

TRICORDER: FROM STAR TREK PROP TO MEDICAL MIRACLE

AUSTRALIAN

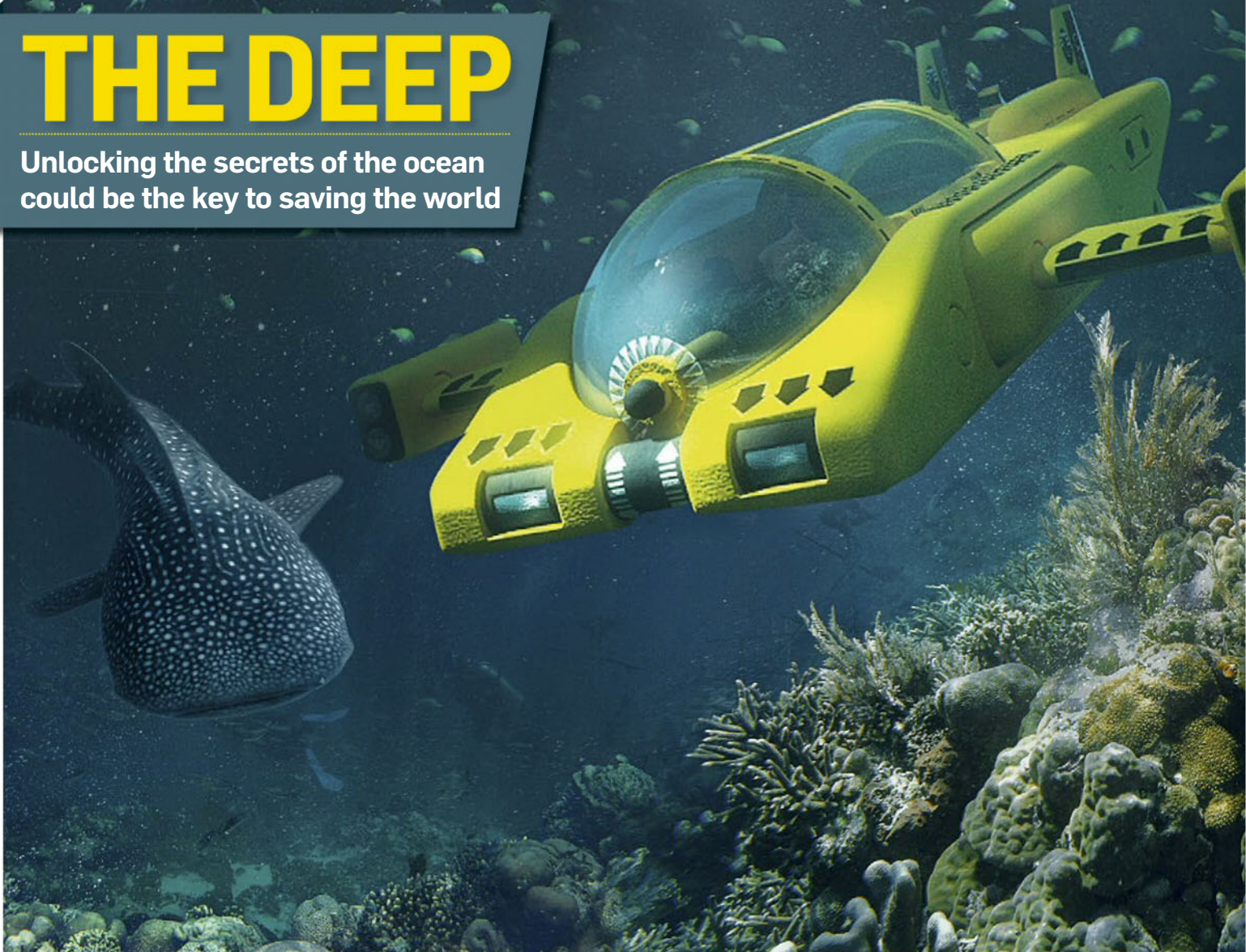
POPULAR SCIENCE



Don't Trust Your Smart Fridge

THE DEEP

Unlocking the secrets of the ocean could be the key to saving the world



THE FUTURE OF GAMING

From VR to AI and beyond



THE SCIENCE OF ZOMBIES

How a B-movie trope became a research tool

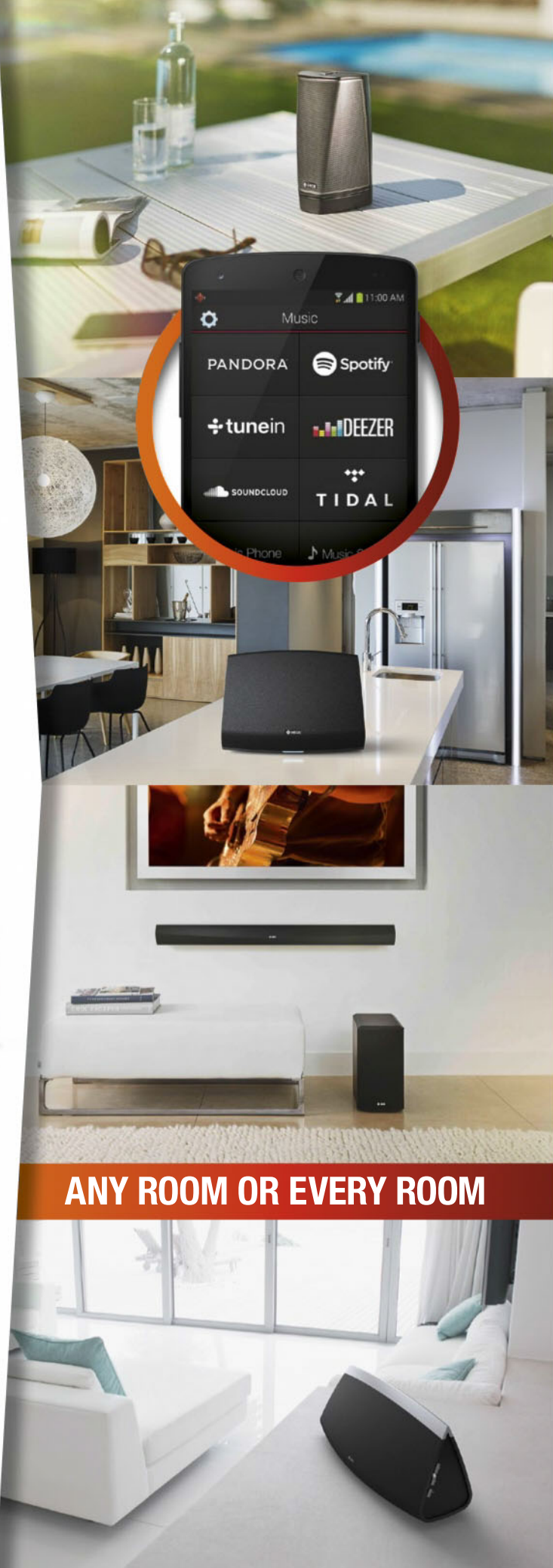
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The Ocean May Not Be The Ultimate Solution

When I was in my late teens there was a sort of craze for Ocean-based sci-fi. Off the back of 1989's *The Abyss*, we had TV shows like *seaQuest DSV* (sic) and a bunch of books, mostly by Arthur C Clarke, such as *The Ghost From The Grand Banks* and *Cradle*. All of these put humans, with high tech, at the bottom of the sea. For a while at least, the ocean was the penultimate frontier.

And why not? Most of the planet's surface is covered by the ocean (yes, there's only one ocean, it all joins up see?) and it's still full of mystery and possibly sharks as big as garbage trucks.

The SF of the 1990s focused on the way the ocean is just full of lovely resources. Minerals, oil, even the water itself can theoretically be processed to extract everything from Epsom salts to gold. All there for the taking.

As a teen, I fully expected we'd have some kind of near-term future as inhabitants of the ocean. Humans would eventually move down into the depths, maybe even as sort of practice for building space stations. New polities would arise, wars of independence would be fought (using badass armoured submersibles), and entirely new cultures would be created.

Of course, things haven't really turned out that way. Peter Thiel wants to build some giant houseboats to dodge his tax, but apart from that, not so much. A couple of decades of pollution, oil spills, over-fishing, the Pacific garbage patch have made me wonder if the ocean could possibly survive colonisation by humans.

The underwater biosphere is a weird place. Things work very differently down there. On the one hand, if you throw a chunk of concrete onto the empty seabed, within weeks it will be absolutely encrusted with new life, desperate to find a bit of real estate in an environment where absolutely every niche is jammed full of some bit of specialised biology, probably predatory. But on the other hand, raise the surface temperature

by a degree or so, and entire coral reefs die overnight. Life in the sea is at the same time incredibly tough and adaptable, but also incredibly fragile and able to thrive in only the narrowest band of parameters.

What research since the 1990s has done is really hammer home this idea that the ocean is the engine of our biosphere. It's not just that we all originally came from the ocean, it's that we still rely on it today for our survival. The ocean creates (most of) our weather. It (or rather plankton in it) generates most of the oxygen in the air. It cleanses the world, renews the land and acts as a vital buffer against changes in the amount of energy in the atmosphere.

I'm starting to think that we should never colonise the ocean, and in fact should work toward more or less the opposite. We should use our technology to remove our last remaining dependencies. I'm not saying never eat tuna again, I'm saying grow them in tanks. Don't stop exploiting the ocean's endless appetite for biological byproducts, but filter our sewage so only the stuff the hagfish and crabs and weird isopods can eat actually goes in there. And forget about the oil.

Oh who am I kidding. Humans will always want to exploit what is there to be exploited. Some research shows that if we stopped all commercial fishing, stocks of depleted species could bounce back to pre-20th-century levels within a decade. But after that, we'd see those vast schools of tuna and haddock and halibut and think... maybe just a FEW.

ANTHONY FORDHAM
afordham@nextmedia.com.au

THE FUTURE OF GAMING

Bigger than Hollywood, weirder than literature, videogames are part of our culture now. So where does this industry, and art form, go from here?

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Wind turbines are nothing new. And to prove it, we look back at the time Popular Science asked readers to show off their own wind-powered hacks...

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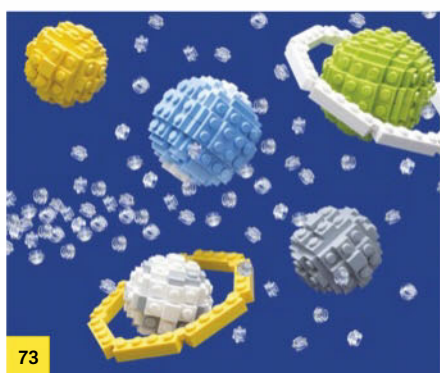
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Now



► SPECS

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THIS SINGLE-VOICE SYNTH IS EVERYTHING GREAT ABOUT ANALOGUE

by
ANTHONY
FORDHAM



HARDWARE SYNTHESISERS don't attempt to mimic other musical instruments, but instead use electronics and waveform manipulation to create unique sounds that you just can't get out of anything else. And that's why this tech has endured for the last 40 years.

Sure, you can buy a "synthesised synth" (or maybe simulated synth?) in the form of an app for your chosen mobile platform, or install a "library" of "voices" in a digital audio workstation (DAW) that runs on a PC - but it's like a real trumpet vs a super-high-resolution digital sample of a trumpet, right? The actual instrument is always better.

Purists go further: the only truly worthy synth is a monophonic synth. Unlike a piano or digital keyboard packed with processors, a monophonic synth can only play one sound at a time.

But what a sound! Korg's Monologue combines proper hardcore filters and

oscillators and a "one knob per function" design that really hammers home the analogue philosophy.

Forget selecting "Hammond Organ" from a list, this is a synth where twisting one knob through fraction of a degree can dramatically change the sound. Yes, you have to "get" this type of music - fat bass, rich harmonics etc - to appreciate it, but that's true of any instrument. Especially the clarinet.

Korg has the rise of digital synths and apps to thank for a resurgence of interest in proper hardware synthesisers.

Classic synths were expensive because they were hand-built and super-niche. Today, mass production gives musicians the Monologue (in five colours no less) for \$459.

It's battery powered, so you can busk with it, but it also supports MIDI and Korg's own Audio Sync to hook it into a bigger setup.

Another neat touch: the 25-note keyboard runs E-to-E like a guitar or bass, so it should slot easily into any band.

Yes there's more than a hint of retro about the Monologue too, with its metal casing and chunk of real (albeit cheap) wood out the back to remind you of the days when companies like Moog and Korg could charge \$15,000 for a monophonic synth...

...oh wait they can still do that. Because analogue synths rule.

In a world where a musician can produce a number one album from their bedroom using a MacBook Pro and \$200 in software, the Monologue isn't an essential tool by any means. But it's a very powerful and interesting option for composers who understand the contribution that hardware analogue synth has made to the history - and future - of music.



