past four decades, there have been at least a dozen commercial airline crashes with just one survivor. Of those documented, four of the survivors were crew, like the flight attendant Vulovic, and seven were passengers under the age of 18. That includes Mohammed el-Fateh Osman, a 2-year-old wreckage rider who lived through the crash of a Boeing jet in Sudan in 2003, and, more recently, 14-year-old Bahia Bakari, the sole survivor of last June's Yemenia Airways plunge off the Comoros Islands.

Crew survival may be related to better restraint systems, but there's no consensus on why children seem to pull through falls more often. The Federal Aviation Agency study notes that kids, especially those under the age of 4, have more flexible skeletons, more relaxed muscle tonus, and a higher proportion of subcutaneous fat, which helps protect internal organs. Smaller people—whose heads are lower than the seat backs in front of them—are better shielded from debris in a plane that's coming apart. Lower body weight reduces terminal velocity, plus reduced surface area decreases the chance of impalement upon landing.

7:02:25 AM

0 feet

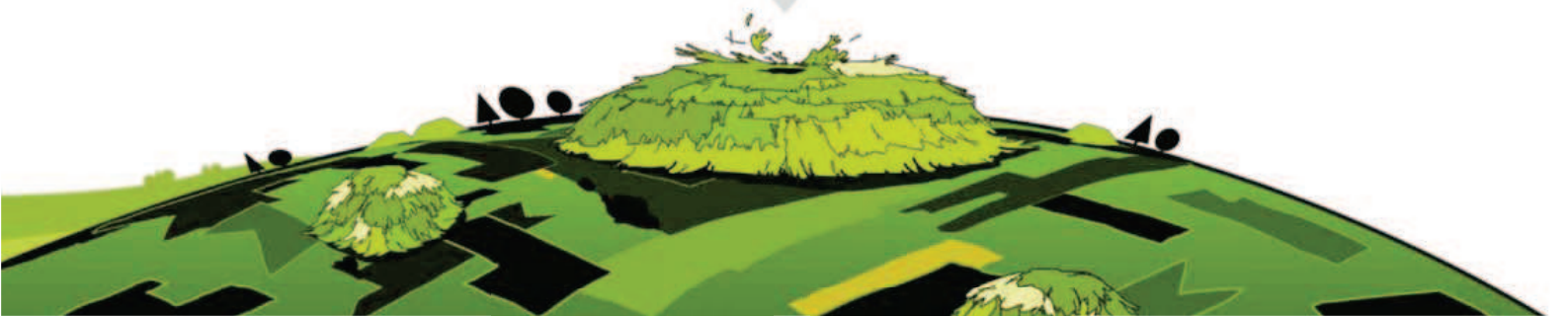
THE GROUND. LIKE A SHAOLIN MASTER, YOU ARE AT PEACE and prepared. *Impact*. You're alive. What next? If you're lucky, you might find that your injuries are minor, stand up and smoke a celebratory cigarette, as British tail gunner Nicholas Alkemade did in 1944 after landing in snowy bushes following an 18,000-foot plummet. (If you're a smoker, you're *super extra lucky*, since you've technically gotten to indulge during the course of an airliner trip.) More likely, you'll have tough work ahead.

Follow the example of Juliane Koepcke. On Christmas Eve 1971, the Lockheed Electra she was traveling in exploded over the Amazon. The next morning, the 17-year-old German awoke on the jungle floor, strapped into her seat, surrounded by fallen holiday gifts. Injured and alone, she pushed the death of her mother, who'd been seated next to her on the plane, out of her mind. Instead, she remembered advice from her father, a biologist: To find civilization when lost in the jungle, follow water. Koepcke waded from tiny streams to larger ones. She passed crocodiles and poked the mud in front of her with a stick to scare away stingrays. She had lost one shoe in the fall and was wearing a ripped miniskirt. Her only food was a bag of candy, and she had nothing but dark, dirty water to drink. She ignored her broken collarbone and her wounds, infested with maggots.

On the tenth day, she rested on the bank of the Shebonya River. When she stood up again, she saw a canoe tethered to the shoreline. It took her hours to climb the embankment to a hut, where, the next day, a group of lumberjacks found her. The incident was seen as a miracle in Peru, and free-fall statistics seem to support those arguing for divine intervention: According to the Geneva-based Aircraft Crashes Record Office, 118,934 people have died in 15,463 plane crashes between 1940 and 2008. Even when you add failed-chute sky divers, Hamilton's tally of confirmed or plausible lived-to-tell-about-it incidents is only 157, with 42 occurring at heights over 10,000 feet.

But Koepcke never saw survival as a matter of fate. She can still recall the first moments of her fall from the plane, as she spun through the air in her seat. That wasn't under her control, but what happened when she regained consciousness was. “I had been able to make the correct decision—to leave the scene of the crash,” she says now. And because of experience at her parents' biological research station, she says, “I did not feel fear. I knew how to move in the forest and the river, in which I had to swim with dangerous animals like caimans and piranhas.”

Or, by now, you're wide awake, and the aircraft's wheels have touched safely down on the tarmac. You understand the odds of any kind of accident on a commercial flight are slimmer than slim and that you will likely never have to use this information. But as a courtesy to the next passenger, consider leaving your copy of this guide in the seat-back pocket. **PM**





By Jim Gorman
Photographs by Micheal McLaughlin

HOUSE MOVING REQUIRES HARD WORK, BOLDNESS AND A SENSE OF TIMING. IT DOESN'T HURT TO HAVE A BIG TRUCK AND A MASSIVE HYDRAULIC RIG AS WELL.

The abracadabra moment comes late on a winter afternoon, when Jay Thompson pulls a lever on the Jahns Structure Jacking System. As pressurized hydraulic fluid surges to carefully positioned jacks, the shingled cottage on New Jersey's Long Beach Island parts ways with the brick foundation that has held it earthbound for the past 120 years. A barely perceptible gap grows until daylight is plainly visible under the house.

Thompson, of Atlantic Structure Movers, has performed this levitational act thousands of times. There's no magic to moving a house, he claims, just lots of gritty labor. But while

watching 25 tons of historically significant lumber hovering several feet in the air, it's tempting to credit him with some degree of wizardry. "Everything we do is based on moving principles used since the ancient Egyptians," Thompson says. Even the most gigantic load can be skidded a short distance, rolled over a long one or levered the last fraction of an inch until its position is perfect. Lighthouses and airport terminals have been transported that way. Those big, bold moves grab the spotlight, but a small relocation like this cottage is standard fare for structure movers, who suddenly find themselves basking in a green glow. After all, what's more environmentally friendly than reusing a house rather than scrapping it?

While it's physically possible to move almost anything, it isn't always economically feasible. The cost of disconnecting power lines, moving traffic signals and streetlights and trimming overhanging tree limbs mounts quickly. In the congested eastern U.S., a move of more than a few blocks is often impractical. In the less populated Midwest and West, a move of 40 miles



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609.597.3530

can make sense. It costs \$12 to \$16 per square foot to move a house. Of course, that price doesn't include a new building lot, a new foundation or building-code-related improvements.

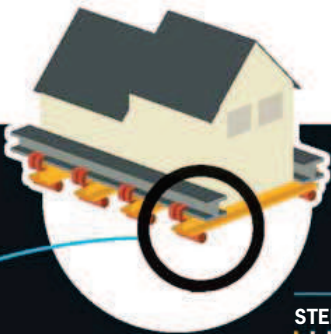
But there are times when history trumps economics. Known locally as the Fisherman's Cottage, the little wood-frame structure was completed in 1880 and is among the last of the island's simple, original dwellings. It stands in sharp contrast to the rambling Victorians that wealthy summer residents were already then building. The house's owner sold it to the local historical society for \$1, and it will get a new lease on life as a small museum. The task for Thompson is straightforward: Transport

the cottage a block and a half to a prepared site.

The real action occurs once the house has been cut loose from water, sewage, electricity and other utilities. Thompson and his crew punch holes through the foundation, slide steel beams under and alongside the house and use hydraulic jacks to lift the structure on this steel frame. "Our methods are easy on the house," Thompson says. "We've moved homes with all the furniture inside and pictures hanging on the walls."

Since the jacks are not tall enough to raise the house in one pass, it's jacked up and supported on cribbing, then the jacks are positioned on the cribbing and the house is raised again.

MOVING DAY



STEEL FRAMING
|| || || || ||



JACKING UP
|| || || || ||



CRIBBING
|| || || || ||

1

Thompson's crew fastens the H-beams under and along the house with industrial-duty, drop-forged C-clamps. The movers tighten the clamps with a wrench, which makes the hardened point of the clamp's screw bear down with thousands of pounds of force. Once the steel is positioned and firmly clamped, the house is ready to be lifted off its foundation.

2

Hydraulic jacks operating at 6000 psi are positioned at regular intervals along each H-beam. The house is raised in 1-foot increments.

3

To keep a house safely supported, Thompson (below) and his men position and reposition tons of cribbing, each a 4-foot-long 6 x 6. Buildings are unevenly weighted; the trailer-mounted hydraulic system behind Thompson can be adjusted to compensate for those variations and ensure that the house stays level as it is lifted.



When the house rests on cribbing piers of adequate height, Thompson takes the wheel of a 2½-ton truck—a former Army “deuce and a half.” He backs its trailer under the house, which is then lowered onto the flatbed. Thompson coaxes the structure forward, unfazed by its tilt even though the only thing holding it in place is friction. “It appears more dramatic to onlookers than it does to us,” he says. “A small angle at the trailer is enough to produce quite a lean on a tall building.”

Then the trailer crawls down the street to the house’s new location. It’s not the cottage’s first move. In 1890, mules hauled it a short distance over logs to where it remained until today.

At the new lot, Thompson again positions the house on cribbing. Then he resorts to a trick that only a structure mover would know. To fine-tune the cottage’s position, he uses tilted jacks that rest on rolls of foam padding. As the jacks take on weight, they straighten and shift the house into place. “If I get all four jacks tilted in different directions,” Thompson says, “I can rotate the house.”