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1

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by
KNVUL
SHEIKH

POKEMON GO

Last year you may have bumped into the reverent heads-down multitude clogging streets. They were playing *Pokemon Go*, the app version of the '90s video game. A cool 45 million players downloaded it and wandered off on a global scavenger hunt. The goal: catch the game's 151 monsters while accidentally learning facts about local 'landmarks' as you go. *Free + In-App Purchases, iOS and Android*

2

FIELD TRIP

Stumped on a great place to eat or shop? Field Trip is a travel discovery app that's better than a crumpled list from your smartypants friend. It taps into sites like Thrillist, Zagat, and Eater, and uses your current location to show you photos and reviews of nearby locations. Or you can let the app alert you to notable spots while you're out. It's like having your smartypants friend in your pocket. *Free, iOS and Android*

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WHERE WE'VE SLEPT

IT'S DARK AND YOU'RE FAR FROM HOME. WHERE DO YOU stay? Back in the day, you had to know somebody. Nowadays your smartphone does. When night falls, every vagabond—old or new—requires a roof over their head and a bed under their bottom. But where we stay has drastically changed over time. Now uncovering a place to crash can happen in a matter of moments.

by
MICHAEL
KOZIOL

PREHISTORY-PRESENT A PAL'S PLACE

Staying at a friend's house—or cave, or loft, or cave-loft—is a tradition as old as friendship itself, and that practice is new again thanks to the sharing economy. Services like Airbnb help you find a room in which to crash.



400-1300 MONASTERY

For the dutiful Christian making his pilgrimage to the holy lands of Jerusalem (in 400) and Santiago de Compostela (in 1000), monasteries were literal lifesavers. Food, shelter, and a lot of awkward chitchat with the monks at breakfast.



1200-1500 CARAVANSERAI

12th century Silk Road traders relied on a network of caravanserais (roadside compounds). Doorways wide enough for camels and open courtyards offered sleeping bays for traveler and animal. A great place to resupply and trade trinkets.



1990 ICE HOTEL

Every November, Swedish workers carve 2-ton chunks of ice from the Torne River to make a 55-room hotel. Travellers dine at ice tables with frozen cups, and sleep on ice slabs (in fur or sleeping bags). Bathrooms consist of less...melty material.



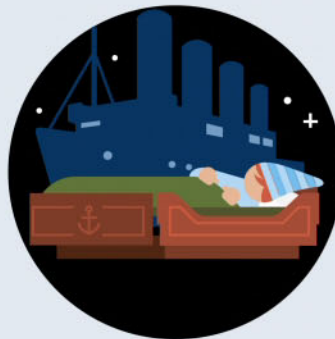
1900-2000S MOTEL SYSTEMS

Thousands of miles of highway constructed in the 20th century attracted travellers, fuelling the peak of motel creation in the 1920s. Thirty years later, motel franchises were booming, providing a uniform and recognisable service across the country.



1912 THE TITANIC

On its maiden voyage, RMS *Titanic* was the height of ocean-liner luxury. As the largest movable object in the world, it included a gym, pool, and squash courts. Aeroplanes caused ocean-travel popularity to sink not long after the *Titanic* did.



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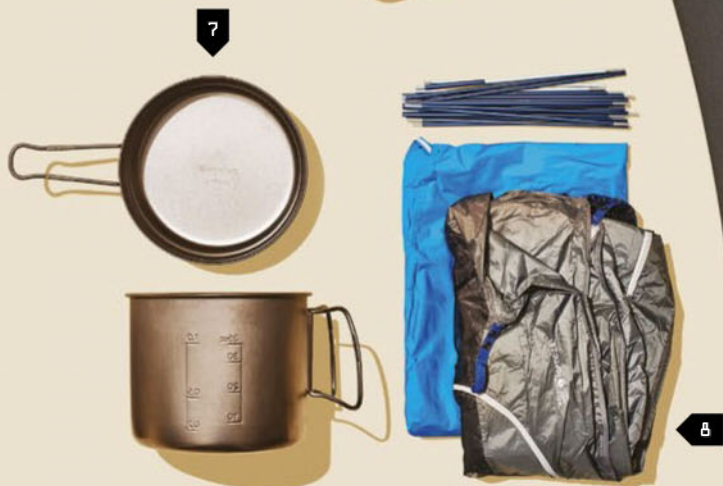
Get Out

GEAR FOR THE LONG HAUL

Nature is the main event, but the right kit keeps you focused on the show. The tools we use to break free from endless suburban sprawl haven't changed: tent, clothes, and a pack to haul it all. Why not stay a while?

by
GRENNAN
MILLIKEN





1/ MSR POCKETROCKET CANNISTER STOVE

Some places don't allow campfires. Others simply have nothing to burn (think snowy mountains). A cannister stove has your back. The PocketRocket folds to the size of a softball and will stick with you forever.

2/ FJALLRAVEN KAJKA 65-LITRE PACK

When camping for a few days, 65 litres of gear is plenty. The frame on this pack adjusts to men's and women's body types, and the lid can be used as a light bag for quick trips from camp. No, it doesn't come in neon.

3/ BLACK DIAMOND ION HEADLAMP

From helping you find that lost s'more to lighting the path for your 0200h pee break, the camper's headlamp is a crucial piece of your kit. They're easy to lose though, so don't spend a ton on one.

4/ ORU BAY KAYAK

In less than five minutes, the Oru transforms from a folding-chair-size box into a fully functioning boat. Made of tough corrugated plastic, its cockpit features everything you'd expect in a nice kayak: a backrest, butt pad, and braces for your feet.

5/ SEA TO SUMMIT TREK II SLEEPING BAG

Mummy sleeping bags are a dream for keeping you warm, but a nightmare if you're claustrophobic. This three-season sleeper's design opens a bit at the top—so you won't feel like you're being prepped for burial.

6/ BENCHMADE GRIPTILIAN

A versatile knife will always serve as the centrepiece for any outdoor kit. The Griptilian is a worthy companion: Its coated steel blade stays sharp and will beast through rope, food, and kindling. Its rigid locking mechanism is both easy to open and super secure.

7/ SNOWPEAK TREK 1400 TITANIUM COOKSET

Cookware is a camping essential. But steel pots and pans are noisy, add weight, and take up space. This cookset locks together to save your ears from the clanking. And at 225 grams, it's also astonishingly light.

8/ MOUNTAIN HARDWEAR OPTIC TWO-PERSON TENT

Mesh walls give you a 180-degree panoramic view of your surroundings. And that fresh cross breeze helps with your awful foot odour. Screens don't do much for precipitation, so yes, it does come with a rainfly.

9/ VUARNET 60TH ANNIVERSARY GLACIER GLASSES

Mick Jagger made Vuarnet glasses rock-star classic in the '80s, but these are more than just hot. Designed for bright slopes, their lenses and side shields protect your corneas from glacier-reflected sunlight.

AN ELECTRIC BIKE THAT MAKES MOLEHILLS OUT OF MOUNTAINS

by
ANTHONY
FORDHAM

WHEN IT COMES DOWN TO

the mechanics of the thing, in terms of the balance between energy put into the system and speed attained, the bicycle is pretty much the most efficient human-powered machine we've ever come up with.

The same energy that will get a runner up to, say 16-17 km/h will propel a bike at 22-25km/h. Also, cycling is kinder on the joints.

Of course anyone who has been following advancements in compact electric motors and lithium-ion batteries might be given to wonder: why don't we just put one of those motors on the rear hub of a bike, strap some batteries up under the seat, and voila. The moped is reborn. Sort of.

To keep ebikes, well, bike-like and riders free of the bureaucratic burden of getting a motorcycle license, current regulations say throttle-controlled ebikes can only have 200W motors, while pedal-assist bikes can have 250W motors.

Both types must be designed to cut power to the motor once the bike reaches 25km/h. Sound weird? Here's how it works:

Our ride, a Riese & Muller Charger GT provided by Sydney-based Eurocycles, is what the company calls an urban fat-tyre. Its tyres are indeed reasonably fat to make jumping the kerb easy, but the tread is more road-bike than mountain.



There's front suspension, but no rear, and eleven gears on the back hub only. Look at the bike from a distance and the frame seems... odd. That's thanks to Bosch's integrated electric system, consisting of a compact 500Wh battery mounted where most people keep their water bottle, a 250W pedal-activated motor replacing the front gears, and a controller module mounted on the handlebars.

This includes a speedo readout, battery state, and also lets the rider switch on the bike's headlamp, among other functions.

The Shimano Deore XT gear shifter on the right handlebar is familiar enough, but on the left is a plus-minus control that sets how much assistance the electric motor will give the rider.

Masochists can ride this heavy bike with no assist at all if they want, but powered settings range from Eco up to Turbo. Tour

is the most sensible, middle setting that should give around 40km of assisted range before the battery goes flat.

Riding the Charger is basically like having magic gears. You notice it most when you come to a dead stop on an uphill slope. To strike off again, just start pedalling. No standing up, no initial wobble as you get up to speed. It's not just easy, it's almost uncanny. And the motor is essentially silent.

Okay, this bike, like all quality ebikes right now, is very expensive. For \$6200 you could get one hell of a road bike, or a pretty good road bike and enough personal training to build up your thighs to a point where your own muscles will make going uphill as easy as Bosch's system does.

But even then you'll still be a lycra-clad superathlete on a gossamer frame of ultralight carbon-fibre. On the Charger GT (or a bike like it) you can wear

RIESE & MULLER CHARGER GT
PRICE: \$6206
WEB: www.eurocycles.com.au

normal pants and a backpack. You can ride in a comfy upright position with nice suspension, and potholes won't ruin your day.

Even so, to some extent, ebikes rely on you having awkward cycling needs. For anyone who has to live with even somewhat restricted mobility, an ebike is liberating. For someone with a 20km cycling commute, it will save valuable time (assuming you can stop the darn thing being stolen, a genuine fear we had every time this very fancy-looking blue and orange beast was locked up for the night).

Still, the regulations are in, the tech is maturing, and battery costs continue to fall. Who knows, ebikes could be the future of short to medium range urban travel. **Ps**

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WACOM'S NEW TABLET DOES ONE THING BRILLIANTLY



ONE OF THE BIG CRITICISMS OF so-called hybrid notebooks is that they do a lot of stuff... but only okay. Even the Surface Pro 4 is kinda too heavy as a tablet, but kinda awkward on the actual lap for a laptop.

Unlike so many manufacturers jumping on the hybrid bandwagon, Wacom has a really good reason for wanting this form-factor. This company continues to maintain a near-monopoly on the (slightly confusingly named) graphics tablet market.

If you do CAD or work at a magazine, or in animation or dozens of other creative industries, you probably use a Wacom Intuos Pro tablet and pen.

On top of that, Wacom licenses its touchscreen and pressure-sensitive pen tech to other companies now, including one of the Surface Pros (not the 4 though), and earlier Samsung Note-series phablets.

Unlike the Surface which compromise on some things, Wacom's tablets need to be very good at one thing: being an all-in-one art creation device.

by
ANTHONY
FORDHAM



► SPECS

■ Wacom MobileStudio Pro

■ Price: \$3499 (as tested)

WEB: buywacom.com.au

Intel's latest generation of mobile chips finally makes this possible. The MobileStudio Pro (which comes in 13-inch and 16-inch variants) can pack a Core i7 and 16GB of RAM, making it a beefy machine by any measure.

An LCD display beneath Wacom's digitiser has either 2560x1440 or 4K resolution, and pro-level colour fidelity.

In no way does this art tablet try to be a "normal" PC, even though it runs Windows 10. Extra touch buttons along one side can be mapped to various functions, which change depending on what application is open. There's no clip-on keyboard or trackpad.

Outputs are sensibly limited to three USB-C ports - this keeps the tablet thin. Also, and this is something we haven't seen before, it's possible to plug in and charge the tablet via any one of the three ports. There's no dedicated power port. Thanks USB-C!

Wacom bundles the MobileStudio Pro with its top-end Pro Pen 2. It can now register 8192 levels of pressure, has better tilt support, and thanks to a combination of fast processor and better digitiser, no detectable lag.

All of this means the MobileStudio Pro feels even more like working on a sketchpad than before. Previous iterations - such as the Cintiq Companion - were too ambitious for the hardware of the day. Responsiveness suffered. They felt like a compromise, a "this is the best we can do for now".

The MobileStudio Pro moves beyond that, giving cashed-up creatives a super-slim PC that really can do it all.

INTUOS CUTS THE CORD

Don't need/want an entire PC just to get pen control? Wacom's core product has always been the Intuos Pro, and the latest version gets the Pro Pen 2. Even better, it now packs Bluetooth for wireless connection to a host PC (a Wi-Fi module used to be extra). New this generation is the Intuos Pro Paper Edition: clip a sheet of paper to the tablet and draw on it using a special gel-tip pen, and it digitises your work as you go. From \$499.

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**Outgoing Secretary of Transportation
Anthony Foxx on our self-driving future**

DRIVERLESS CARS ARE moving fast. Google and Lyft flash us their self-driving-car schemes, and Uber has already put robo-cabs to work in Pittsburgh. But if autonomous cars are going to chauffeur us, we need to regulate them.

During his time as Secretary of Transportation, Anthony Foxx, who leaves his post at the end of January, penned laws to keep us safe on these changing roads. And he has some tips for the new hire.

What advice would you give the new secretary?

We've laid out a template for the future, one that you can build upon. Take our work on data sharing. It's one thing for a company to build an autonomous vehicle and

collect data on it. It's another for a manufacturer to collect data, anonymise it, and share it with other manufacturers. When one car avoids a crash using a specific manoeuvre, other cars can learn from that. Taking a proactive approach on laws that require autonomous automakers to share information will help keep roads secure in the future, and we've laid the groundwork for that.

+STATS

NAME

Anthony Foxx

MISSION

Keep driverless cars safe

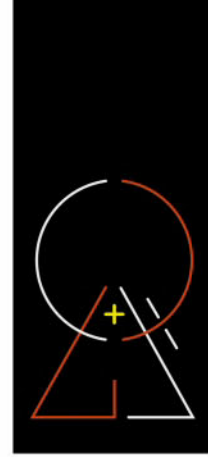
CURRICULUM VITAE

Mayor of Charlotte, N.C., 2009-2013

Is being open something we should demand of these companies?

The government and the Federal Aviation Administration have kept the skies safe without mandates. Commercial carriers voluntarily share anonymous data with us on accidents and near-collisions. We're able to work with them to reduce risk in the skies, so we've had experiences with nonmandatory data sharing. Whether that works in the automobile space where everyone is hypercompetitive, I can't say. But we've started to open that conversation with carmakers.

In the past, US highway planning neglected minority and impoverished neighbourhoods. Could an



by
XAVIER
HARDING

autonomous future also be biased?

We've already seen it. We've seen how modern travel can be biased toward those of a certain economic class. Many systems today trade money through the use of smartphones and credit cards, though there are still large numbers of people who might not have one or both. When you think of a service like Zipcar, those rental cars reside in certain communities. You're going to have the same situation with some of these autonomous-vehicle services.

To combat this, companies have to think about how the facilities they build actually serve the communities that they touch.

What's been your main challenge in crafting policy for driverless cars?

We're doing something we've never had a chance to do: be a part of developing a culture of safety around driverless cars from the beginning. We didn't have that chance with the original automobile or the aeroplane. Those technologies existed before our department did.

We're laying out guidelines to set expectations for present-day stakeholders but simultaneously forecasting the driverless-car arena of the future. We want people to think of what we're doing less as a final word and more as a beginning.

LEFT TO RIGHT: STEPHEN VOSS/REDUX; MARC OLIVIER LE BLANC



COMPUTER ON WHEELS

Carol Reiley, president of AI-fuelled software company Drive.ai, wants cars to talk to us

MANY PEOPLE'S FIRST experience with a driverless car is as a bystander. So part of our mission is transparency: making sure our vehicles can communicate intention to pedestrians. A roof-mounted LED or lasers projected onto the ground would allow that communication through words or even emoji. You can tell people when the car is in self-driving mode by using a blue light. Even people who are

colour-blind can see blue.

On the inside, we use artificial intelligence that teaches the car through deep learning. We wanted to bypass the need to hard-code detection of specific features—such as lane markings, guardrails, and bicyclists—and avoid creating a near-infinite number of “if, then, else” statements. That’s too impractical to code when trying to account for the randomness that occurs on

the road. This sort of “deep driving” can identify objects and intent, and can process piles of data. We’re using it for everything from creating maps to identifying objects to combining the input from sensors. Deep learning also offers a smoother ride by learning from examples. This eliminates jerkiness.

And then there’s the roughly two hours of commute time you gain back each day from your car driving itself. We think this will trigger the next big app boom. Thinking of the car as a computer platform, it will become your third living space. It’s not just about getting from point A to point B. It’ll be like you’re sitting inside your cellphone. —as told to X.H.

+STATS

NAME

Carol Reiley

MISSION

Make driverless cars smarter

OTHER OBSESSIONS

Surgical robots and DIY: At age 8, she designed a humane mousetrap to catch a renegade pet hamster.

PLAN(ET) NINE FROM OUTER SPACE

A YEAR AGO, ASTRONOMERS announced evidence for the existence of an undiscovered planet way, way out on the edge of our solar system. Nobody's found the mystery world yet, but that hasn't stopped scientists from speculating about how such a planet could have ended up so far from the rest of us.

New simulations, presented in January 2017 at the American Astronomical Science meeting, suggest that it may have once been a rogue planet, stolen (or maybe recruited?) by the Sun.

If it's out there, Planet Nine is expected to be 10 times the size of Earth and 1,000 times farther from the Sun. By comparison, Pluto and pals orbit out around 40 times farther than Earth, so Planet Nine is a pretty big outlier. Assuming it's a standard(ish) planet and not something even

weirder, how did it get so far away?

There's a chance it was just born out there in

the middle of nowhere. But the duo leading the search for Planet Nine — astronomer Mike Brown and astrophysicist Konstantin Batygin from Caltech — think it's an outcast. According to their theory, Planet Nine formed close to the sun, like our other planets, but the neighbourhood was crowded, so Planet Nine got bumped out — way out.

Another possibility is that we snatched it. Planet Nine may have formed around another sun, which may have gone nova and ejected it into interstellar space. It would then have wandered around as a rogue planet, before our solar system's gravity captured it.

James Vesper and Paul Mason from New Mexico State University recently simulated what would happen if rogue planets of various sizes and trajectories encountered our solar system. They ran 156 simulations and found that sure, 60 per cent of the time, the rogue planet got booted out by our solar system — sometimes taking one of our own planets with it. But the

225-250

Estimated length,
in millions of
years, of a
"galactic year",
the time it takes
the solar system
to travel around
the centre of the
Milky Way.

other 40 per cent of the time, the rogue was captured and stayed in orbit.

Vesper and Mason haven't yet published their findings. An earlier study suggested that compared to other theories, there's a less than two per cent chance Planet Nine is a captured rogue. So the verdict is still out on where Planet Nine came from, but hopefully this riddle will be solved—assuming it exists, and assuming that we can actually find it.

by
SARAH
FECHT



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EXPAND

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Now

Need To Know



WHY WIFI ROUTERS AREN'T BORING

BACK IN OCTOBER 2016,

an attack on DynDNS shut down the internet. It soon became clear that the attack was possible because of an overwhelming number of new, unsecured, internet-connected devices — the Internet of Things (IoT). This year's Consumer Electronic's Show has introduced us to plenty of new IoT devices, including cute robots, new capabilities for Amazon's Alexa, and even a smart hairbrush and pillow, which both sound very necessary.

(For more on how the IoT could be a BotNet paradise, check our article on p.28.) But, for the home at least, there could be an ironically-centralised solution.

SYMANTEC, the company behind Norton AntiVirus, has come up with a unique answer to the growing IoT problem. Rather than protecting each of your devices individually, Symantec's new wifi router (the Norton Core) will use the company's expertise and software

to protect up to 20 laptops, computers, tablets, or smartphones

— and an unlimited number of IoT devices — in one fell swoop.

The router scans every packet of data that you send or receive, for threats to your online security. If it detects one, it automatically quarantines infected devices.

Users will be able to monitor these threats, as well as all devices connected to the router, through a smartphone app.

The app also allows for certain devices to be prioritised over others, ensuring those that need more bandwidth get faster internet connections.

MCAfee announced that its own security software will soon be available in a modem/router combination. But unlike Norton, it's not making its own hardware. Instead, the newly-announced McAfee Secure Home Platform will come in each model of the Arris SURFboard Secure Home Gateway fleet, beginning with the ARRIS SURFboard SBG7580-AC. Rather than scanning all data like Symantec's router, the ARRIS will check McAfee's database of safe websites and warn if a user tries to go to a site known for phishing.



The Arris router can be purchased for US\$210. McAfee has not yet announced how much its security software will cost in addition to the router, but plans to do so later this year.

It will also offer many of the same security features and parental controls as the Norton Core, which can all be controlled via the McAfee smartphone app.

As consumer tech increasingly meshes with the internet, we need to make sure we're securing it and protecting ourselves from hackers, botnets, and anyone else who would seek to abuse those who unknowingly use vulnerable devices. Of course, any security product carries its own potential for disaster. This past June, Google found "multiple critical vulnerabilities" in several of Symantec's products; the flaws have since been fixed.

And then there's the associated cost. The Norton Core can be pre-ordered for US\$200 (the price will eventually go up to US\$280 and it will cost even more if it comes to Australia); after one free year, Core users will have to commit to paying an extra US\$120 annually (a monthly \$10 fee, not including taxes) to maintain access to the security software.

If they don't pay up, they'll be left with a regular old wifi router.

by
JASON
LEDERMAN

VF Commodore 9" Infotainment System

SS / SSV / SV6 / STORM / CALAIS / CALAIS V / EVOKE



CUSTOM INTEGRATION SOLUTION
OF THE YEAR - 2017

Designed and developed exclusively for VF Commodore, the Alpine Infotainment system integrates seamlessly into your dash with a premium OEM finish. Boasting an ultra-large 9-inch capacitive touch screen display, the X901D-VF delivers an incredible navigation and multimedia experience.

ALPINE
Driving Mobile Media Innovation

www.alpine.com.au/VF

Next

A stylized illustration of a city skyline at sunset. In the foreground, two zombies are silhouetted against the bright orange and yellow sky. The zombie on the left is in the center, with its arms outstretched. The zombie on the right is slightly behind and to the side, with one hand raised. The background shows the silhouettes of city buildings and a grid of windows in the upper left corner.

WHY SCIENTISTS STUDY THE ZOMBIE APOCALYPSE, FOR REAL

WHEN THE ZOMBIE APOCALYPSE COMES, IT WILL BE SWIFT AND BRUTAL.

Within 100 days of the dead rising to feast on our flesh, only 273 people will remain. Or so suggests a grim estimate from students at the University of Leicester, published recently in the school's *Journal of Physics Special Topics*. This is not satire, it's real scientific work and it has a purpose.

While there's plenty of research on "real-world" zombies, animals whose minds have been taken over by parasites, "braaaaaains!"-type Zombies too have been used to help us understand how infectious diseases spread, teach us about maths or neuroscience, and help us model our response to real health crises.

by
KATE
BAGGALEY

ZOMBIE MATHEMATICS

When using maths to predict how an disease outbreak will develop, zombie survivalists must ponder questions like: how many people can a zombie attack in a day? How likely is it that those victims will be infected? How quickly can the zombies be killed? How will our population's rate of zombification change as people become more skilled at killing or evading the undead? What happens if we find a cure?

Epidemiologists ask pretty similar questions when modelling real-world diseases. "All these things that you can play around with that are just as applicable to an influenza outbreak or a mumps outbreak — like we're seeing in Arkansas right now — as they are to a zombie outbreak," says Tara C. Smith, an epidemiologist at Kent

State University in Ohio (and member of the Zombie Research Society).

So zombies can illustrate how a hypothetical illness might spread under different conditions. The made-up nature of zombification as a disease is actually an advantage: "It's difficult sometimes to model diseases that we know," Smith says. "We have all these parameters we have to fill in, and we think we know a lot about each of them, and sometimes we're wrong."

But with zombies, scientists are free to set up the model however they want. "You can have them spread only by bite, by mosquitoes, by air, you can have them have an incubation period of 30 seconds or five days," Smith says. "You can make up everything, look at how that spreads, and look at how different prevention methods

500+

Number of
zombie-themed
films released,
since 1932

can play a role in mitigating the spread."

A few scholars have done just that. In 2009, University of Ottawa mathematician Robert J. Smith? (yep, the question mark is part of his name) and his students showed that humans would have to strike back quickly and fiercely against the walking dead to avoid "the collapse of society as zombies overtake us all." The class project grew into a chapter in a book about modelling infectious diseases.

Smith? went on to edit a book called *Mathematical Modelling of Zombies*. One chapter suggests that it's better to buy time by running from a zombie horde than trying to slow it down. "Fleeing for your life should be the first action of any human wishing to survive," the paper's authors note.

**"Fleeing for
your life should
be the first
action of any
human wishing
to survive,"**

Another tip for survivors in the US: head for the Rocky Mountains. A team from Cornell University came up with a simulation for a zombie outbreak in the continental United States and worked out the best places to hide. The epidemic would quickly plough through cities, and most of us would become zombies in the first week. But four months later, remote parts of Montana and Nevada would still remain zombie-free.

"Zombies form a wonderful model system to illustrate modern epidemiological tools," wrote the researchers, whose zombie model is a cousin of the SIR (susceptible, infected, and resistant) models used to understand many illnesses.

Their results were used to create an interactive map called *Zombietown, USA*, which lets users start a zombie epidemic anywhere in America and watch it sweep the nation.