At last, the cottage is oriented. Once the foundation is completed inside the cribbing perimeter, Thompson will jack up the house again to remove beams and cribbing, then lower it on the foundation. There it will remain—until its next move. **PM**



TRUCKING
| | | | |



PRELIMINARY POSITIONING
| | | | |



FINAL POSITIONING
| | | | |

4

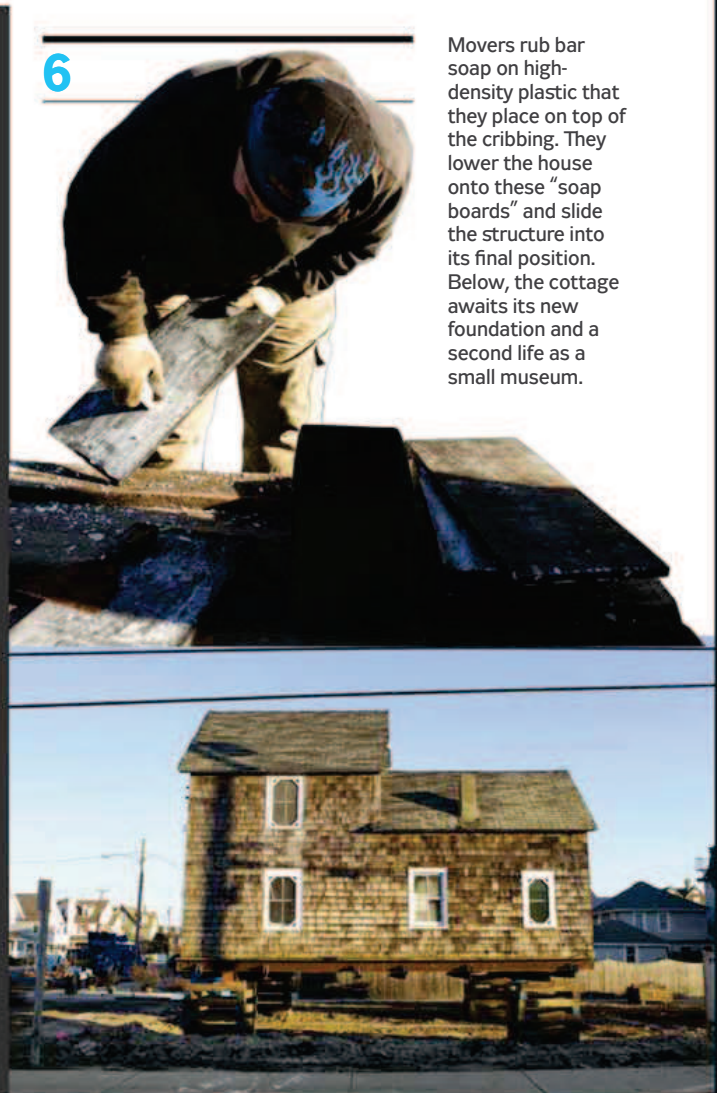
It’s 21 feet from the street to the house’s peak—higher than a 13-foot-tall tractor trailer—so utility crews stay busy moving wires. Still, there’s no rush. “We move at a crawl,” Thompson says. “You take your foot off the gas and push in the clutch, and the truck comes to an almost immediate stop.” Otherwise, it’s man versus machine as Thompson wrestles the truck in and out of tight spots. “The truck is equipped with what we call arm-strong steering,” he says with a laugh.

5

At the new lot, Thompson positions the trailer above a footing built earlier by a masonry contractor. He jacks up the cottage and drives out from under the structure.

6

Movers rub bar soap on high-density plastic that they place on top of the cribbing. They lower the house onto these “soap boards” and slide the structure into its final position. Below, the cottage awaits its new foundation and a second life as a small museum.



WHAT WENT WRONG

DISASTER ON THE YENISEI

● ● ●
LOCATION: SIBERIA, RUSSIA
EVENT: SAYANO-SHUSHENSKAYA
HYDROPOWER PLANT EXPLOSION
DATE: AUG. 17, 2009

★ MOSCOW
SAYANO-SHUSHENSKAYA •

JUST BEFORE 8 AM ON AUG. 17, 2009, WORKERS ON THE morning shift stepped off a clattering Soviet-era tram and made their way past security and into position at the Sayano-Shushenskaya hydroelectric power plant in south-central Siberia. In the 950-foot-long turbine hall, custodians mopped the stone floors and supervisors handed out assignments. On the roof, a technician began installing a new ventilation system. Above him soared a concave dam 80 stories high and more than half a mile wide at the crest. When operating at full capacity, the plant's 10 interior penstocks funneled water from the reservoir behind the concrete barrier to the hall below him, where it tore past the blades of 10 turbines, spinning them with tremendous force before being flushed out of the hydro plant and down the Yenisei River.

Completed in 1978, the Soviet-era hydro station is Russia's largest, with enough output to power a city of 3.8 million. It was undergoing extensive repairs and upgrades that morning, so more workers were in



BY JOE P. HASLER •



Rescue workers clear debris and search for victims near the wreckage of Sayano-Shushenskaya hydroelectric dam's Turbine 2. The 1500-ton piece of equipment exploded out of its seating and flew 50 feet in the air on Aug. 17, 2009; 75 people died in the accident.

the hall than usual: 52 on the main floor and another 63 down in the bowels of the plant. Nine of the 10 turbines were operating at full capacity—including the troublesome Turbine 2, which had been offline but was pressed back into service the previous night when electricity production dropped because of a fire at the Bratsk power station, 500 miles to the northeast. A few minutes into his shift, the technician felt the roof begin to vibrate. The vibrations grew louder and gradually turned into a thunderous roar. Alarmed, he scrambled off the roof.

At 8:13 am, two massive explosions rocked the hall. Security guard Aleksandr Kataytsev told English-language news station RT that he was one level below the turbine hall when he heard “a loud thump, then another one, like an explosion, and then the room went pitch-black.”

Turbine 2—a 1500-ton piece of machinery topped by a power generator—blasted through the floor and shot 50 feet into the air before crashing back down. The penstock water that had been spinning the turbine geysered out of the now-vacant shaft at a rate of 67,600 gallons per second. Like a massive industrial waterjet, it tore down the metal joists over Turbines 1, 2 and 3; the roof there crumpled like aluminum foil and collapsed in a tangle of glass and metal.

Water continued to pour into the hall, flooding its

lower levels and eventually submerging other turbines. The plant’s automatic safety system should have shut down the turbines and closed the intake gates on the penstocks at the top of the dam, but Turbines 7 and 9 still operated at full speed, in excess of 142 rpm, triggering the crackling short circuits that darkened the plant. Amateur video footage taken downstream at the time of the accident shows bright flashes and a huge explosion in the vicinity of Turbines 7 and 9 as a wall of water spews from the structural breach near Turbine 2.

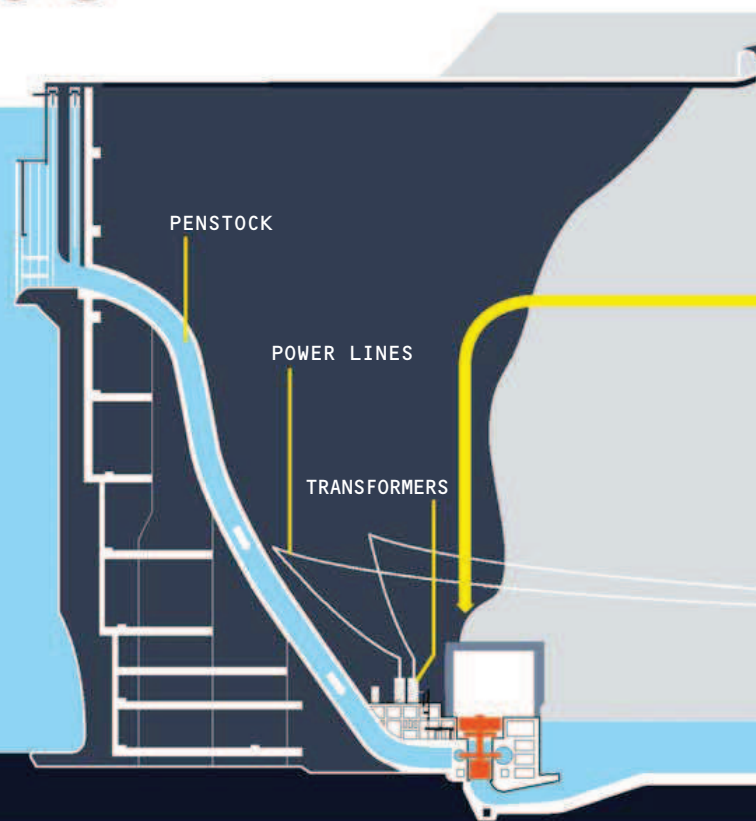
As the water level rose, employees stampeded toward the main entrance. Fearing a total collapse of the dam, many phoned relatives downstream and urged them to seek shelter in the surrounding Sayan Mountains. Among the fleeing workers were several supervisors in charge of safety and emergencies, which added to the confusion. On the fourth floor, shell-shocked midlevel operators telephoned up the chain of command for a contingency plan. No one answered.

Using his mobile phone as a flashlight, security guard Kataytsev found his way to an exit and made for higher ground. At the crest of the dam, he and several other employees struggled to manually close the penstock intake gates. By 9:30 am they had sealed all the gates, and the destruction below ceased.

PHOTOGRAPHS BY REUTERS (PREVIOUS SPREAD), GETTY IMAGES (THIS PAGE)

ANATOMY OF A TURBINE FAILURE

This photograph of the Sayano-Shushenskaya hydroelectric power plant, located 2000 miles east of Moscow in Siberia, was taken after the Aug. 17, 2009, accident that destroyed a section of the 950-foot-long turbine hall (circled in white). Water from the Yenisei River flows through 620-foot-long penstocks to power 10 turbines, which generate up to 6400 megawatts. Turbine 2 had been offline until the previous night, when it was brought online to compensate for energy lost because of a fire at another plant. Here’s how the disaster unfolded.



In the wake of the accident, rescue crews mobilized to search for survivors. RusHydro, the partially state-owned utility company that operates Sayano-Shushenskaya, assembled 400 employees to pump out the flooded turbine hall and pick through the twisted debris. Russian president Dmitry Medvedev dispatched Sergei Shoigu, his emergencies minister, and Sergei Shmatko, the energy minister, to oversee rescue efforts. Environmental clean-up crews attempted to contain the oil spill that stretched 50 miles down the Yenisei River and killed 400 tons of fish at trout farms. Over two weeks, 2000 rescuers removed 177,000 cubic feet of debris, pumped 73 million gallons of water and pulled 14 survivors from the wreckage. But 75 workers—those trapped in the turbine hall and in the flooded rooms below—weren't so lucky.

For Russians, the catastrophe called to mind the 1986 disaster at the Chernobyl Nuclear Power Plant in Ukraine, which was then part of the Soviet Union. Speaking on a Moscow radio station, Shoigu called the hydro dam accident “the biggest man-made emergency situation [in] the past 25 years—for its scale of destruction, for the scale of losses it entails for our energy industry and our economy.” Some commentators have called the events at Sayano-Shushenskaya the “Russian Chernobyl.” And just as Chernobyl raised questions globally about nuclear safety,

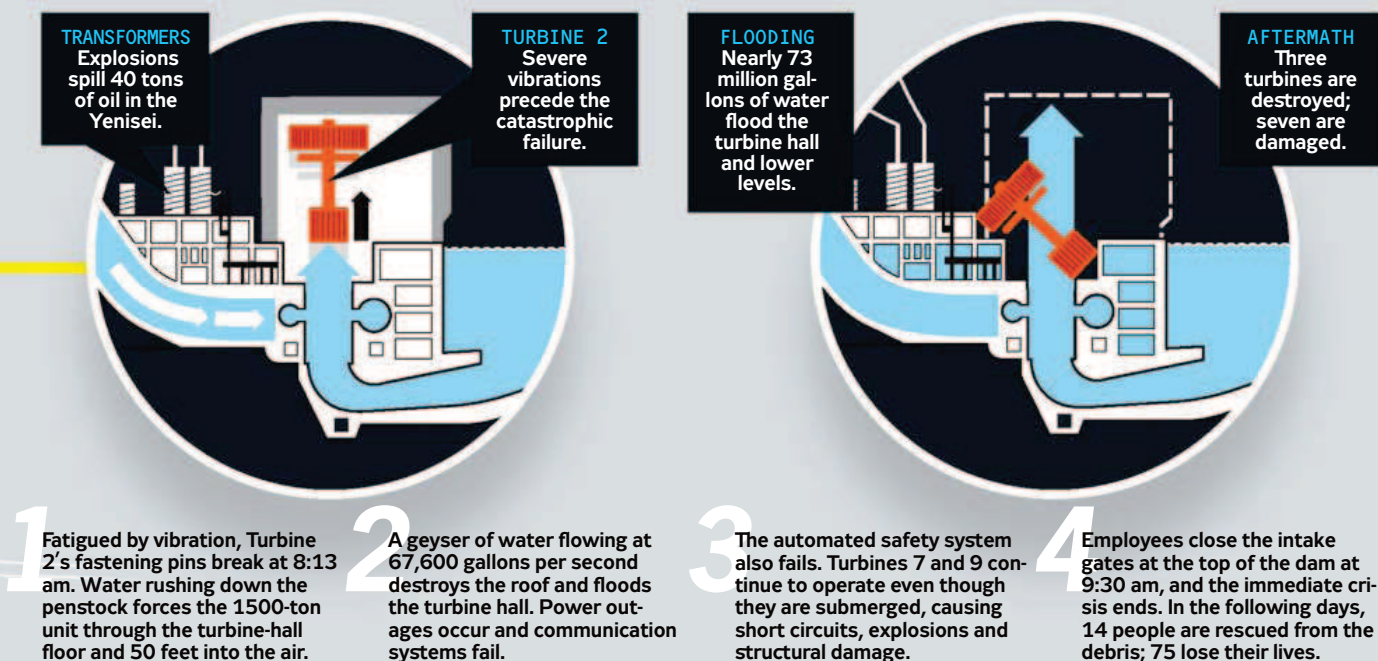
Sayano-Shushenskaya has made other nations wonder: Are other hydropower plants at risk?

THE INVESTIGATION

IMMEDIATELY AFTER THE ACCIDENT, RUSSIA'S Federal Service for Ecological, Technological, and Nuclear Supervision (Rostekhnadzor) launched an investigation. The official report, released on Oct. 3, blamed poor management and technical flaws for the accident.

According to the report, repairs on Turbine 2 were conducted from January to March 2009, and a new automatic control system—meant to slow or speed up the turbine to match output to fluctuations in power demand—was installed. On March 16, the repaired turbine resumed operation. But it still didn't work right: The amplitude of the machine's vibrations increased to an unsafe level between April and July. The unit was taken offline until Aug. 16, when the Bratsk fire forced managers at Sayano-Shushenskaya to push the turbine into service.

Back in operation, Turbine 2 vibrated at four times the maximum limit. As the control system decreased the turbine's output on the morning of Aug. 17, the vibrations increased. The unit acted like the engine of an automobile being downshifted on a hill, shuddering violently and stressing the fatigued metal pins holding it in place. LMZ,





the St. Petersburg metalworks that manufactured the plant's turbines, gave the units a 30-year service life. Turbine 2's age on Aug. 17 was 29 years, 10 months. Investigators determined that the power failure after the initial explosion had knocked out the safety system that should have shut down the plant—and a malfunction turned into a catastrophe.

Officials from RusHydro and the government have called for more stringent oversight of hydropower plants, but economic pressures may still put financial considerations ahead of safety. Six days before rescue efforts were halted on Aug. 29, repairs at Sayano-Shushenskaya were already underway. Rebuilding will take five years and cost

approximately \$1.3 billion—but a pair of nearby aluminum smelters, property of global aluminum giant RusAl, can't wait that long. They consumed 70 percent of the station's output and need replacement power to maintain production. RusAl and RusHydro are pressing the government for additional financing to accelerate completion of a joint venture at Boguchansk on the Angara River, now in its 29th year of construction.

● **COULD IT HAPPEN HERE?**

THE U.S. HAS AN INSTALLED CAPACITY OF NEARLY 100 gigawatts and an annual production of 250 terawatt-hours, which make it the world's fourth largest hydroelectric producer. Yet even with a water-

power history dating back to the 19th century, and more than 2000 such plants in operation, the U.S. has never had an event to match Sayano-Shushenskaya.

Experts agree that a similar accident is unlikely to occur here because American equipment is held to more stringent performance standards and rigid inspection regimes. The Bureau of Reclamation manages 58 hydropower plants, which produce 44 billion kilowatt-hours per year. Dan Drake, chief of the Hydraulic Equipment Group, the unit responsible for upkeep at iconic Western dams like Hoover, says bureau turbines are taken offline at the first sign of abnormal performance, and redundant automatic systems are in place. "If a unit were experiencing violent or abnormal

vibrations," Drake says, "it would shut down, and the gate at the top of the penstock would close." Regular equipment repairs and replacement also keep dams safe.

Russia's immediate solution to its power problem is to build more dams, but that won't fix a bureaucratic culture that seems to devalue safety. "If they were running a turbine with known deficiencies, in essence, they're putting economic concerns before human-life safety factors," says Eric Halpin, the special assistant for dam and levee safety for the U.S. Army Corps of Engineers, America's largest hydropower operator. "The principles we use are just the opposite. If it's not safe, if there's a risk of failure, all other benefits—be they economic, environmental or anything else—those all go away."

PM



BEFORE (Above): The turbine hall housed 10 640-megawatt turbines. Normally, 12 people manned the hall, but because of repair work, 115 people were on site on the day of the accident.

AFTER (Opposite): In the wake of the accident, 2000 rescuers removed debris, pumped water out of the flooded turbine hall and searched for survivors.



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Home

Early Risers

THE GROWING SEASON CAN START LONG BEFORE WARM WEATHER HITS—ALL IT TAKES IS A COLD FRAME. BY JOSEPH TRUINI

→ **Spring is still** many weeks away, but you can get a start on a bountiful summer garden by building a cold frame now, in the depths of winter. It's a simple carpentry project that takes advantage of passive solar heating to effectively turn the calendar ahead.

Essentially, a cold frame is a miniature greenhouse—a bottomless box with a clear lid that captures sunlight, insulates plants and warms the soil. Lynn Ocone, a gardening expert and an author, uses her cold frame every year at her home in chilly Burlington, Vt.

INSIDE

× NONSLIP FLOORS + BUILDING CLOSETS + DRILL-BIT BASICS

"Long before spring arrives, I start plants indoors under grow lights and then move them out to the cold frame after the last of the hard frosts," she says. Ocone has two recommendations for late-winter or early-spring gardeners. First, position the cold frame with its clear lid facing south. "A south-facing cold frame captures the most solar energy and helps keep plants warmer longer," she says. Second, make it light enough to be portable. "Most people put a cold frame in one spot and never move it, which is fine," Ocone says. "But occasionally it's nice to be able to move it into the garden and start the plants right in the soil."

Cutting the Parts

→ **The body of** the cold frame I built for my own backyard is made up of tongue-and-groove red cedar 1 x 8 lumber held together with screws and vertical 1 x 4 cedar battens. The material is lightweight and naturally resistant to rot and bugs. The lid is 2 x 2 cedar, grooved to accept a clear acrylic plastic panel.

I started by using a power miter saw to crosscut 1 x 8s for the two side panels. For each panel, I cut three 30-inch-long 1 x 8s and one 15-inch 1 x 8.

Next, I used a table saw to rip off the groove from the bottom edge of two of the 30-inch-long 1 x 8s, but you could just as easily use a circular saw. Those grooveless pieces serve as the bottom panel on the sides.

Then I formed each side by tapping together three 30-inch 1 x 8s, topped with one 15-inch 1 x 8.

Next, I attached two cedar 1 x 4 battens to the inside of each side panel using waterproof carpenter's glue and 1¼-inch galvanized decking screws. It's important to position each batten ¾ inch from the edge of the sides. That recess accepts the front and rear

panels. I then trimmed each side panel to 25 degrees with a circular saw.

I cut six cedar 1 x 8s to 46½ inches long for assembling the cold frame's rear and front panels. As with the sides, I started by ripping the groove off two 1 x 8s, but I also bevel-ripped the tongue off two other 1 x 8s to serve as the top boards. They provide a sloping edge for the lid to rest against.

Assembling the Cold Frame

→ **I began assembly** by using 2½-inch-long decking screws to fasten the two front boards to the side panels. I drove screws through the front of the boards and into the edge of the 1 x 4 battens. I also drove screws through the side panel and into the ends of the front-panel boards. This double-direction method creates an incredibly strong, long-lasting corner joint. The same technique was used to attach the rear of the cold frame to the side panels.