ZOMBIES: A TEACHABLE MOMENT

Epidemiologists and university students aren't the only targets of zombie experts. Smith (the one without the question mark) uses the undead to teach people of all ages about real sicknesses. "Most of the modern zombie tales, at least since [2002 film] *28 Days Later*, really have focused on the zombie as a contagion, as an infectious disease," Smith says. "So it's a perfect way to talk about the spread of infection, how you control it, why you should vaccinate, and how you can prevent other real infections like influenza or measles."

Zombies have also inspired brain research. Neuroscientists have considered how the zombie brain might deteriorate to cause symptoms like a shambling gait or ravenous hunger, and how some neurological diseases can resemble Hollywood-style zombification.

The various zombie stories that have come to dominate pop culture, from books to films to comics to seemingly endless TV adaptations of those comics, often share one core idea: civilisation is destroyed not just by zombies, but by a failure to respond properly to what is, at its core, another global epidemic on the scale of, say, the Black Death or the 1918 Influenza.

In 2015, Smith wrote about the history of zombie outbreaks in the *British Medical Journal's* annual Christmas issue, which

chronicles playful ideas tackled with scientific rigor. The cases she described, like those in *28 Days Later* and *The Walking Dead*, are of course fictional, but her call for better funding and cooperation among the international community applies to real-world epidemics too.

"In 2014 we had this huge Ebola outbreak in West Africa. We've known about Ebola since 1976, but we were still completely unprepared," she says.

"Even these pathogens that we've known about for many years, they can still surprise us. And we still don't have any good way to respond globally very quickly, very nimbly, and to stop these pandemics before they happen," Smith says. "We're always one step behind each pathogen."

0

Number of humans
turned in zombies
after contracting
a zombie virus from
a zombie bite,
since 1932

YOUR BRAIN ON DRUGS

For millennia, psychonauts have ingested both natural and man-made substances to see the world in new ways. Now, brain scans and other studies reveal how these buzz-builders work, helping scientists harness their power for good and expose the roots of addiction.

► PREFRONTAL CORTEX

COCAINE

Normally dopamine carries signals between neurons, binding to cell receptors until a transporter removes it. But cocaine keeps the neurotransmitter latched in place. Dopamine then floods the brain, causing an addictive euphoria. Continued use alters this decision-making centre, making it even harder to resist using the stimulant.

► AMYGDALA + NUCLEUS ACCUMBENS

MARIJUANA (THC)

THC binds to cannabinoid receptors on nerve cells, altering communications all over the brain. It can cause contentment in the nucleus accumbens, a reward centre, and paranoia via the amygdala, which regulates fear and emotion. THC curbs pain and nausea by hindering signals from sensory nerves.

► REWARD PATHWAY

SUGAR

Sometimes we alter our brain chemistry with sweet stuff. Eating sugar activates a reward pathway that includes the striatum, which tells you to eat that tasty treat again. The cortex then decides whether to act on the urge. Certain types and high amounts of sugar can disrupt this pathway, triggering addiction in some people.

"I gazed at my hand, and it seemed to fill my visual field, getting larger and larger while at the same time moving away from me. Finally, it seemed to me, I could see a hand stretched across the universe...."

OLIVER SACKS, RENOWNED NEUROLOGIST AND POT SMOKER

by
CLAIRE
MALDARELLI





"Reality is inconceivable without an experiencing subject...an ego in whose deepest self the emanations of the exterior world, registered by the antennae of the sense organs, become conscious."

—ALBERT HOFMANN, CREATOR OF LSD

► SENSORY CORTEX

LSD

Usually the areas controlling introspection and sensing the outside world light up at the same time only if your eyes are open. But people on acid show simultaneous activity even with their closed eyes. This may be why users report feeling connected with their surroundings. LSD may ease anxiety by changing how we perceive and react to threats.

► VISUAL CORTEX

MUSHROOMS (PSILOCYBIN)

Digestion turns shrooms' active ingredient into psilocin, a psychedelic that causes hallucinations. It's chemically similar to the neurotransmitter serotonin, whose 5HT_{2A} receptors are found throughout the brain, especially in the visual cortex. When psilocin commandeers those receptors, it puts the "magic" into those "magic mushrooms."

► BRAIN STEM

OPIATES

Drugs like morphine and codeine block pain messages sent from the body to the brain. They work by dulling neural activity and hijacking opioid receptors to dump dopamine into the brain. The resulting pleasant feelings overwhelm any pain signals, creating an intense sense of well-being. But opiates are also highly addictive.

"I take very small doses of it regularly against depression and against indigestion, and with the most brilliant of success."

SIGMUND FREUD,
FAMED PSYCHOLOGIST AND
COCAINE ADDICT

Next

Future Imperfect

CES 2017: A BOTNET PARADISE?

by
KELSEY
ATHERTON

AT THE CONSUMER ELECTRONICS SHOW

in Las Vegas, companies showcased all their latest schemes for putting the internet into things. All things. And while it might be a way of getting people excited enough to pay \$300 for a toaster again, this trend might also be good for hackers. Because hackers frequently take command of the weak security on internet-enabled home devices to build botnets: networks of compromised computers that together can conduct massive online attacks.

This isn't just speculation. A massive attack toward the end of 2016 was powered not by compromised PCs, but by hacked cameras and DVRs. Because as great as PCs are for this kind of chicanery, PC users have this annoying habit of turning their PCs off. IoT devices, on the other hand, are designed to stay on and stay connected all the time! Even when you think you've turned them off, standby mode can keep that network link alive for overnight updates and such.

Of course not all internet-connected

devices can be compromised in this fashion, but many companies are thinking first about getting a product to market, and last (or not at all) about the security of that device. Security in the Internet of Things is, for now, an external cost, one borne by victims of attacks without any direct repercussions for those who made the compromised, internet-connected devices in the first place.

Here are five new internet-connected gizmos that could be commandeered into a hacker's botnet.

1 WI-FI GARBAGE BIN

A bin is a pretty simple device. It's just a durable box in which to put a bag for garbage. Even advanced bins simply provide mechanical improvements: a lock for the lid, a pedal on the floor to open the top with a simple foot-tap, a sensor to open the lid with nary a touch (if you want to get real fancy about it). What else is there?

Okay, maybe opening a lid is hard, and maybe a foot-pedal isn't for everyone. Simplehuman's voice-activated "trashcan" responds to commands like "open" and "close," which is fine - if perhaps a debasement of decades of research into voice-recognition and language-processing.

But it's the version of the bin coming out in May of 2017 that could spell trouble. The new bin will add Wi-Fi, additional languages, and the ability to track stock of garbage bags.

Paired with a phone app, the bin will also order itself bags via Amazon Dash. More languages is nice, but there's no need for a bin to always be connected to the internet to learn new vocabulary or order more bags.

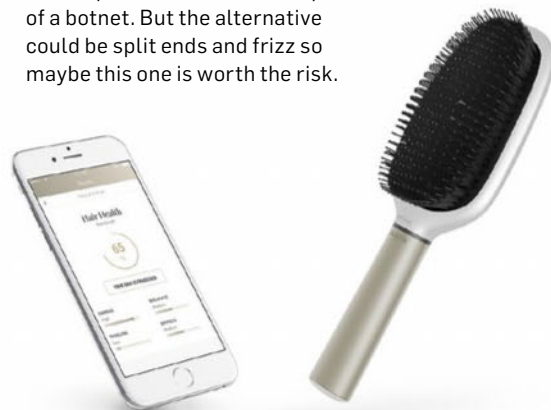
Constant connectivity is a great way to end up in a botnet, however, so the next time

Netflix is down from a distributed denial of service (DDoS) attack, it might just be the work of an army of compromised bins.



2 WI-FI HAIRBRUSH

The Kérastase Hair Coach bills itself as the world's first Wi-Fi enabled hairbrush, an important and very necessary step forward for hair care. Built by L'Oréal and Withings, the brush uses load sensors, an accelerometer, and a gyroscope to provide measurements and analysis of a person's hair as they brush it, because not all of us have a Jane-Austen-style older sister to brush our hair for us by candlelight or whatever. Those measurements are sent to a smartphone app via Bluetooth or Wi-Fi, so the hairbrush can combine measurements with weather data to recommend additional products for the user to put in their hair. And since it's Wi-Fi enabled, there's a non-zero chance it could be compromised and used as part of a botnet. But the alternative could be split ends and frizz so maybe this one is worth the risk.





3 SMART LAWN MOWER

Note that you don't need a smart lawn to use this mower, it's the mower that's smart (the smart lawn is a post-nanotech thing, see *Popular Science* February 2027). After a long day IP-troubleshooting the garbage bin, the hairbrush, and the mirror, it's probably time for the young technophile to spend some time outside. "What if," at least a large enough group of people necessary to get this thing built must have thought, "I wanted to ride a lawnmower that was also connected to the internet?"

At CES this year, Craftsman displayed a ride-on mower that keeps track of its maintenance needs and sends that information to a smartphone or tablet app. This is a great way to track if the oil in the ride-on mower is too low. You could also do the job with dipsticks and rags, which can't be recruited to help take down your favourite websites (yet).

4 SMART MIRROR

Mirrors, like fancy bins and hairbrushes, are tools from antiquity that were the exclusive domain of the mega-rich until the industrial revolution made mass production possible. That was back in the 19th century, so the mirror is overdue for a v2.0. You may think that Wi-Fi is not capable of improving a surface's ability to reflect your image back at you, but that's because you're not thinking in apps.

Griffin Technology's Connected Mirror, uh, connects to Wi-Fi to display the time and weather, as well as phone notifications. For people who are all-in on having a home full of Wi-Fi devices, the Griffin mirror can also display updates from Griffin coffeemakers

and Griffin Bluetooth toasters. Congratulations: you no longer have stuff, you now have an ecology.

An always-on IP-enabled mirror could indeed be compromised by a botnet, but we also think there is some complicated irony in the idea that, depending on router settings, this mirror could cause an address conflict with some other Wi-Fi device in the home and cause your phone to drop off then network. Indulge your narcissism via an actual mirror, or via Instagram? It's a next-gen dilemma!



5 SMART PILLOW

Are you still using your phone or smartwatch or one of the other half-dozen types of gadget you can use to track your sleep? That's no way to live! Thanks to the Zeeq Smart Pillow, spotted at CES, it's possible to rest your head on a little piece of the internet every night (because every device connected to the internet via IP is, by definition, part of the internet, see).

"What if your pillow could be an active participant in your sleep, rather than just a dumb rectangle," intones Warrick Bell, the co-inventor of the Zeeq pillow, confident in the geometric fact that even if your pillow is a square it is still a type of rectangle. What if indeed! The pillow features eight speakers, a three-axis motion sensor, and a tiny microphone—so that it can play soothing music, record your snoring, detect your movements while you sleep, and still

be soft and comfy somehow. The pillow, which can also wake you up with a gentle vibration, successfully raised \$400,000 on Kickstarter last summer.

It also records sleep statistics, which you'll of course need to view via smartphone apps or online. The most shocking thing

about this smart pillow? It's not the only smart pillow heading to market!

So are these things useful? Maybe. But though you might convince your partner once and for all that they snore louder than you do, but you could also end up snoozing on a footsoldier in a huge botnet army.



Next

Wish List

WHY REAL DOCTORS WANT STAR TREK'S TRICORDER

The hospital of the future may be a tiny, high-tech medical kit

by
CLAIRE
MALDARELLI

IN SO MANY WAYS, THE GADGETS SEEN

in Star Trek remind us that the show is *science fiction*—a fantasy world inspired by the one we live in. Sure, there's alien silliness and mysterious energy fields, but at times, the show can act as a glimpse into the future.

The medical tricorder — an all-in-one portable device that can accurately diagnose anything with almost literally a wave of a techno-wand — sits somewhere in the middle of that spectrum.

Medical tech has gotten smaller and more accurate, but we've yet to design a single, self-contained device that can diagnose everything, be it bacterial infection, an incipient blood clot, or early-onset dementia. That could change soon.

Back in 2012, the microchip company Qualcomm started the Tricorder XPRIZE Competition, which challenged inventors and engineers to create a device weighing less than 2.5kg that could accurately diagnose a fixed set of 13 health conditions (as well as continuously monitor five vital signs). Of the devices submitted, only two made it through to the final round. Now, those final two will be going through more rigorous consumer testing. The winner will receive a final prize of US\$6 million (\$8.15m).

While the medical tricorder seen in Star Trek is a single, handheld device, the one in our immediate future might be more of a high-tech version of a doctor's bag (remember those?). The two finalists,



Dynamical Biomarkers Group and Final Frontier Medical Devices, both designed multiple tiny devices that come packed into a single, portable carrier.

Dynamical Biomarkers' prototype, designed under the guidance of Harvard Medical School's Chung-Kang Peng, has a miniature EKG heart monitor, a small wireless blood pressure cuff, and a small thermometer to monitor key vital signs. An accompanying app takes users through a series of questionnaires on symptoms and other medical information, then guides them through using the devices. Tiny samples of blood are taken to test for things like anaemia and diabetes, and a miniature otoscope lets users take pictures of the inside of their ears—which are then sent (via internet) to an algorithm that can detect infection.