With the body of the cold frame completed, I screwed the hinge cleat to

Cold Frame Construction



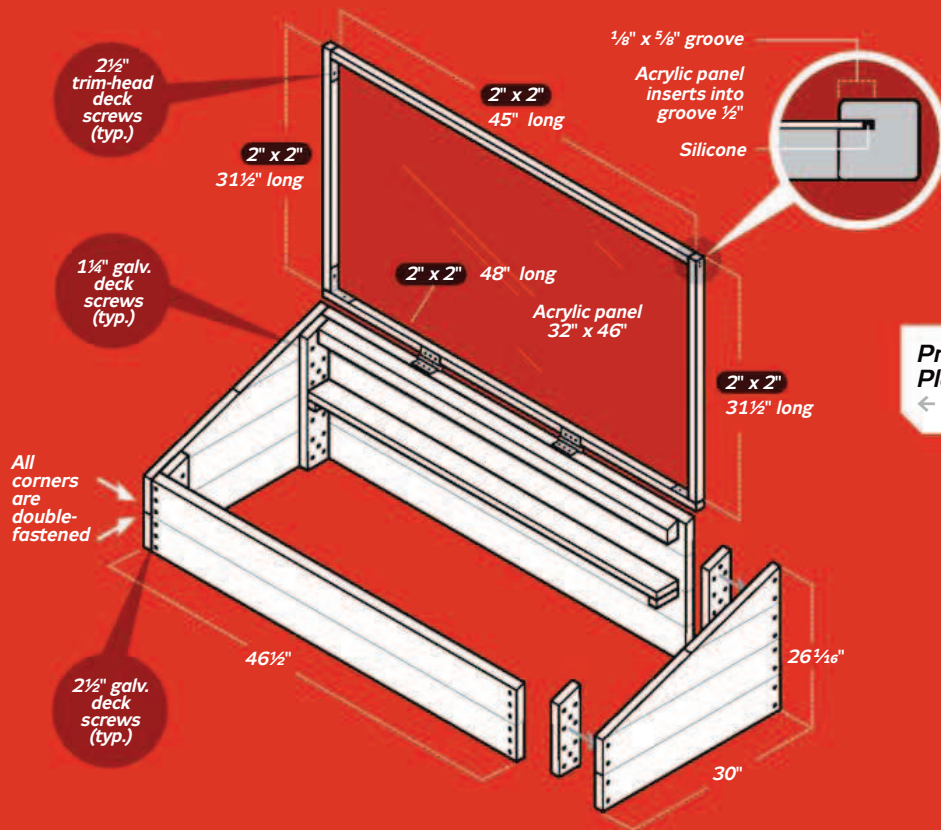
- [1] Mark a line across the panels for the batten's offset. Then screw the batten in place.
- [2] Saw the sloping edge on the side panels. Cedar is soft and easy to cut, and a cordless saw works well.
- [3] Fastening the sides from two directions produces a strong, weather-resistant joint.
- [4] With the sides, back and front

assembled, attach the hinge cleat.

- [5] Saw the lid groove using a combination rip-crosscut blade on a table saw.
- [6] Bore ¾-inch pilot holes before driving lid assembly screws.
- [7] Attach the automatic lid opener mounting brackets to the lid rail and to the front panel and slip the opener into place.

the rear panel. The top edge of this cleat is sawed at an angle to match the sides, and the lid hinges are screwed to it. Then I cut two small shelf cleats and attached them to the rear batten. By placing a small 1 x 4 shelf between the cleats, I can fit another row of plants into the cold frame, increasing its storage capacity without unduly shading the plants below. It's a simple trick that a first-time builder may overlook.





a pair of 2½-inch trim-head decking screws at each corner joint. I bored pilot holes, to avoid splitting the 2 x 2s, and reinforced the lid with a 3 x 3-inch metal bracket in each corner.

Next, I squeezed a continuous bead of clear silicone adhesive into the grooves in the frame parts and across the upper surface of the bottom rail. I slid the acrylic panel into the grooves until it was flush with the bottom rail, and then clamped it and allowed the silicone to cure overnight.

Finishing Up, Digging In

→ I fastened the lid to the cold frame with two 3-inch galvanized butt hinges, each of which was attached to the beveled back cleat. I then

set the lid onto the cold frame and screwed the hinges to the cleat.

A cold frame is designed to protect plants from the cold, but the interior can get so hot that the plants will die. The most common way to avoid this problem is to simply prop open the lid with a stick. However, a more convenient way to ventilate is with an automatic cold-frame opener (\$60 at www.mastergardening.com; Item: TOO-1023), which automatically raises the lid when the temperature inside gets too high.

The opener has a liquid-filled piston that expands when warm and contracts when cold, opening and closing the lid in the process. It can be adjusted to expand at any temperature between 60 and 140 F. It has a lifting capacity of 15½ pounds and will open the lid up to 18 inches high.

With the opener installed, I dug the cold frame into the lawn against a south-facing stone wall. The wall provides a little wind protection, but I still dug down about 4 inches to keep the wind from blowing in from underneath and to increase heat retention.

Then I started adding plants. It's a satisfying feeling on a chilly day to put your next crop into a cold frame. Spring doesn't seem so far away after all. **PM**



Next, I began work on the lid by cutting cedar 2 x 2s to length. Using the table saw, I cut a ⅛-inch-wide x ⅝-inch-deep groove into the two side pieces and top rail, but not into the bottom rail. It's important to note that the grooves aren't centered on the 2 x 2s, but instead are positioned ⅜ inch from the top surface.

I then ripped the bottom rail to 1 inch thick, and here's why: Making the

bottom rail thinner than the other parts allows the clear acrylic panel to overlap the bottom rail. That way, rain will cascade right off the lid without damming up against the bottom frame member. Not only would that puddle eventually rot the lid's bottom rail, but it also could cause a leak at that point—and then the dripping water might damage the plants inside.

I fastened the lid parts together with

Homeowners Clinic

by Roy Berendsohn

Q+A

Slippery When Wet

Q My garage floor is slippery when slush melts off the cars, which is bad news because I back the cars out and use the garage as a shop. Will painting the floor make it less slippery? The step on my garden tractor is also slick, especially when wet. I'm used to it, but my wife skinned her shin when she slipped on it. Now she won't use the tractor. Please suggest some solutions. Thanks.

Adding a pound of sand to a gallon of floor paint creates a slip-resistant coating.

A It makes sense to correct these problems. Slip-and-fall accidents kill thousands of people every year and injure thousands more. In 2004, that amounted to about 18,000 deaths, according to the National Safety Council, a nonprofit organization dedicated to eliminating these and similar hazards.

Fortunately, the fix is easy.

"From an engineering point of view, there's required friction [the friction a person needs to walk safely] and the available friction [the friction the floor surface presents to the person]," says April Chambers, lab manager at the University of Pittsburgh's Human Movement and Balance Laboratory. "Your first goal to prevent a slipping accident is to ensure that available friction is greater than required friction." Translation: Add friction, add safety.

How aggressively you treat the surface depends on the severity of the slip hazard. In the case of your garage floor, I would treat it very aggressively, because a smooth concrete surface that has slush and water on it is almost as slippery as a surface can get. One solution is to apply rows of nonslip tape that has a very coarse, abrasive particle bonded to its face. One of the best is 3M's Safety-Walk; it's available

STUDIO D

in various levels of coarseness to suit the specifics of the application. I'd use the 700 series because it has the roughest surface and it resists moisture. You can also use it on the footing surfaces of tractors and trailers and on boat decks and docks. Porous surfaces need to be sealed with 3M Safety-Walk primer before the tape is applied.

Chambers cautions, however, that you never want to increase friction in a manner that creates a false sense of security. That is, taping one section of a slippery floor but not another can actually increase the chance of a fall as someone steps from a secure high-friction surface to one that's slippery.

A good way to uniformly increase the friction of a large area is to add abrasive particles to floor paint. Skid-Tex is a fine-grained silica sand that you can add to floor paint at the ratio of 1 pound per gallon. You simply stir it in and then paint as normal.

Adding Space

Like most 1950s houses, ours is short on storage space, so I want to build a couple of closets. Should be pretty simple—two walls and a door. Right?

Yes. Building closets is simple, and the project is pretty much as you describe it. Before you build closets, though, be sure that you've made maximum use of existing closet space. There are lots of ways to do this, from building efficient plywood shelving and dividers to installing factory-made storage hardware.

Assuming you go ahead with the project, there are a few things to keep in mind. First, if you'll be using factory-made closet hardware inside the closet, size the closet's length and width accordingly. Also, if you use a standard hinged door, you have to account for the door's sweep into the room. Your other alternatives are bifold doors or hanging closet doors, more practical alternatives for most rooms because they don't take up additional floor space for a swinging door.

A dark closet isn't particularly useful, so you'll have to think about lighting it. Go to popularmechanics.com and see the article "Your 6-Step Action Plan to Brighter Closets."

Framing the closets will be straightforward carpentry. It's unnecessary to

use 2 x 4 lumber for this job. This framing is wider and stronger than is needed for a closet, and you gain square inches of closet volume by using 2 x 3s.

First, carefully measure the floor-to-ceiling height in several places and make the wall studs $3\frac{1}{4}$ inches shorter than that dimension. This accounts for the thickness of two horizontal wall plates and $\frac{1}{4}$ inch of air space to prevent the wall from getting stuck in place as you pivot it into position (which can lead to floor and ceiling damage). If the floors and ceiling look wavy, allow for more airspace than $\frac{1}{4}$ inch. Not to belabor the point, but it's not a bad idea to cut a test stick from a piece of 2 x 3 (to serve as a model of the wall being raised) and try pivoting it into place along several locations where the closet walls will be built. The lumber won't be wasted. Removing $3\frac{1}{4}$ inches from it turns it into a wall stud.

Shim the walls into place so that they are plumb and drive screws into the floor and ceiling to hold everything

in position. If the wall plates at the ceiling don't fall where there's framing, use hollow wall fasteners to anchor them.

Cold Storage

I'm in the process of building a 10 x 12 nonheated shed to store my lawn mower and yard tools, and I'm wondering whether I can store hand and power tools in there, too, especially cordless tools. It gets cold here in Minnesota, sometimes going down to minus 40 F.

A shed is good for storing a lot of things, but not hand and power tools. I've had cordless and corded tools survive nights in an ice-cold truck, job site or garage. But those tools also died an early death. Why subject expensive tools to the wide swings of heat, cold and humidity that a shed experiences? That amounts to an accelerated wear cycle, a bit like a torture test in a lab.

Another compelling reason not to store hand and power tools in a shed is that if you need them when it's really

NOW YOU KNOW

Don't Slip—Instead, SLP

Some years ago, I was cutting dovetails in a mahogany chest. The floor was littered with blocks of waste wood. I slipped on one and fell forward while holding the dovetail saw in my right hand. The saw raced down my left forearm, over my wrist, down my hand and over the tip of my index finger, splitting the nail in half. To avoid slips, just remember SLP: Sweep up, light up and pick up.

→ Sweep Up.

Don't let sawdust, planer shavings, wood chunks, metal filings or demolition debris accumulate where you work. Take a break and clear the floor as you work, and again when the job is done.

→ Light Up.

A dimly lighted area conceals hazards, especially at floor level. That's particularly dangerous in a work area where you'll likely be handling power tools. Light should be directed from above and from one side to fill in shadows.

→ Pick Up.

Stow boxes, work materials and subassemblies on shelves and sawhorses. It seems strange to think of the humble sawhorse as a safety aid, but it is. I build extras at every opportunity and use pairs of them just to keep stuff off the floor.



3M's Safety-Walk is like a coarse sandpaper that you stick to slippery surfaces to improve traction.

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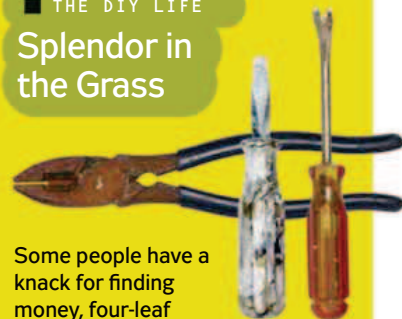
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cold, you have to bring them inside and let them thaw out before using them.

Finally, most sheds are used to shelter lawn and pool chemicals—corrosive substances. I recently pulled out a garden trowel that was stored near some fertilizers and herbicides. The trowel's blade was severely rotted, and the tool was ruined. Lesson learned.

THE DIY LIFE

Splendor in the Grass



Some people have a knack for finding money, four-leaf clovers or arrow-heads. With me, it's tools. It started one day when I was a kid walking in the woods behind my house. I caught a glimpse of an odd shape and fished out a rusty ball-peen hammer from the leaves. I went home and cleaned it up with sandpaper, painted the head and applied linseed oil to its handle. Then I presented it to my dad, who hung it on the pegboard above the workbench that we built together.

Here's another one: a linesman screwdriver I found lying on the shoulder of the road. The tool was brand spanking new, and I was pleased to see that it had a shaft running fully through its handle. Not needing another screwdriver, I put it to work as painting equipment. I admit, that's not particularly fitting for such a well-built tool, but it really pops a paint-can lid, and the butt of its handle thumps the lid down. There are others—a tack puller I found in a gutter and pliers I found under a dryer.

Found tools have rounded out my tool collection, especially with stuff I wouldn't have bought. So keep a sharp eye cocked for a glimpse of shiny steel or rust. It may be the next great addition to your toolbox. — R.B.

Drill Down

I need to buy some drill bits, and I'm wondering what kind I should get, especially for drilling metal. Would you agree that cobalt bits are the best?

Your best bet is to get a set of general-purpose twist drills made from M2 high-speed steel (HSS). It contains a rich blend of steel-improving elements, such as carbon, tungsten, molybdenum, chromium and vanadium. Sounds exotic, but it's really pretty common stuff, widely used in cutting tools. It just so happens to be exceptionally tough and wear-resistant and ideal for drill bits. There are two other types of HSS steel used in drill bits: M7 and M42, both designed for industrial users, especially the M42 variety, which contains cobalt. Those bits are tough enough to drill quickly into tough materials like cast iron and stainless steel. While that sounds like a handy capability, it comes at a price. Cobalt bits cost five to six times what standard M2 bits cost.

For almost all homeowner purposes, the garden-variety M2 HSS type works just as well and doesn't cost a fortune. A set of 13 bits from 1/16 inch to 1/4 inch (in 1/64-inch increments) costs about \$10. For your money, you also get a fold-down case, so the bits don't get lost and dulled rolling around in the bottom of your toolbox. These bits are typically sold with a cone-shaped tip that measures 118 degrees, a good general-purpose tip.

Dripping Faucet

I have a freeze-proof faucet on the side of my house that drips. How do I repair it?

Now that cold weather is settling in, this is one repair you better hop on, because if that dripping water freezes, it can damage the faucet and lead to a

larger repair. A frost-proof faucet (it's not really freeze-proof; under truly deep-freeze conditions, even a well-protected faucet might freeze) is like a standard faucet, except that it's an exceptionally long-fitting one. When you turn the handle on the outside of the house, you're also turning a stem (a rod to which the handle is connected). The stem may be 6 to 30 inches; that's long enough to reach into

the house to a point where water at the base of the stem will not freeze.

On the end of the stem is a washer, which bears against a faucet seat. If the washer is worn, water will leak past it even though the handle has been turned down tightly. The fix is to shut off water leading to the faucet, then remove the stem and replace either it or just the bib washer on its end.

PM

Got a home-maintenance or repair problem? Ask Roy about it.

Send your questions to pmhomeclinic@hearst.com or to Homeowners 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.



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IF YOUR ENGINE'S TEMP GAUGE IS PEGGED, IT MIGHT BE TIME FOR A NEW RADIATOR. HERE'S HOW TO MAKE THE SWAP. *BY MIKE ALLEN*

→ **A competent** Saturday Mechanic can relatively easily diagnose automotive maladies that are heard or felt—but smells are more difficult. Say you're cruising along and notice

a strange whiff of ... something. It's an unnaturally sweet and puzzling odor. But after you round the next corner, it's gone. As the road straightens out again, it's back. It's like someone has set a towel soaked in maple syrup on fire. Within a few more miles, that whiff of sweetness has

INSIDE



RADIATORS + TORQUE WRENCH TECH + SPARK OR NOT?

become cloyingly overwhelming. Soon, it's clear what the problem is: That stench is coolant, leaking underhood somewhere from the cooling system. Sure enough, before you manage to scoot home, the temperature gauge starts to creep upward and small curls of steam are peeking out of the grille. After letting things cool off for a half-hour, you gingerly open the hood, expecting to see something obvious, like a loose cap or a split hose.

Not a chance, pal. There's dragon-vomit-green coolant everywhere. Next step, hose everything down with fresh water and let it all dry off. A quick couple of quarts of water added to the radiator will let you start the car without baking the engine. But before you put the hose away, water starts to drip from the radiator. It's immediately apparent where the leak is—bilious green coolant is seeping from a crack in the plastic end tank. Your radiator is (sorry) cooked.

You Can't Patch Plastic

→ **When aluminum-and-plastic** radiators first hit the market a generation ago, people actually tried to repair them. There was the obvious fix of simply epoxying up the cracks—hey, it's just plastic. If I can patch a plastic gas tank, fender or even a windshield washer reservoir, I should be able to plug up a little crack less than an inch long, right?

Wrong. Trust me, I've tried this—usually late at night when I needed to get something back on the road and the parts were still days away from arriving. It's a waste of time. The plastic tank flexes too much with the heat and pressure, and any adhesive just gives up. Besides, the tank's glass-reinforced nylon structure has likely grown brittle over the years. Another crack will appear nearby fairly soon.

Again, when plastic-tank radiators were first introduced, a lot of dealerships tried to fix them. One failure mode, in addition to our aforementioned cracked tank, was in the long O-ring seal between the aluminum radi-

ator and the plastic end tanks. The repair involved uncrimping the steel finger clamp holding the two together, replacing the tank or O-ring and crimping it all together. (I even have a special pair of uncrimping-crimping pliers in my toolbox for the job.) This repair has become less common because radiators are now far less expensive than they once were.

Bottom line: If you have a bad plastic-tank radiator, you might as well just buy a new one. If you have a copper-

and-brass radiator, it might be repairable at a radiator shop. Either way, save some money by doing the removal and installation yourself.

Let It Bleed

→ **Start by draining** the coolant. Now, do I need to tell you to let the car cool off first? Didn't think so. You're supposed to recycle this stuff, and most GM dealerships have a coolant-recycling machine. (GM is big on recycling and made all its dealers buy coolant-recycling machines a few years back.) Don't use the same drain pan you use for oil and transmission fluid—even a few drops of oil will contaminate used

1. The Suburban radiator we transplanted for this story, like those of many vehicles, has a radiator drain cock that is cleverly aimed directly at a frame rail, which makes the stream of coolant splash and dribble over a 1-yard-wide area. You'd need a kiddie pool to catch it all.

2. Loosen the clamps on the coolant hoses and carefully pry the hoses off the spouts on the end tanks. Consider changing the hoses, which have a normal service life of five to seven years.

3. The steel cooler lines are attached with thin steel or brass hex fittings. It's always best to use the right tool—in this case, a flare-nut wrench that will grip all six of the fitting's corners, not just two.



coolant, which then has to be disposed of as hazardous waste. Call your local department of public works or fire department for advice on disposal. Flushing it down the drain or using it to kill weeds isn't acceptable.

Don't leave any used coolant lying around. The glycol-based liquid has a syrupy-sweet taste, and children and pets need ingest only a few spoonfuls to kill them. Most coolant on the market today has been treated with an extremely bitter taste to prevent fatalities. Soak up any small spills with kitty litter, sawdust or sand, and dispose of the sweepings properly.

When the coolant has stopped drip-

ping, swap drain pans. Most automatic transmission vehicles have a transmission-oil cooler in the radiator, and our photo truck also has an engine-oil cooler. Remove these lines, either by undoing the hose clamp on the fittings or unscrewing them. Cap these hoses to keep foreign matter out and expect a few ounces of ATF or oil to dribble from the lower port on the radiator into your catch pan. Stubborn radiator hoses may need to be cut off.

Easy Out

➔ **See if there are any** fan-shroud pieces to remove, but you might only need to undo the fasteners and sneak

the radiator straight up and out without actually removing the shroud. Don't bend the fan blades, and watch for rubber radiator-mounting cushions trying to escape by jumping under the car.

Unbox the new radiator and give the old and new radiators the hairy-eyeball side-by-side treatment to be sure you have the correct one. Carefully drop the new radiator in place. Don't bend any fins; you'll reduce the new radiator's ability to reject heat.

Button up the clamps, reinstall the hoses and cooler fittings—it's time to top everything off. If the hoses won't slip over the spigots, try lubing with a little bit of coolant. If that doesn't make them slip on relatively easily, it's time for new hoses.

Fifty-Fifty

➔ **Often, you can** just top off the system, fire up the engine and go. But many vehicles have specific bleeding procedures, requiring that bleeder fittings be, well, "burped." In some instances, the front of the vehicle must be raised up to get all the air out of the system. That's because the pressure cap is below the highest point in the engine where coolant flows. Failure to get a pocket of air out of the cylinder head could cause overheating, so be sure to follow procedure. Top off the overflow tank to the COLD line, too.