The technology is currently about 85 per cent accurate when compared to standard diagnosis from an experienced GP.

A similar adapter takes a picture of moles and skin lesions to diagnose melanoma with 90 per cent accuracy.

Final Frontier's prototype looks and functions pretty similarly, with slightly different mechanisms and devices: A fist-sized smart stethoscope helps a computer system diagnose pneumonia, and a device where the user blows into a tube uses differences in air pressure to diagnose chronic obstructive pulmonary disease.

For the final round of testing, the teams will attempt to use their devices to diagnose patients who have already been diagnosed by a physician in order to test their accuracy.

While the tricorders were invented to fit within the competition's guidelines, their designs and potential applications reflect today's technological advances as well as the challenges faced by healthcare providers. Unlike the ones used in Star Trek, these devices are made to be used mainly by consumers, as a sort of first step before seeing a doctor, or as a way to monitor or prevent chronic health conditions.

Harvard's Peng says he envisions his device also being used in remote areas that don't have much access to medical facilities or doctors. And Harris, who is an emergency room physician himself, hopes his device can be used by people who don't have a regular physician and would normally turn to an emergency room for minor

illnesses. "So many people that show up in the ER don't have any other place to turn," says Harris.

Both teams say they want to add additional pieces, such as a way to perform a complete neurological exam to diagnose subtle neurological diseases; a way to diagnose and monitor concussions; or device that can perform an EEG. These will come when the technology and knowledge is ready.

Before either of these two products hit the market, each device within the package will need a rubber stamp of approval from regulators. But both Harris and Peng envision this type of device—in whatever form it might take—as a centerpiece in the future of healthcare. Harris thinks versions of these devices could serve as medical kiosks of sorts at your local pharmacy. He also envisions different versions of the device being made, one for consumers and one for physicians, with different gadgets in each to reflect their needs.

As for creating a truly singular device like the tricorder in Star Trek, Harris remains optimistic. "Even in Star Trek, the tricorder wasn't invented until the 24th century," he says. "The winner of this device is really just scratching the surface and starting the forward motion."



Dynamical Biomarkers

A high-tech 'doctor's bag' of diagnostic tools let patients do initial testing. Data is crunched thanks to a smartphone app.

Final Frontier

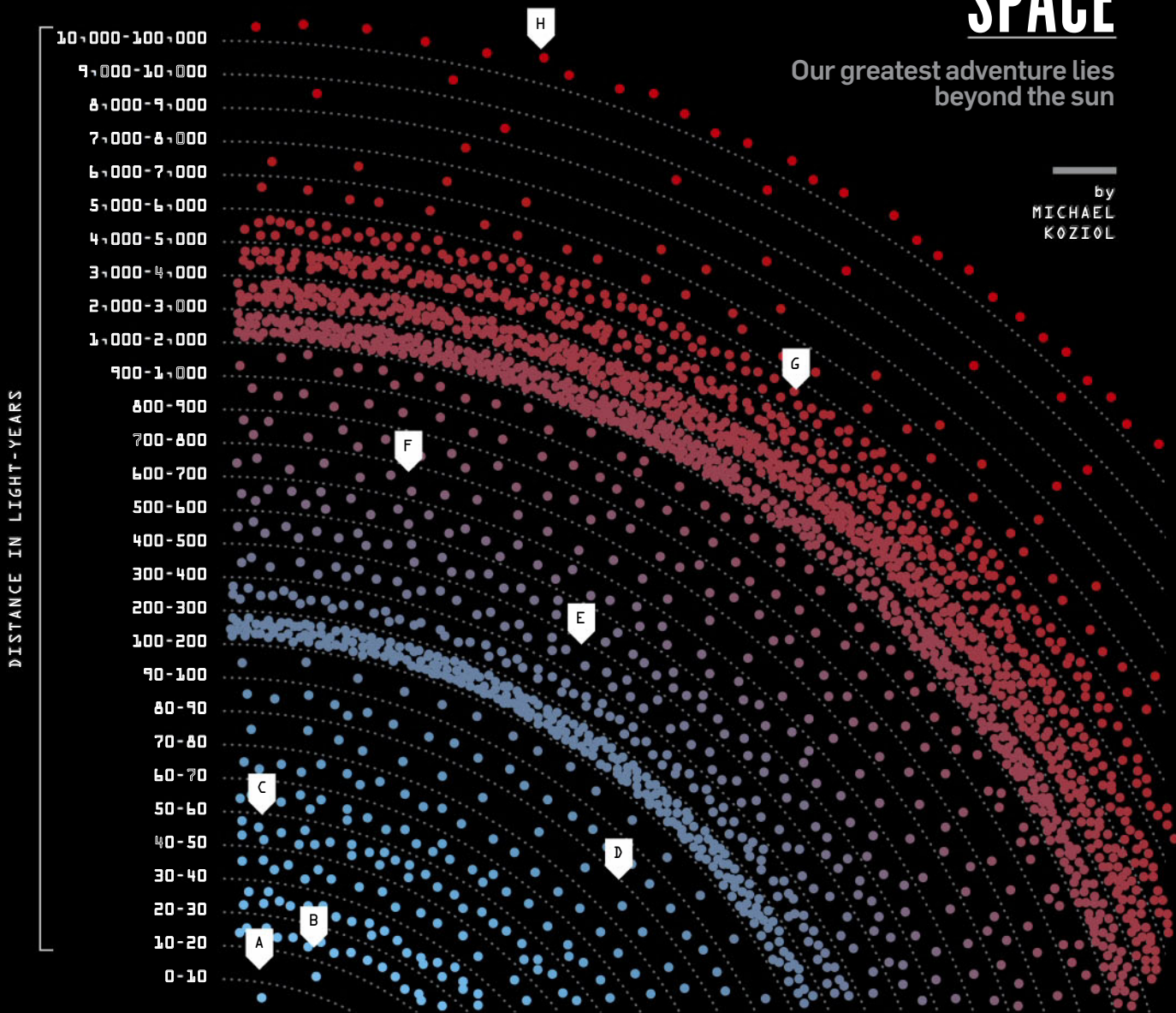
The principle is the same, the mix of tests slightly different. Key to both systems is ease of use and a compact design.



FOUND IN SPACE

Our greatest adventure lies beyond the sun

by
MICHAEL
KOZIOL



THE GALAXY BRIMS WITH BILLIONS OF planets, but they are located at what could only be called “inconveniently inhuman” distances. Unfortunately for would-be star trekkers, even the closest would take lifetimes to reach with current technology. Until we get warp drive, we’ll have to do our exploring with telescopes. But good news: Those visual expeditions are about to get better. The Transiting Exoplanet Survey Satellite and the James Webb Space Telescope, launching in 2017 and 2018, will analyze what these distant worlds are made of, and whether alien life might be there. Set your itinerary with the chart above.

A/ EARTH

You are here! And *Voyager 1*, the man-made object farthest from Earth, is just 0.004 light-years away—after a 37-year journey.

B/ PROXIMA B

Earth’s nearest exoplanet is 4.2 light-years away, and it might be habitable. Tiny, laser-powered “spacechips” could fly there and prove it—in a few decades.

C/ 55 CANCRI E

This planet might be made of diamond. Or maybe it’s filled with magma. Or it’s oozing super-hot water. One thing’s for sure: It’s a weird world.

D/ WAR OF THE WORLDS SIGNAL

Radio waves from the 1938 broadcast of H.G. Wells’ novel have traveled 78 light-years by now. But are probably too weak to pick up.

E/ ARRAKIS

Desert planet from the novel *Dune*

F/ KEPLER 22B

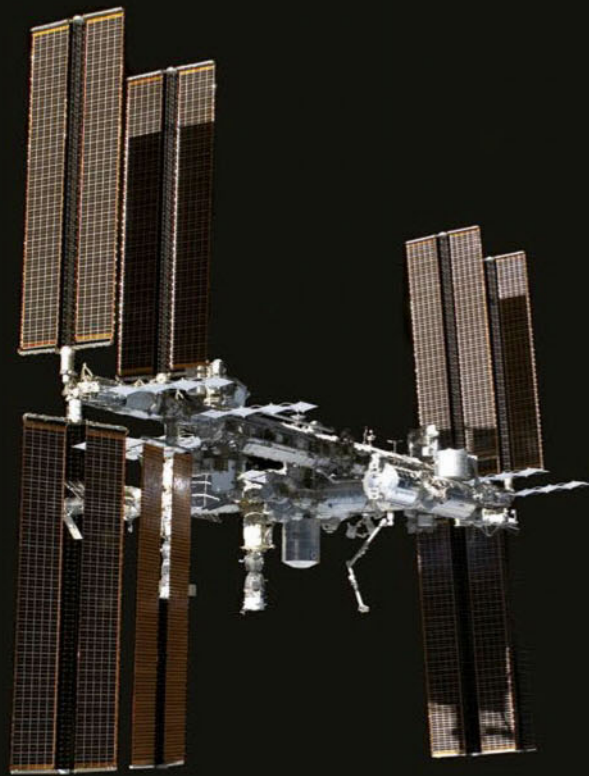
The entire surface of this world may be covered in a vast ocean. And where there’s water, there could be fish (probably not, but life, at any rate).

G/ KEPLER 47

Planets in this system orbit two stars, just like Tatooine from *Star Wars*, minus the sand dragons and gambling.

H/ USS VOYAGER

Star Trek: Voyager begins 70,000 light-years from Earth—a 75-year journey at maximum warp. With today’s tech it would take about 189 million years.



THE SKY IS NO LONGER THE LIMIT.

The screens of the Future are available today!

Screen Innovations has worked with NASA to develop a one-of-a-kind, ambient-light-rejecting, zero-gravity screen to be installed in the International Space Station...

Until now, astronauts on the International Space Station communicated with Mission Control and their families back home on tablet-sized 13-inch displays. Now they will have a large roll-out screen from Screen Innovations, together with a laser projector that should last more than 30,000 hours of use – that's a movie a day for more than 40 years.

The criteria for a screen in space were unique, from the obvious need for extreme lightness and easy storage to trickier requirements such as screen rigidity in zero gravity and the ability to reject the bits of food and other detritus that have a habit of floating around zero-gravity environments.

Although the theatre in your home resides in a more-worldly environment with picture quality taking a front row seat it's nice to know that Screen Innovations also delivers the best down-to-earth solution around.



Network Audio Visual Pty Ltd
02 9949 9349 sales@networkav.com.au www.networkav.com



screeninnovations.com/SPACE

THE WORST PLACES LIFE LOVES TO LIVE

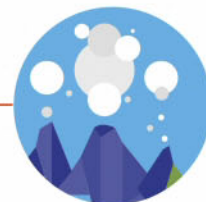
MOST OF US EARTH-DWELLERS PREFER THE EASY LIFE. WE'RE not built to live beyond a certain Goldilocks set of environmental conditions. However, a hardy few of our fellow passengers, namely microbes, thrive in places the rest of us would find hostile. By studying such extremophiles, scientists hope to better understand the limitations of life. That in turn can hold clues to how humans can survive, and thrive, on Mars and beyond.

by
CLAIRE
MALDARELLI



DESERT

Chroococcidiopsis is a cyanobacteria, a microbe that obtains energy from sunlight. It requires extremely little water, and thus can survive even in the driest nonpolar location on Earth: the Atacama Desert, which NASA uses as a model for Mars.



OCEAN

Methanopyrus kandleri strain 116 lives in hydrothermal vents, cracks in the ocean floor that spew magma-heated hot water. It can survive temperatures up to 122°C, the hottest living conditions ever documented for a microbe.



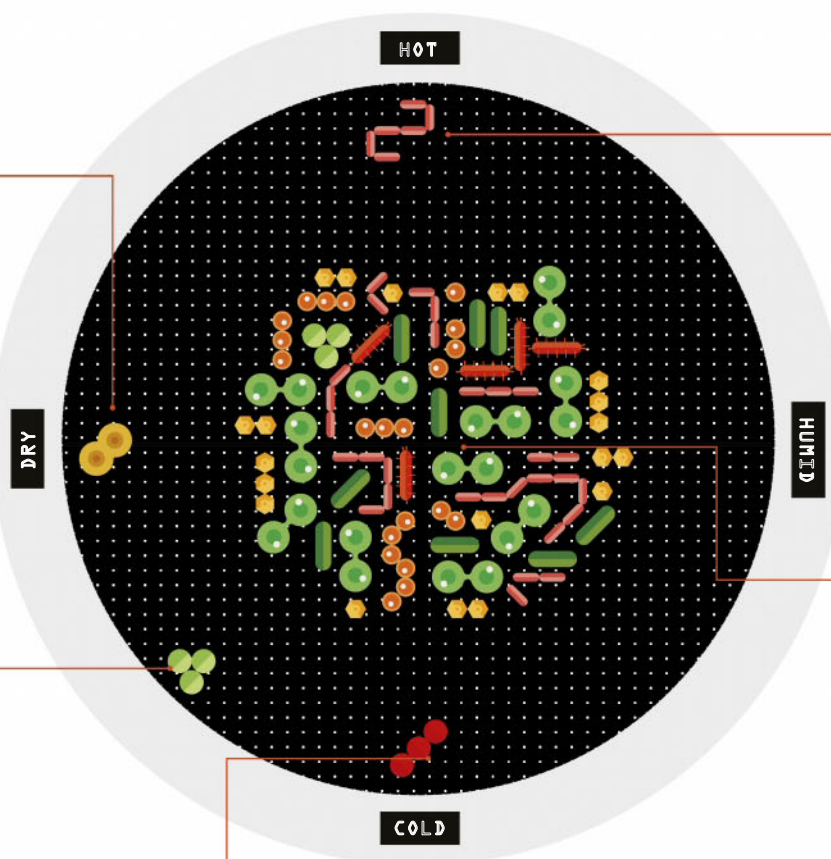
RADIATION

First discovered in an irradiated can of meat, *Deinococcus radiodurans* contains multiple copies of its genome, so if radiation damages one, there's still a blueprint for repair. The bacterium can also survive extreme cold and dehydration.



SPACE

Scientists are genetically modifying nonextremophile bacterium *Anabaena* to excrete sugar for other microbes to eat—in space. As part of a self-feeding ecosystem, it could nourish future humans. NASA will test it in space in 2017.



TUNDRA

Methanosarcina soligelidi lives in the extremely cold and dry Siberian permafrost. Scientists are studying its structure, and how to find it in the wild, in order to search out similar life-forms on Mars—where temperatures average 60 degrees below zero—and other planets.

KEY



Methanopyrus kandleri



Chroococcidiopsis



Deinococcus radiodurans



Methanosarcina soligelidi



Staphylococcus aureus



Escherichia coli



Lactobacillus acidophilus



Micrococcus luteus



Anabaena



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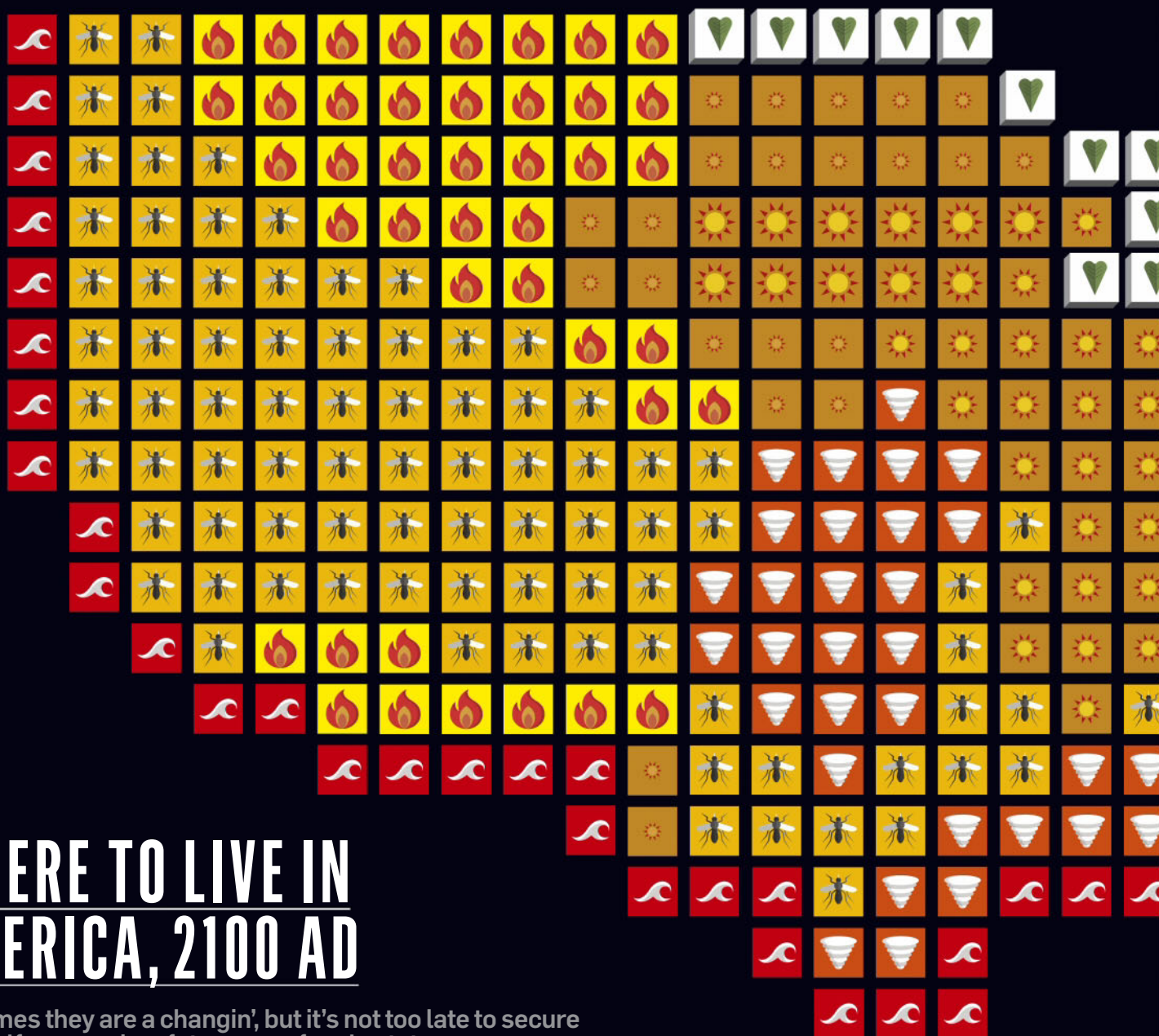
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Next

Location, location, location



WHERE TO LIVE IN AMERICA, 2100 AD

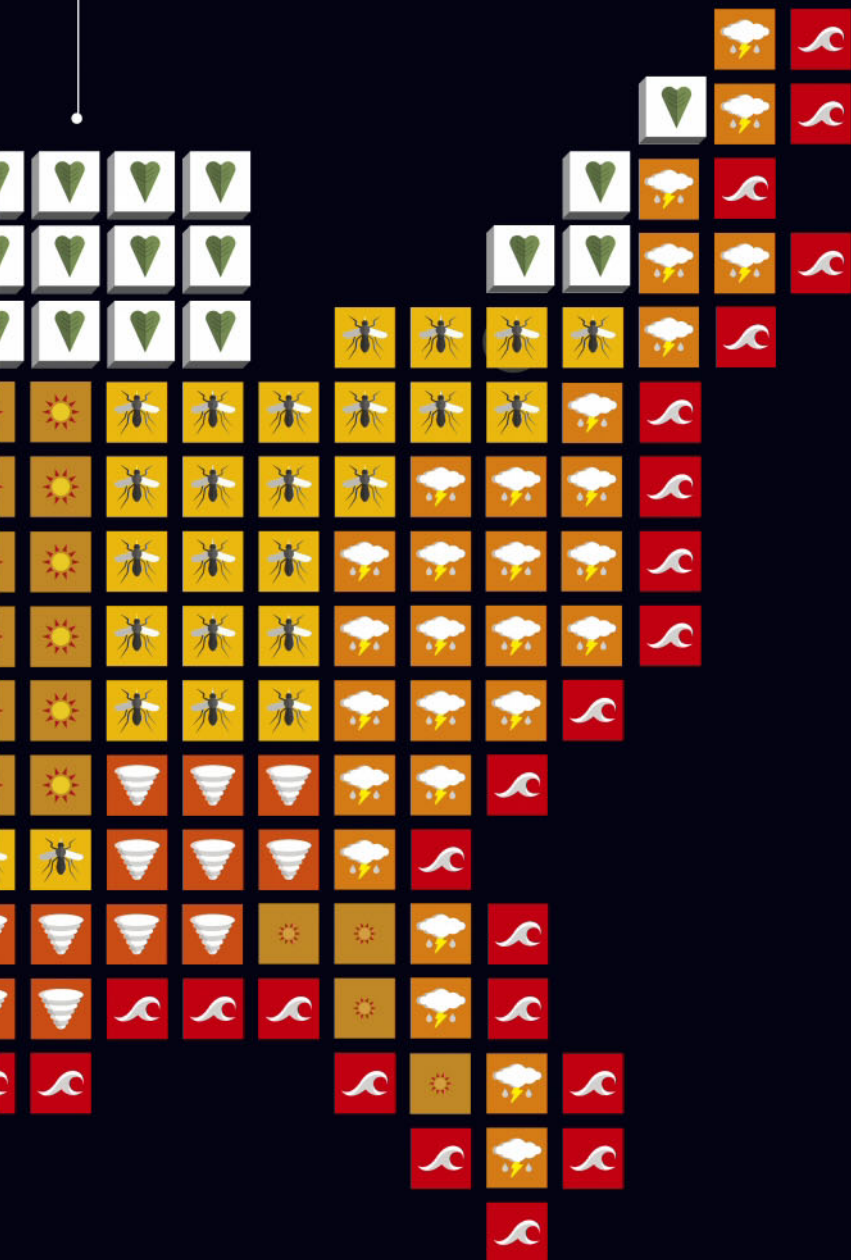
The times they are a changin', but it's not too late to secure yourself some prime future-proof real estate.

SEASON AFTER SEASON EXTREME WEATHER BOMBARDS THE continental United States. Over the next 83 years, its cascading effects will force US residents inward, upward, and away from newly uninhabitable areas. But don't worry: We've mapped out how these factors will alter the country's landscape in 2100. Now go nail a quality spot while the pickings are still slightly more plentiful. —Additional reporting by Sarah Fecht and Grennan Milliken

by
PETER
HESS

Your New Home:

Let's all move to Sault Ste. Marie! Nestled in Michigan's upper peninsula, this small city will be only slightly warmer than it is now (don't sweat it; you can still ice fish) and will be lucky enough to escape most of the changes wreaking havoc on the rest of the country.



DROUGHT

Almost the entire country is at a greater risk of drought, with the most significant dry spells in the Great Plains. We will all need to seriously ramp up our water-conservation efforts by using more-efficient techniques. This is especially true for croplands, which use around 70 per cent of the world's fresh water.



MOSQUITOES

Over the next century, mosquitoes that carry pathogens like Dengue and Zika are predicted to expand their range across the Southern and coastal states, sparing only the north central part of the US. Insecticides will help, but disease-carrying mosquitoes of this magnitude will require some backup plans.



WILDFIRES

As the West continues to heat up and dry out, wildfires will spread over larger areas. Earth scientists predict that in some states, these fires will burn 650 per cent more land for every 1 degree Celsius rise in temperature. This is bad news, as Western states could get hotter by up to 5 degrees as we hit the middle of the century.



TORNADOES

As air warms, by 2080, the resulting rise in water-vapour concentration will make tornadoes more severe and frequent in the Southeast. Plus, the number of tornadoes each year will be extremely unpredictable. So for homes without a basement, the best bet for shelter is an interior windowless room, cupboard, or hallway.



HURRICANES

Climatologists don't expect the total number of hurricanes America experiences to increase during this century. But they do predict that the number of strong (Category 4 or 5) ones will double by 2100. To top that off, these future storms could peak farther north, so Northeastern cities like New York City and Boston will get hit even harder than they do today.



SEA-LEVEL RISE

Geologists predict sea levels could rise up to 2 metres by 2100. This will affect coastal communities most, and flood zones and areas at risk of storm surge will move farther inland, making cities like New Orleans, Miami, and New York particularly vulnerable. So if you live near the coast, take a drive inland and tour your inevitable future home.

NEW TALENT IS GETTING LOST IN THE FOG

GAMING, UNLIKE SO MANY OTHER INDUSTRIES

in these troubled times of transition, continues to grow, with more money being funnelled into development each year, and more money being spent by consumers to feed their ever-growing appetite for everything gaming. There are many possible factors that have led to explosive growth in this newest of entertainment sectors, from the Moore's Law driven advance of technology making gaming more spectacular and affordable, the commoditisation of high end processors (also a function of Moore's Law) making even high end system cheap, the larger presence it has in pop-culture, the seeming stagnation of the film industry and the democratisation of game development. All of these factors have played a part in the rapid growth of the games industry, but this last aspect, the democratisation of development and the rise of independent developers, is proving to be something of a double-edged sword.

The PC has always been the platform at the vanguard of gaming. For programmers, it's truly open with a wide choice of development environments from hold-your-hand software like Gamemaker: Studio all the way to hardcore old-school languages like C+. Really, to make a PC game all you need is a PC.

At the end of 2016, Valve software's Steam (a digital distribution platform that has a effective monopoly, certainly as an outlet for developers not backed by a major publisher), released a rather alarming metric, and here it is: nearly 40% of all games currently available for purchase on Steam were released in 2016.

That's especially remarkable when you consider Steam itself was launched way back in 2003.