Now it's time to start up the engine and look for leaks. Top off the transmission and engine if you spilled any when you disconnected the cooler lines.

There used to be one kind of coolant on the market. These days, there are more than a half-dozen, in a rainbow of colors. Your car's manufacturer has a specific recommendation, which should be followed. Sharp-eyed readers will note that we're refilling this GM vehicle with conventional green coolant, instead of the factory-recommended orange long-life Dex-Cool that GM installed at the factory. For whatever reason, a previous owner had changed over to green, and we elected to continue that practice. Dex-Cool can take a long time to provide corrosion protection when it hasn't been used in the system for a while; the anti-corrosion additives in conventional coolant work immediately.

PM



4. Most radiators are only clamped into place. Remove the clamp bolts and lift the rad out.

5. These cracks, the typical failure mode of plastic radiator tanks, are not repairable.

6. No matter how long you let it drip, there are still several quarts of liquid lurking in the system. Now would be a good time to fill with water and flush out any old, nasty

coolant. Look up your cooling system's capacity in the owner's manual. It might be as little as 12 or as much as 22 quarts. Divide this in half, and add that much straight, undiluted coolant. Top off with demineralized or distilled water, ensuring you've got the correct mixture.



CRACKS



Car Clinic

by Mike Allen

Q+A

DIGITAL
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CONVERTER

Highly Calibrated

Q I inherited my grandfather's torque wrench. It's still in good condition, but when I showed it to my mechanic, he said the wrench was so old that it was probably out of calibration and that I should just hang it on the wall as a curio. What do you think?

A I'd get a new mechanic, because although torque wrenches do need to be calibrated annually (more often if they're in daily operation or used for really critical applications like engine assembly), your wrench should work fine after an adjustment and a little TLC. And I'd bet this guy isn't getting his torque wrench calibrated as often as he should, either. Expect to pay \$25 to \$35 for a decent shop to calibrate your wrench properly. I used to have both of my torque wrenches, a 0-to-50 ft-lb and a 0-to-150 ft-lb, calibrated regularly by a fellow who did them for all the mechanics at the local dealerships. He had a truck with the calibration gear in it, and on the day he would come by the dealerships, all the mechanics lined up like they were buying burritos from the roach coach. He charged a princely 10 bucks. Sadly, the price has risen, so I just picked up a Powerbuilt Digital Torque Adapter. It's a small battery-powered gadget that will let you calibrate your own wrench, and it costs about \$50. The Powerbuilt will also work in a pinch as a torque wrench itself, in concert with a ratchet or a flex handle. But I prefer to use my favorite clicker wrench and save the torque adapter for calibrating it.

Keep your torque wrench clean and lubricated, and always return the scale to zero after every use to keep the internal spring from taking a set and letting the calibration drift.

Safe Scratch Treatment

What's your take on using rubbing compound to eliminate scratches? Is it even possible to eliminate them? My car is only two years old and looks like it has light, hazy scratches all over it. So I'm not sure if the brush at the carwash had something in it or what.

The fix for light scratches used to be rubbing compound, back in the days before clear-coat paint. Aggressive compounding can completely polish through the thin clear layer over the pigment, requiring respraying. And uh, yes, this would be a Bad Thing. There are other remedies for your patina of

scratches, involving less-aggressive polishes and wax to fill in small scratches. Several products include Mothers California Gold Scratch Remover, Turtle Wax Scratch & Swirl Remover, Autoglym Paint Renovator and Meguiar's Deep Crystal.

Frozen Fasteners

I just got a sealed beam to replace the old headlight in my 1988 Pontiac Firebird. I need to remove the frame that holds the light in place, and my screws are stuck. I used WD-40 on the screws to try and loosen them, but they still won't come out. The screws seem to have a small clamp behind them. What's the best way to get a driver on these buggers?

Those tiny Phillips-head trim screws are always a pain to remove. They're cheaply cad-plated, and they rust solid

within a few months. Yours have had 20 years of crusty buildup. Penetrating oil usually doesn't help much. Start by using a proper No. 1 or No. 2 Phillips, depending on the size of the screw. Give yourself a break by using a relatively new screwdriver, not one that's already been used to round off hundreds of screws during its distinguished career. Remember to push hard against the screwdriver to keep it seated in the screw head. Of course, there's the danger of pushing hard enough to break the tab on the plastic trim piece, so be careful.

When that doesn't work, and it probably won't for at least a few of the screws, you may have to resort to twisting the screw with Vise-Grips. No, not the screw head itself—that's recessed 2 inches into a ¼-inch-diameter hole. Try twisting the shank of the screw from behind the clip it screws into. If you

can't access the rear of the area, you'll be forced to drill the screw head off. Warning: These screws are hardened and don't drill easily—in spite of the fact that they rounded off as easily as a block of margarine in the hot sun. Use a sharp drill and moderate speed or you'll just melt the plastic tab.

And when you are purchasing replacement hardware to put this all back together, I have only one word of advice: stainless.

Water Shortage

Three months ago, my seldom-used 1985 Chrysler New Yorker steamed up under the hood. When it cooled off, I discovered that all the coolant had gone. After refilling and checking it regularly, I found none was leaking on the ground. Yesterday the same result: no coolant. Where does it go? Presumably it disappears only when I am driving.

That coolant is leaking, for sure. And it's leaking one of several possible ways. It could be going into a combustion chamber and leaving as steam through the exhaust ports. Or it's leaking into the oil. A small leak would leave the oil mostly water-free, as the PCV system will pull a lot of moisture out of the system if the vehicle is driven far enough to warm the oil to around 180 F and keep it there. One other possibility is that, once hot, it's leaking in small amounts either as steam or onto a hot spot (like the exhaust manifold), where it will evaporate without leaving a wet spot. Also, a tiny leak in the intake manifold gasket might get into the manifold itself, where a small amount of coolant could simply be sucked into the combustion chambers, turned into steam and—buh-bye. You hope that's the case, because the other possibilities would mean pulling the cylinder heads to replace the head gaskets, which would probably cost more than the car is worth.

There are ways to chase these leaks. The easiest is to pressurize the cooling system with compressed air and listen for the hissing at the exhaust pipe, the oil filler cap or the top of the carb or throttle body. Stant and others make an adapter to fit the radiator neck with a hand pump and a gauge. Just pump up the system and start

YOU NEED THIS Spark Plug Tester

I turned the old pickup's key and knew instantly—it was dead. There was no juice left in the battery. Someone had rescued a garage-find dead battery, charged it and shoehorned it into the truck on the cheap. The bad battery fried the aging alternator, and it wound up in my shop for a charging-system transplant. Hours later, after a new battery and alternator had been installed and I'd chased a couple of parasitic drains, the engine still wouldn't start. I'd been tinkering around in the fuse box, so I figured I had jiggled some of the shaky wiring harness loose. In these situations, one of the first things to do is check for spark. Just pull a plug wire, clip on the spark

tester, crank the motor and look for spark jumping the gap, right? **There's an easier way: the OK Spark plug tester.**

Just hold the tester's probe near a plug wire (or even near a coil-on-plug coil assembly) and you can tell if the plug is firing. It will even detect a fouled plug, something a conventional spark-gap type of tester won't do without removing the

plugs. It's a huge time-saver. I just had to hold the probe near any of the plug wires while someone cranked the engine. I found my problem in the injection harness easily, knowing for certain I had spark. OK Spark means you don't have to pry stubborn plug connectors off, keeping you clear of the engine's red-hot exhaust manifolds. — M.A.



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chasing leaks. Trouble is, some leaks only leak when the engine is up to operating temperature, so don't burn yourself. If that doesn't work, you may need to add fluorescent dye to the system and use a UV light and yellow goggles, *CSI Miami*-style.

Troubling Transmission

I have a question about my 1997 Eclipse Spyder (it barely has 80,000 miles on it). Recently, when I get ready to leave my house, I push down the clutch to start it and it seems to require way less force than it used to. Then, when putting the transmission in reverse to back out of the driveway, it grinds a little. If you try a few times, it will eventually go into gear with no problem. After a few shifts, the gearbox starts to act normally. What's going on?

Your Eclipse, unlike many vehicles that use a mechanical linkage or a cable, uses a hydraulic clutch actuator. Air in the hydraulic line is keeping the clutch from disengaging sufficiently. A few pumps will purge the air, but it seeps back into the master cylinder overnight. I'd start by flushing out the old fluid (actually, just DOT-3 or DOT-4 brake fluid) and bleeding the system thoroughly. If that doesn't fix it, you've got a leak that's sucking in air. Rebuilding or replacing the master and slave cylinders should cure it.

Fuelish Solution

I have old premixed boat gas; 8 gallons of it, mixed 50:1 with oil. It's too old to use in my two-cycle outboard. Can I put it in my 1997 Land Cruiser? I figured I would dump the mix in with the tank half full and top it off with fresh fuel afterward, or do it 4 gallons at a time for further dilution. Will it foul my fuel injectors with that bit of oil? Or should I just throw it away?

Gummy, old, oxidized premix gasoline is a poor candidate for use in a modern, catalytic-converter-equipped car. Come to think of it, so is old, oxidized gas without the extra two-stroke oil, too. The oil can potentially contaminate an expensive cat, and any varnish (produced when gasoline oxidizes, in

the same way that oil-based paint cures) might foul the fuel injector pin-tle valve(s), which are also not cheap to replace. No, the fuel filter won't catch the varnish. And if it did, you'd need to change the filter soon, and that usually involves removing the gas tank from the car, which will cost far more than your out-of-date fuel.

Plus, there's the problem of phase separation caused by water making any ethanol drop out of the solution. Odds are any fuel stored in a container that's not perfectly sealed will soak up atmospheric moisture. This will leave you with a layer of water and ethanol in the bottom of the tank and a layer of cloudy gasoline floating above it—and neither layer will burn well enough to run your, or any other, engine.

Adding more alcohol (gas line drier, like Heet or Dri-Gas), the traditional solution for water in the gas, won't work. There's nothing you can add to remove the oil or water.

My advice? Call the local DPW or fire department and find out a safe, legal way to dispose of the fuel.

Self-Taught

I recently did some work on my old 1996 GMC pickup that had started to run erratically. It seemed to be dropping a cylinder and losing power. I checked for fuel and spark ... I pulled the plugs, etc. I suspected a cylinder was not firing, but the plugs all worked fine.