Over 4200 new titles went on sale, and while this is a fine indicator of the rapid growth of gaming as a hobby

as well as the perennial staying power of the PC as a platform, it reveals a problem that has already reared its head in the various "app stores" of the mobile gaming market: a lack of proper curation to weed out unfinished, broken, basically-a-scam (even oops-I-didn't-mean-to-hit-publish) or otherwise terrible games that have no place in the market and crowd out far more deserving titles.

Of course, there is no real impetus for a digital distribution network to limit the number of files being sold. The server space to store and bandwidth to distribute these little games is handily subsidised by the major titles. To Valve, every sale delivers a profit, and having more titles available for purchase means more potential for profit.

Unfortunately this glut works against the interests of gamers and the industry as a whole, as the sheer mass of titles make it harder for quality games (or at least those not artificially boosted by marketing campaigns) to find a foothold and thus for quality indie developers to recoup the funds needed to make another game.

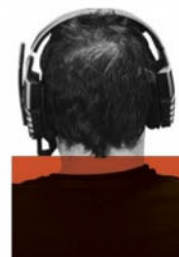
You, the PC programming savant, may have created the next Minecraft in your bedroom, but if you just shove it up on Steam it may never see the light of day. Oh it might appear in a "latest releases" list, but then disappear hours later, never to be seen again.

There is also the issue of "Early Access" games – unfinished titles that can be purchased under the assumption that they will someday be finished. The idea is noble enough: players keep the developer solvent with a cash injection plus they get to influence how the game is built. Of course this assumes the developer keeps building it and doesn't just go "hmn, I now have a half-finished game and \$100,000. I think I'm done here!" and disappear (Early Access purchases are promoted by Steam as "buyer beware" and paying money does not guarantee you will get a finished game.)

These aspects of digital distribution are new when it comes to retail, and consumer rights. The unique nature of a "virtual" store means companies can carry vast inventories. If a virtual shelf of stuff isn't selling, they don't clear it out like a real shop would. They just expand the server and add a new shelf.

This isn't true of all digital distribution. Other services, like Xbox Live, PSN, Good Old Games and Humble limit their inventories to those that are either carefully curated by the owners of the service, as is the case of GoG and Humble, or are closed systems with a number of safeguards and checks put in place, like Xbox Live and PSN.

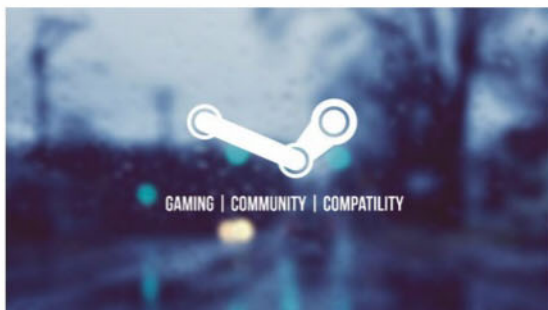
These closed systems guarantee a certain level of quality (and only sell complete games) but they make it difficult, if not nearly impossible for truly independent games to appear on their platforms. For gaming to grow as an industry, and not simply expand, there needs to be a balance between these two styles of digital distribution. ^{ps}



by
**DANIEL
WILKS**



DANIEL WILKS is the editor of PC PowerPlay, Australia's best-selling gaming magazine. He misses the days of dim, dark bricks-and-mortar videogame shops staffed by weird dudes and full of nothing but flight sims. Just not very much, that's all.



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THE END OF MATERIALISM?

SINCE THE END OF WORLD WAR 2, THE CONSUMER economy has made a lot of people extremely rich. And despite the many critics of materialism, the way you can buy stuff in shops has inarguably improved the quality of life for billions of people.

But all good things must end. Ask the doomsayers, they'll point out consumerism is fated to collapse when we inevitably run out of resources. Critics of globalism are worried about the way "stuff" now gets made for less in other countries, leaving some groups unemployed even as others are exploited for their labour. And over all this hangs the spectre of automation, those dastardly machines who will rob the working class of their right to stand at a conveyor belt for day after day, mindlessly screwing caps onto toothpaste for \$5.83 an hour before tax.

Seriously though, big sections of the economy that used to rely on making a thing for \$10 and then selling it for \$50 are starting to fret. It's a double whammy see: better manufacturing tech and the internet's global market mean it now only costs them \$5 to make the thing. But everyone else is making stuff for cheap as well, so they can't sell the \$5 thing for \$50 anymore. They have to sell it for \$20. Eventually, the numbers stop making sense. It's not that selling 10,000 \$20 things for \$150,000 profit is bad, it's that this is a one-shot deal. And adding insult to the injury: the thing that was sold, let's use a camera as an example, is now more technologically mature. It's better than the old \$50 camera and has a longer lifespan. Everyone wanted to upgrade a 4MP camera for an 8MP model, but a 14MP DSLR with multi-point autofocus will take awesome pictures for years. People are starting to hop off the upgrade treadmill.

It gets worse. Online services are changing consumer ideas about the value of their dollar. Your social media is "free". Apps cost a handful of loose change (and an \$8 app gets bad reviews for being "overpriced"). Amazon will sell you books for a fraction of their "old" values. Even

in the real world, big chains like Bunnings price products like fans and mowers at prices that seem... impossible. Under \$150 for a four-stroke mower? Nine dollars for a three-speed fan with swing? What the hell is going on?

To make big money in the future, you want to get out of selling products, and get into selling services. DVD and Blu-ray sales are dropping off as people subscribe to online streaming apps like Netflix and Stan. Apple's iTunes uses a "store" model, but really it's a service too, as is Spotify of course.

The next phase of this popped up at CES in January.

The Relonch camera is an intriguing idea: you give your old camera to the company, they give you a leather-wrapped Relonch for free. Then, you snap some pics. The camera's built-in 4G data connection uploads the photos to Relonch, Relonch's "AI" crops and filters the photos according to a bunch of instagram-like algorithms, and the next morning the photos pop up in your inbox. You download the photos you like for US\$1 a pop.

Sure, pro photographers haven't been impressed with Relonch so far, but

that's the not the intended market. Neither is the smartphone LOL-selfie crowd. But for people who fall somewhere between Snapchat and messing with F-stop on a \$3000 DSLR, Relonch could be a revelation. Especially since they don't have to first pony up hundreds of dollars for a camera.

Expect to see "[insert concept] as a service" more and more this year. It might take a while, but the idea of buying a chunk of tech for a lump-sum will become less and less mainstream.

Ultimately, 3D printing is going to not so much disrupt as completely overturn the whole concept of manufacturing. But absent a nanotech revolution in the next few years, we have time to prepare for this. A decade? More? Point is: the age of inventing a thing and then getting rich after selling a million units of that thing is coming to a close. So get ready.

Don't worry. We'll still be here to help you make sense of the transition.



by
**ANTHONY
FORDHAM**



**ANTHONY
FORDHAM**
is the editor
of Australian
Popular Science.
He wanted to
be an inventor,
until the day
he met a real
inventor and
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Sylvia Earle

At 81, the record-breaking diver isn't done with the depths

BY MARY BETH GRIGGS



WHEN SYLVIA EARLE WAS 3 YEARS OLD, playing on the Jersey shore, a wave knocked her to the ground. "At that moment," she says, "the ocean got my attention."

It's held it ever since. Known as "Her Deepness," Earle would go on to lead the first all-female team to live underwater (for an entire week in 1970); set a record for walking the ocean floor, untethered for two hours, at 381m (1979); and become chief scientist at the National Oceanic and Atmospheric Administration (1990).

At 81, she remains a bluewater advocate, an ambassador to the deep who cares as much for extreme microbes that thrive near boiling ocean vents as she does for migrating whale pods that display social complexity. "What's held my attention, and what should hold everyone's attention, is the splendour of life," Earle says, "all these creatures that are like us in so many ways."

In 1953, Earle strapped on one of the first scuba tanks in the U.S. Over the next few

decades, she became a prolific diver. She has logged a total of 7,000 hours (the equivalent of 291 days) underwater, and is still at it. "As long as I'm breathing," she says, "I'll be diving."

She now heads Mission Blue, a nonprofit she launched in 2009. Its goal: the legal protection of 20 per cent of our oceans by 2020. To that end, Earle teaches about what she calls "Hope Spots," places critical to the health of oceans. She lobbies governments and citizens all over the world to protect these areas, from the algae-covered Sargasso Sea in the North Atlantic to the rocky shores of California's Monterey Bay.

In September, Earle stood alongside President Obama as he announced the quadrupling of Hawaii's Papahānaumokuākea Marine National Monument, expanding it to a 1.5-million-square-kilometre "no-take" zone, off-limits to fishing and some commercial activities. Earle thanked Obama, not for herself, but "on behalf of all people and all life everywhere." Then she gave him a picture of a fish that lives only there, which has no name yet, but will be named for him.

He said, "That's a good-looking fish."

For Earle, pictures are only a start. "Any astronaut will tell you, satellites are vital to seeing Earth," says Earle. "But sending a picture is not good enough; you need to be there." So she is helping develop technology to bring people face to face with the deep. Another venture Earle started, Deep Ocean Exploration and Research Marine, makes crewed subs, camera housings, and grasping tools that scientists use to study ice in Antarctica and to film fragile coral reefs. But Earle wants more people to see these things. "We still don't have the chariot to take us deep into the ocean," she says. "Millions of people fly 7 miles up in the sky watching movies. Why are we not as thrilled about exploring this part of our world as we are about Mars or the moon? We know so little about the deep. What we do know is the deeper we go, the less we know."

DEPTH GAUGE

1953

While still a student, Earle becomes one of the first oceanographers to use scuba equipment

1966

Earns her Ph.D. from Duke University with a dissertation on algae in the Gulf of Mexico, catching the attention of the oceanographic community for its enormous and unprecedented scope

1970

Leads the first all-female team on a habitat mission, Tektite II, living 15 m underwater for more than a week

1979

Using the JIM—a pressurised, armoured diving suit—walks the ocean floor, at a depth of 381 m, untethered for more than two hours

1990

Becomes chief scientist of NOAA

2009

Founds Mission Blue in an effort to protect important areas of the ocean

BIO

► AGE 81

► AFFILIATIONS

Mission Blue, Deep Ocean Exploration

► SPECIALTY

Deepwater diving and advocating for the legal protection of 20 per cent of Earth's oceans



► AGE 62

► AFFILIATION

Professor of
Biological
Oceanography at
Duke University
Marine Laboratory

► SPECIALTY

Biological
oceanography, *Alvin*
pilot

DEPTH
GAUGE

1982

Part of the first expedition to explore hydrothermal vents in the East Pacific Rise, a line running from Antarctica to the Gulf of California where tectonic plates are pulling apart

1990

First (and only) female *Alvin* pilot

1993

Helped explore and characterise Lucky Strike, one of the largest-known and most biologically unique hydrothermal-vent areas

1997

Publishes *The Octopus's Garden*, a memoir.

2005

Helps devise ways to protect vents from deep-sea mining

2006

First female director of the Duke University Marine Laboratory

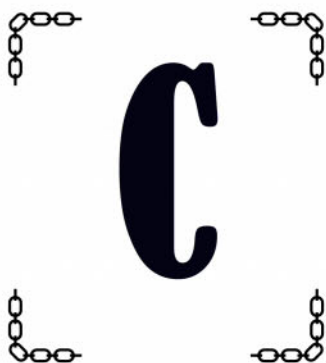
2015

Co-developed a first of its kind robotic sub that can vacuum up huge volumes of plankton to study

CINDY LEE VAN DOVER

Breaking the glass ceiling on the ocean floor

BY SARA CHODOSH



CINDY LEE VAN DOVER HOLDS MEMBERSHIP IN A most exclusive boys' club: Of 42 gearheads, engineers, and former Navy commanders who have piloted the submersible *Alvin*—the stubby, three-crew midget research sub that explored the *Titanic*—she is the only woman. “The hardest thing I’ve ever done in my life,” Van Dover says, “was to become an *Alvin* pilot.”

To earn pilot certification takes months of training, memorising the language of check valves, autoclaves, ballast systems, oxygen monitors, electrical systems, and a Rube-Goldberg system of mechanical levers and knobs. You must master and execute it all 3000m underwater, where there’s no other way up or out. Since Van Dover’s first piloted dive in 1990, she has descended to the ocean

floor 273 times, discovering dozens of exotic invertebrates living off hydrothermal vents.

Even as a kid who spent summers flipping horseshoe crabs and inspecting snail eggs on the beach, all she wanted, she says, was “to see these animals living on the seafloor.” In 1989, she earned a Ph.D. in biological oceanography. That year she won a passenger seat in *Alvin*—and vowed to become a pilot. After nine months studying manuals and schematics, she earned her certification. Most biologists wait years to get a research project written, funded, and green-lit for an *Alvin* mission. But a pilot can dive every other day. “It was quite a strategic move on her part, and one that took a lot of guts,” says Dan Fornari, a marine geologist at Woods Hole Oceanographic Institute and a colleague of 30 years.