Then, I went to looking for a bad injector, without a scan tool. Well, using one of my R-12 Freon gauges, I hooked up to the fuel-pressure rail (Schrader-valve type). Then I turned on the key and watched the pressure go up and remain steady. After gaining access to the multiconnector for the fuel injectors on top of the intake plenum, I one by one ran a hot lead jumper to each of the eight connectors. Each time I did that, the pressure gauge would drop as I opened the injector—except for one particular cylinder. Was that one cylinder the culprit and the reason

for the dropped power and low-speed miss?

After further investigation, I found that replacing all the injectors was better than replacing just the faulty one. Either of these two individual components could have been defective, and the cause of my problem. With most of the labor involved in accessing the fuel injectors, I felt it was more prudent to replace them all with new (and better designed) units rather than only one cylinder's worth. The new ones differ from the originals, in that the injector and poppet valve are made from metal and are an integral unit. The original GM design consisted of plastic components, with a solenoid section and poppet valve that are separate from each other. Eight new ones obviously cost more. However, with the 350,000-plus miles on the original injectors, others were sure to fail in the near future. After it was all said and done, I had a neighbor who has a scan tool hook it up to read the codes and zero them out, just to make certain nothing else was happening that I didn't know about.

Couldn't have said it, or done it, better myself. The flat-rate book says that replacing a single injector takes 2.6 hours, and only another 18 minutes to replace them all, so it makes sense to do all eight at that kind of mileage. The only thing I might add is that if you fixed the bad injector, the Check Engine light would have gone off on its own after a couple of engine start-stop cycles. Or you could have pulled the engine-control-module fuse for a few seconds, or even just lifted the battery negative post to clear the code.

PM

Got a car problem?

Ask Mike about it. Send your questions to pmautoclinic@hearst.com or to Car 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.



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Tech

Desktop Recording Studio

WITH THE RIGHT SOFTWARE AND A FEW PLUG-IN INSTRUMENTS, ANYONE (REALLY, ANYONE) CAN BE A ROCK STAR IN HIS OWN HOME. BY GLENN DERENE

→ **Consider it another** marvel of the digital age—or the latest evidence that the beautifully difficult, soul-taxing art of music creation has irretrievably slid into the hands of talentless idiots. Either way, with the help of a computer, a few peripherals, a variety of entry-level software and two weekends' worth of struggle,

Entry-level music-production gear such as M-Audio's KeyStudio 49 keyboard and Fast Track audio interface can plug in via USB.

INSIDE

✕ URL SHORTENERS + iPHONE ICONS + NOOK E-BOOKS

STUDIO D

I have produced my first single.

It's hardly a secret that musical production has been striding boldly into the digital age over the past three decades. Software that enables instruments to interface directly with PCs was pioneered in the 1980s, and current programs pack all the goodness of a full production studio into a laptop, with virtualized instruments, amps, effects, mixing boards and multitrack recording machines all onscreen. This has had a profound effect on the music industry—lowering the barrier to entry to the point where a small band with a computer, a microphone and a few instruments can produce studio-quality recordings.

Instruments have changed, too. Much of the computational heavy lifting that used to be done by circuitry inside digital keyboards and drum pads has been off-loaded to PC-based software. By turning instruments that used to play independently into computer-connected USB peripherals, manufacturers have reduced the cost of some of these devices to within reach of the musical dabbler. That's where I come in.

My last formal musical instruction was in high school. I took a year of piano and drum lessons, and I have since forgotten far more than I ever learned. But the basics of drum rolls and chord progressions remained in the stickier regions of my subconscious, and I can generally noodle around with such instruments so long as no sheet music is involved.

I started by picking up KeyStudio 49, a software-hardware combo recently launched by M-Audio. For \$130, the kit comes with a 49-key MIDI USB keyboard and a mini-USB audio interface, as well as the company's entry-level Pro Tools M-Powered Essential software. The software comes with more than 60 virtual instruments, hundreds of loops and templated recording sessions. As a basic launchpad into digital music production, it's a darn good deal; the keyboard alone is worth the money, since it can be used with multiple music programs.

Digital music-production software can be a bit overwhelming if you've never

worked with it before. Much of it caters to the obsessive audio engineers who populate the music industry. M-Powered Essential is pitched as a "streamlined" version of parent company M-Audio's industry standard Digidesign Pro Tools suite of software. The advantage to this approach (as opposed to software such as Apple's GarageBand, which was designed from the ground up for newbies) is that once you've learned how it works, you are well on your way to learning how professional music is made. The disadvantage is that, if you're like me, you don't give a damn how professional music is made, and you may end up grinding off several layers of tooth enamel trying to weed through all of the menus and submenus that don't apply to you before finding the stuff that does.

Regardless of what software you pick, there are a few basic concepts that are common to all digital music-production

software. Understanding these basics will help you focus your use of the software on what's relevant.

Multitrack Recording

→ **This is a carryover** process from the days of analog tape, when producers would record elements of a song on different tape tracks, edit them separately, then combine everything into a cohesive whole. Computers have simplified this process immensely. "New Track" is one of the easier-to-find menu items in most programs—so building a song is like layering ingredients on a sandwich. I started with a percussion line, then added a bass line on a separate track, then another for rhythm instruments, another track for piano, then vocals and so on. And, I was free to tinker with individual tracks without altering everything at once.

Musical Instrument Digital Interface (MIDI)

→ **MIDI is a standardized** language that helps instruments digitally communicate



Three Devices = Infinite Instruments

THIS BASIC SETUP WILL PLUG YOU IN TO A WIDE WORLD OF SYNTH INSTRUMENTS AND DIGITAL AUDIO EFFECTS.

- 1. DRUM PAD** Most music-production software will come with a variety of "drum kits"—sampled percussion instruments that vary by genre (rock, salsa, dance, etc.). While you can play these on a MIDI piano or even a qwerty keyboard, a drum pad or digital drum set lets you break out the sticks. **Available from** Roland, Alesis, and Yamaha; expect to pay between \$140 to \$4000 for a full set.
- 2. AUDIO INTERFACE** To choose a USB audio interface, first determine what you want to plug in to your computer. Most have basic analog-to-digital audio converters inside to capture vocals and analog instruments through a microphone. Others integrate MIDI inputs and have built-in dials for manual adjustment of input levels. **Available from** Cakewalk, M-Audio and Behringer; expect to pay between \$45 and \$1000.
- 3. MIDI KEYBOARD** The most flexible digital music device you can buy—a MIDI keyboard can be made to imitate any instrument imaginable. More expensive models have manual controls and settings—some have onboard audio processing and can play independent of a PC. **Available from** M-Audio, Yamaha, Roland, Korg; prices range greatly, from \$50 to \$4000.



Writing sheet music is hard, but using software that does it for you is easy. With programs such as Sibelius First (\$130) from Avid, all you need to do is play an instrument into your PC, and your computer will transcribe the notes.

with computers over interfaces such as USB or FireWire. Instead of sending actual sound to a PC, a MIDI controller—usually a keyboard or drum pad—sends data about pitch and intensity of notes, and the computer translates that info into sound. That allows a MIDI device such as my KeyStudio piano to function as any one of thousands of virtual (sometimes called synth) instruments—these vary from the general (grand piano) to the highly specific (Modular Moog 3C). Each virtual instrument has software controls that adjust variables such as sustain, attack, delay, reverb, etc.

Plug-Ins

➔ In digital-music parlance, the production program that you use to record and edit your songs is called the host software. Users can supplement that program with additional software elements such as virtual instruments and effects, known as plug-ins. Most host software comes with a variety of virtual instruments, effects and loops, but users can add to that with third-party plug-ins. This adds a lot of flexibility to the host software but can also complicate and confuse things a bit. Plug-ins tend to be host-specific (for instance, plug-ins that worked with my M-Powered Essential software would also work with other Pro Tools software, but not with Cakewalk's competing Sonar software), but some work with multiple hosts. In general, the more plug-ins you get, the more tied to a particular host platform you become.

Loops

➔ All music-production host software will come with a stockpile of pre-arranged loops in a variety of categories, and they vastly simplify the process of music creation. By using loops, you can quickly arrange a background melody by making tracks of simple loop arrangements. I, for instance, can (sort of) play piano and (kind of) play drums, but I don't know the first thing about brass or wind instruments. So, by

browsing my host software and looking online at places like vstplanet.com and audiomastermind.com, I was able to grab a few different loops of trumpets and clarinets and oboes or an entire orchestra, then stitch them together to add another dimension to my song. If you can't find exactly what you want, some software lets you clip a sample from an existing song and use it as a custom loop. In fact, there are musical genres in which songs are formed entirely of arranged loops.

Putting It All Together

➔ Digital pianos and drum pads get the most obvious benefits from a computer interface, but electric guitars can also get a performance boost. There are a few high-tech MIDI guitars that can interface directly with computers, but you can plug an ordinary guitar in to a PC via a USB audio interface. Audio interfaces can get sophisticated and expensive, but a basic model, such as the Cakewalk UA-1G, can be had for \$100. With the computer interface, you can bypass a conventional amp, letting the software create a virtual amp and effects pedals. Guitarists (admittedly, I'm not one of them) can get pretty geeky about the sound characteristics of certain legendary amps, and software engineers are just as geeky about faithfully reproducing them. Want to play your Gibson Les Paul guitar through an '85 Mesa/Boogie Mark IIc+? There's a plug-in for that.

I had far more fun with the digital tricks that can be applied to vocals. Most of the same audio interfaces that work with guitars also work with microphones, and there are a variety of effects that can change the character of the voice or other acoustic instruments. Reverb, echo and specialized effects—my favorites were "mouse voice" and "helium breath"—can add character (or comedy) to your performance.

I was able to piece together a workable song (well, depending on your standards—my 11-month-old son seemed to like it) with M-Powered Essential. However, as a newbie, the experience was frustrating. There's very

little hand-holding for beginners unfamiliar with the logic of the program; instruments and effects are buried in submenus that are not always clearly labeled. And some elements are positively annoying—the software won't even start unless you have the USB audio interface plugged in, and scattered throughout the menus are items that don't actually work but instead launch pop-up windows that try to up-sell you on higher-end versions of M-Powered in which those features are actually functional.

After a weekend of working with M-Powered Essential, I decided to try again with software that is actually aimed at beginners. Apple's GarageBand, first launched in 2004 and now in its fifth generation, comes installed on all new Macs. GarageBand was obviously designed to walk you right into the process of music creation. It instantly recognized the M-Audio MIDI keyboard. Tracks are easy to arrange, instruments are organized logically—and assigning virtual instruments to the keyboard was a snap.

For those who just want to jam with a backing band, GarageBand Jam instantly gives you a multi-instrument rhythm section in whatever musical style you select. And if you don't know the first thing about music, you can follow instructions on the basics of piano or guitar, or download (for \$5) Artist Lessons from famous musicians. Sting, for instance, will teach you to play "Roxanne."

There is no direct analog to GarageBand for the PC, which is a pity, since most people still use Windows PCs, but there are some programs that come close. Sonar Music Creator (\$35) is well-priced and has a clean interface that is simple to use, as is Acoustica Mixcraft (\$65)—and both programs use the popular DirectX and VST plug-in formats.

So after tinkering with multiple programs, I finally got a song I'm satisfied with—at the very least, it has a discernible beginning, middle and end. I've exported it to an MP3 file, and it's currently sitting on my iPod, where only I can listen to it—for now, the rest of the world is safe.

PM

Digital Clinic

by Seth Porges

Q+A

Is That Short URL Hiding Something?

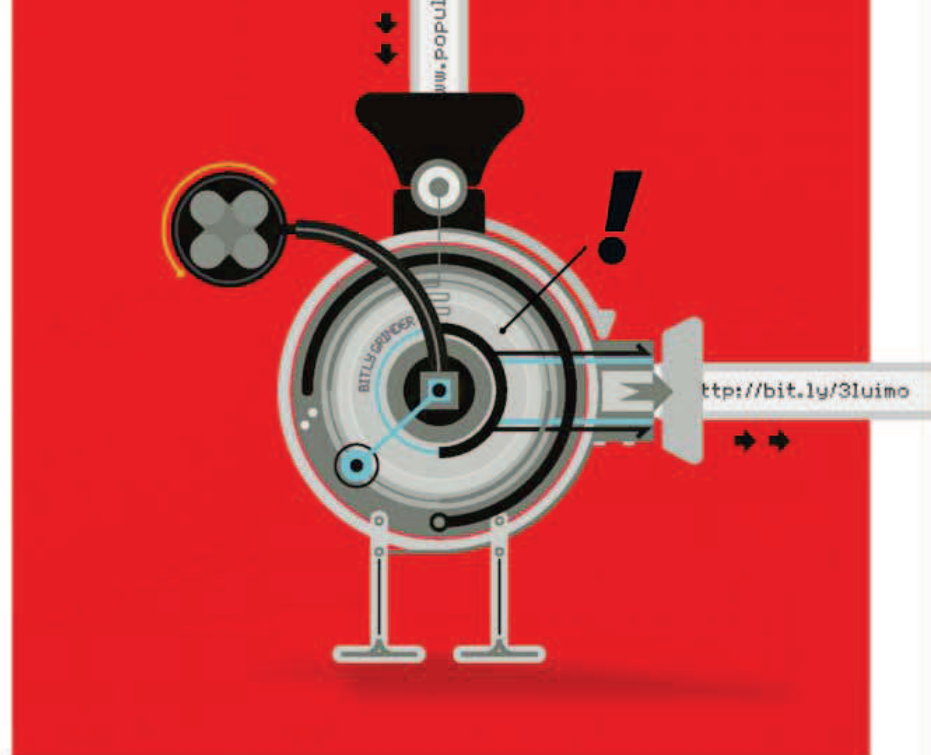
Q Are there any dangers to using URL-shortening services such as bit.ly or TinyURL?

A Web-address URLs can be unwieldy beasts. Click past a site's home page and the string of seemingly random letters and numbers is likely to stretch on for dozens of characters.

Of course, this creates a problem for Twitter users—the microblogging service limits all posts to just 140 characters, and a long URL can easily eat up the bulk of these.

To get around this, sites such as bit.ly and TinyURL offer URL-shortening services. These enormously popular sites are very easy to use: Copy and paste in the big URL, and the site spits out a shorter Twitter-friendly address. This shortened URL (typically under 15 characters in total) acts as a proxy link, redirecting Web surfers to the real URL. The upshot: Twitter users (or anybody else who doesn't like dealing with massive Web addresses) can share links with ease.

Useful? Absolutely. But these URL shorteners are also potentially hazardous. Clicking on one of their links is like opening an e-mail attachment sent by a complete stranger (and you know better than to do that, don't you?). The services can be used as smokescreens for spammers, phishers and virus-pushers who can easily lead you to believe you are clicking on a legitimate link.



! It's impossible to see where shortened URLs are sending you—so they could act as smokescreens for viruses and spam.

This happened last June, when hackers broke into the cli.gs URL-shortening service and redirected a whopping 2.2 million links. The hacked links didn't load up anybody's computer with viruses or Trojans, but the incident illustrated a severe shortcoming in how these sites operate. Quite simply: You don't know what's on the other end of these links, and it could be malicious—or at least too lewd for the office.

And URL shorteners have another problem. There's no guarantee they'll stick around. The Web is an immense network of links. As shortening services grow in popularity, shortened URLs will inevitably represent a greater portion of the entire Web's links. If one of these services shuts down, it will instantly result in an avalanche of dead links that could make it difficult to find particular pages.

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the limits of Twitter make these services a necessity. But when you use them, it makes sense to exercise caution—if you don't know who posted or sent you a link, it might not be a good idea to click it. And if you want to make sure a link is accessible as far into the future as possible, consider tweeting, e-mailing, blogging or posting the full version.

In the long term, I'd like to see more sites move away from the obnoxiously long Web addresses that have made these services a necessity. If more sites start using their own shorter URLs, it will be easier for everybody to click away with confidence.

Playing Nooky

I am thinking about purchasing the Barnes & Noble Nook e-book reader. My question: Does the Nook's ability to "lend" e-books to friends work with other e-book readers, or does it only work with other Nooks?

One of the coolest features of Barnes & Noble's Nook e-book reader is its Lend-Me feature, which allows users to "lend" an e-book to a friend, much like you've always been able to do with real books. How does it work? When your e-book reader is near a friend's, it can wirelessly beam a book to the other device. For up to two weeks, that book will then live on the other e-book reader, during which time it will be inaccessible to the lender (just like a real-life borrowed book).

Of course, this feature becomes more useful as more people possess compatible readers. So it's reassuring that it does, in fact, work with some non-Nook e-book readers, as long as they are models (such as those made by Plastic Logic) that tap into the Barnes & Noble e-book-store ecosystem. One warning: It's up to publishers whether or not they want their books to be lendable—so if you're dead set on lending out a particular book, best to check whether it's compatible before you buy.

Circling Around

At the top of my iPhone's screen there is a little circle where it usually says "3G." What's this mean?

The techy answer: Your iPhone is now on the GPRS data network. The English translation: "Sorry for the really slow data speeds."

In a perfect world, all smartphones would always have access to fast and reliable 3G networks. Of course, the problems with AT&T's often-overloaded network are well publicized, and anybody who's ever tried to use an iPhone in a dense city knows that slow speeds are far from unusual. So when a 3G network isn't available, an iPhone 3G or 3GS regresses to the slower EDGE (short for Enhanced Data rates for GSM Evolution) network, and will let you know by displaying a capital "E" at the top of the screen where it usually says "3G." But what if even EDGE isn't available? In those all-too-common cases, the phone kicks it down one more notch, and you're left with GPRS—or General Packet Radio Service. This slower data network—signified by the circle in question—should suffice for sending and receiving simple text e-mails and is certainly better than no signal at all, but don't expect it to be very useful for surfing the Web, streaming music or running data-intensive mobile applications.

NAS Backup

Do I need to buy Apple's Time Capsule network attached storage drive if I want to take advantage of my Mac's Time Machine backup program, or will ones from other companies work with it as well?

It will never cease to amaze me how

many people simply don't back up their data—a fact that is all the more remarkable when one considers how inherently fragile spinning hard drives are, and the fact that, sooner or later, literally all of them (and their years of irreplaceable files) fail.

The easiest way to back up your data is to use a network attached storage (or NAS) drive. Because they have the ability to automatically pull your computer files over your home network, they make it easy to automatically back up your documents, photos, music and movies without having to really even think about it. One of the easiest programs to facilitate this is Time Machine, which comes built into all Macs that run on the Leopard or Snow Leopard version of Mac OS.

Officially, Time Machine doesn't support any third-party NAS drives. But that hasn't stopped some other companies from building storage drives, such as the Iomega StorCenter ix2-200, that sync up with Time Machine. But users should be cautious: Apple has been known to block such workarounds in the past—as it has done with the Palm Pre phone's unauthorized ability to sync its music library with iTunes—so there's no guarantee that these drives will always work with Time Machine.

PM

Got a technology problem?

Ask **Seth** about it.

Send your questions to pmdigitalclinic@hearst.com or to Digital 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.



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This Is My Job

*DEMOLITION BLASTER

Name: CODY GUSTAFSON

Location: DUBOIS, WYO.

Age: 27

Years on Job: 8

1. CUTTING TORCH

Weakened steel beams require fewer explosives to collapse. Gustafson uses a torch that runs on acetylene or propane, burns at over 6000 F and cuts 1/2-inch-thick steel at 3 feet per minute to create weakness.

2. LINEAR-SHAPED CHARGES

Made of RDX (the main component of C4) and copper tubing, LSCs provide directed explosions for cutting through steel beams. Gustafson cuts a 4-inch-high window in an I-beam, then places four 600-grain LSCs (which will each cut through 3/4 inch of steel) in the window.

3. DRILL BIT

To make shallow holes in concrete, Gustafson uses a drill bit attached to a jackhammer or a drill; for holes up to 160 feet deep, he uses a tread-mounted drill and tempered drill steels connected end-to-end.

4. DYNAMITE

Gustafson packs holes with 1/3 pound of explosive per yard of concrete. The first stick is joined to a blasting cap, then to a fuse; temperature and pressure from this explosion set off the other sticks. Dynamite is pretty stable, but "when you drop a stick in a hole, you cringe," he says.

5. NONELECTRIC SHOOTER

Electrical activity wreaks havoc when charges are electrically wired, so Gustafson uses a nonelectric shooter that ignites Nonel tubing, which burns at 8000 to 12,000 feet per second.



Cody Gustafson drives 80,000 miles a year to visit bridges, factories and coal silos—and then he destroys them. The 27-year-old (whose father and grandfather are also active blasters) has demolished more than 75 structures in 40 states, not to mention 300 Minuteman II nuclear missile silos. Gustafson loves walking high steel and riding in a crane basket to place explosive charges. But the real payoff comes with the blast itself, the slow-motion milliseconds when charges explode into a lattice of smoke with a chest-rattling *ka-boom*—and the whole shebang crashes down into heaps of rubble and dust. "Everybody loves blowing stuff up," Gustafson says. — JY MURPHY



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