Van Dover now spends her days at a desk, organising expeditions in her eponymous lab at the Duke University Marine Laboratory. But she’ll always remember her last dive. More than 1500m underwater in the Gulf of Mexico, the carbon-dioxide scrubber on *Alvin* failed. As the CO₂ levels started to build up, she and the crew had to drop ballast, strap on oxygen masks, fire thrusters, and ascend. She never panicked. “I know that submarine so well,” she says. “I knew we’d get back up.” Despite the constant urge to go to sea, that dive will likely be her last. “It was such a memorable one,” she says. “I might just leave it at that.”

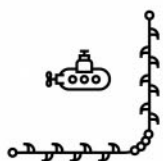




Chris German

Looking for aliens—in the Arctic

BY KEVIN GRAY



YOU MIGHT NOT EXPECT AN oceanographer to be high on NASA's speed dial, but when the space agency needed help mounting a mission to Jupiter's ice-covered moon

Europa, it called one: Chris German. Ever since the geochemist found hydrothermal vents teeming with life in the Atlantic Ocean in 1997, he's been an Indiana Jones in the search for vents, creatures, and the origins of life.

A senior scientist at Woods Hole, German was among the first to use programmable underwater robots to explore the seafloor. The skill to operate them in difficult conditions—4500 metres deep and under three-metre-thick ice—is what NASA likes about him. Last September, they teamed up for a two-month Arctic expedition, a dry run for what NASA might one day try on Europa.

Geochemists theorise that the ocean's hydrothermal vents—which spew heat, gas, rocks, and chemicals that sustain life—may have birthed all life on this planet. Can the same be true in other

watery worlds? That's what NASA hopes to find in Europa's abyssal seafloor: evidence of life—or life's chemicals—embedded in the top of the ice. "Wouldn't it be great," asks German, "if we could fly around the outside of Europa, look down, and detect that stuff? Or land there and scrape up ice samples that could give us an answer?"

For years, no one thought life-sustaining ocean vents existed beyond active volcanoes, until German found a vent field in the Atlantic, far from any active volcano. "He's a genius at finding life and working at abyssal depths," says Adam Soule, chief science officer at the Woods Hole National Deep Submergence Facility.

German's work in the Arctic could help NASA decide where and what to look for when it sends the Europa Clipper to take flyby pictures, thermal images, and magnetic soundings of the frozen moon in 2022. Exploring extreme worlds on Earth, he says, will help us search in nearly any ocean habitat. "That's where I come in," he says. "We're going to look pretty dumb if we get up there and find something we didn't plan for."

DEPTH GAUGE

1986

Goes to sea for the first time, visiting the site of the first "black smokers"—vents that spew iron-sulfide clouds—discovered in the Atlantic Ocean

1997

Discovers the first tectonically controlled hydrothermal vent to exist away from an active volcano zone

1999

Discovers the first sites of active venting in the Antarctic, on the East Scotia Ridge

2004

First to use an autonomous underwater vehicle (AUV) to search for, locate, and photograph seafloor hydrothermal vents robotically

2011

Discovers the first live tube worms in the Atlantic, previously thought to exist only in the Pacific

2014

Leads mission using a fibre-optic tether to send a remotely programmable sub under the Arctic ice

BIO

AGE 53

AFFILIATIONS

Woods Hole Oceanographic Institution;
Most Excellent Order of the British Empire

SPECIALTY

Geochemistry, finding life in extreme habitats



BIO

► **AGE** 84

► **AFFILIATIONS**

University of Rhode Island/Ocean Exploration Trust

► **SPECIALTY**

Oceanography, finding shipwrecks and traces of ancient civilisations

DEPTH GAUGE

1973

Takes part in Project FAMOUS (French-American Mid-Ocean Under-sea Study), his exploration of the Mid-Atlantic Ridge in a submarine helping prove the theory of plate tectonics

1977 AND 1979

Helps discover "black smokers": hydrothermal vents on the seafloor, areas so seemingly inhospitable to life, researchers are shocked to see the diversity there

1985

Discovers the *Titanic* under 3650 metres of water, 73 years after it sank

1989

Discovers the German battleship *Bismarck*, which the British navy sank in 1941

2008

Founds Ocean Exploration Trust, a nonprofit focused on "pure exploration," not academic grants; it buys a research vessel and names it *E/V Nautilus*

Robert Ballard

Finding the *Titanic* at the bottom of the sea was just the start

BY MARY BETH GRIGGS

F

researcher picks a project that lies along the route of *E/V Nautilus*, the 50-crew research ship Ballard commands. Ballard's crew then sends a remote operated vehicle (ROV) to the research site. The ROV feeds video and data to the surface, which the crew beams to the Inner Space Centre at the University of Rhode Island, which Ballard founded in 2009. Workers there post it to YouTube for public and scientific viewing. Among the images Ballard has given the world: mud-spitting volcanoes, barnacled World War II patrol boats, Byzantine amphorae (old clay jugs), and fuzz-covered iron-chewing microbes.

"We run it like an emergency room," Ballard says of *Nautilus* and its shifting missions. "We don't know what our ambulance is going to bring in: a mother having a baby, a heart-attack victim, a gunshot wound—God knows." On one recent expedition, Ballard's crew beamed video of fuzzy microbes at the bottom of the Caribbean Sea to a Harvard biologist, who viewed them via Wi-Fi-connected laptop, 35,000 feet in the air, sitting in economy class, somewhere over Illinois.

Ballard loves stories like that. But he himself is no laptop explorer. He began his career as a Naval officer assigned to Woods Hole Oceanographic Institute in the 1960s. In 1977, he discovered the first "black smokers," hydrothermal ocean vents. Three years after *Titanic*, he found the remains of the German battleship *Bismarck*. This July, he'll look even deeper into human history. He will sail *Nautilus* off the Los Angeles coast, following an older, ancient coastline that the sea swallowed after the last Ice Age. He'll be looking for caves that were once on land. Since caves are natural shelters, and these have been sealed with salt water for millennia, he hopes to find evidence of humans who migrated into North America. For Ballard, it's a sweet spot of ocean exploration. "The shallow explorers quit when you can't scuba dive," he says. "The deep explorers don't start until they're past the continental shelf. So there's this no-explore zone." He adds, "It looks like fun."

FOR 73 YEARS, RMS *TITANIC* LAY LIKE a silt-coated tomb, 3650 metres below the surface of the North Atlantic, where it sank after a violent run-in with an iceberg. In 1985, Bob Ballard, a Naval officer-turned-ocean archaeologist, dragged a deep-sea robot over the site and, using powerful sonar and a video feed, found it. It was the first time anyone had viewed the ship since it went down with hundreds of people on board in 1912.

Those grainy first images of the ghost ship ran on repeat across the planet's TVs. They also gave Ballard an idea. Plenty of smart ocean researchers (archaeologists, biologists, geologists, vulcanologists) can't raise money for a big expedition or spend an entire month at sea. What if Ballard brought the ocean to them? These days, he does it via telepresence.

No, it's not a Cisco setup with a big screen and interactive graphics. It works like this: A



DEPTH GAUGE

2002

Moved from Japan and began working with researchers at Woods Hole Oceanographic Institution

2003

Spent 42 days at sea on her first ocean-going research cruise with Woods Hole

2006

Helped establish the magnetic time scale of the Jurassic Quiet Zone in the Pacific, an era that saw several back-to-back magnetic pole reversals

2011

Conducts her first geological survey on dry land, in Norway

2016

Among the first researchers to gather three-dimensional magnetic profiles of geologic formations on the seafloor

2017

Plans to examine the magnetic properties of geological formations in ancient seafloors that are no longer submerged, in North Carolina and British Columbia

BIO

▶ AGE 37

▶ AFFILIATION

Texas A&M University, heads up an applied physics lab for earth sciences

▶ SPECIALTY

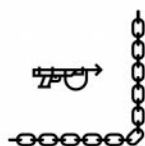
Geology and geophysics, studying magnetic rocks



Masako Tominaga

Uses rock-sniffing subs to predict polar magnetic flips

BY PETER HESS



EARTH'S MAGNETIC POLES have flipped many times over the past 20 million years. Each time that happens, geographic north and south stay put, but magnetic north and south reverse. These flips, known as chrons, can take between 10,000 and 100,000 years. Marine geophysicist Masako Tominaga searches the Pacific seafloor to help predict the next one, which could devastate life on our planet.

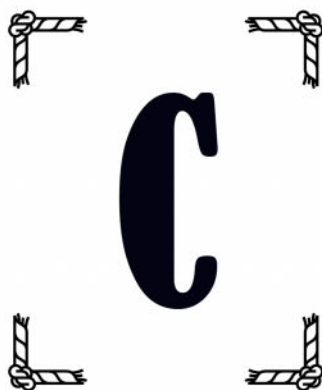
Here's why. Earth's magnetic field protects it from solar magnetic storms. When the field starts to flip, it weakens, letting those storms strike the planet. It's not the full flip that's the problem, it's the process. The beginning of the next one could let solar storms fry our power grid, our satellites, and expose humans and animals to space-radiation-induced DNA mutations. Knowing the speed of previous flips and how Earth generated its field during those eras can help prepare us for the next one. We think. It's a mission Tominaga finds both urgent and personal. "Growing up in a natural-

disaster-plagued country," Tominaga says, "it's inevitable that you think about why we have these phenomena and what's driving them."

A native of Japan, she moved to the US in 2002 and started working with researchers at Woods Hole. She studied the Pacific seafloor with a robotic sub and helped figure out that during the Jurassic era, Earth's field was weak and flipped many times. "It was kind of in fibrillation mode," says Maurice Tivey, a senior geologist at Woods Hole and Tominaga's longtime mentor. "She made a very big contribution." Tominaga now leads her own team at Texas A&M University. She uses a similar robotic sub to sniff out seafloor rocks that contain magnetic stripes. Mineral orientation in these stripes reveals the era and speed of a swap. "They are weak and hard to identify," she says. There's evidence we may be on the road to another flip since the magnetic field started destabilising 2,000 years ago. But, says Tivey, it likely won't happen for "thousands, or even tens of thousands, of years."

COLIN DEVEY


Charting the volcanic eruptions that are pushing our world apart **BY KNVUL SHEIKH**



COLIN DEVEY LAUNCHED HIS VOLCANO-HUNTING career on land, studying a 66-million-year-old lava flow that once covered half of India. But in 1987, he scored an empty bunk on a Tahitian research cruise. Though it's hard to see volcanic rock on the seafloor, he found the landscape geologically simple. "The continents are complicated because they've been around for billions of years, and they're messed up, like a billboard covered in 150 advertisements, layer on layer," Devey says. "The oceans are like a new billboard."

For the past 30 years, Devey has busied himself reading those billboards and hauling news of their movements to the surface, altering what we know about plate tectonics and how continents drift apart.

Thousands of underwater volcanoes make up the Mid-Atlantic Ridge, a roughly 59,000-km-long chain of divergent tectonic plates running north to south. Geologists and geochemists like Devey once thought these volcanoes all erupt with equal force, driving continents apart at the same rate along the ridge's length. Devey, a UK native who works at GEOMAR Helmholtz Centre for Ocean Research in Kiel, Germany, found asymmetrical activity: patches of extreme violence and relative calm. Because of him, we now know that the North American, Eurasian, South American, and African plates spread at different rates in different spots. We know too that these blasts circulate minerals from inside Earth and (along with magma) help push the plates apart. "The seafloor is where most volcanic activity takes place," says Devey. "We want to understand why they are there and what they do."

Devey's next billboard reads will (he hopes) explain the murky geochemistry of a little-studied region in the North Atlantic: the volcanically active Reykjanes Ridge, south of Iceland. In June 2018, he will drop an ROV into its depths to study fresh lava and figure out why the ridge is spreading about 25mm every year. If the past is any indicator, he's sure to find something to pique our curiosity. "This planet is fascinating, and we know almost nothing about it," he says. "The most important thing is to go out there and explore it." 



BIO

► **AGE** 55

► **AFFILIATION**

GEOMAR
Helmholtz
Centre for
Ocean
Research in
Kiel, Germany

► **SPECIALTY**

Geologist, seafloor
volcanoes

DEPTH GAUGE

1994

Achieves his deepest dive: 3500 m, in the Pacific Ocean. During the dive, a squid rockets past his submersible and explodes a cloud of black ink. "I would have jumped out of the submersible if I could, it was so scary."

2004-2006

Co-chairs the Inter-Ridge program, an international cooperative for studying midocean ridges and oceanic spreading

2015


While searching for deep-sea organisms off Brazil, discovers the largest cache of round, black manganese deposits ever found in the Atlantic Ocean, some as big as bowling balls and 10 million years old

2016

Studying new volcanic rock in the South Pacific, found that the magma held recycled Archean sediment that had been stored deep in the earth for over 2.5 billion years before rising to the surface as magma

The Future of Gaming





FROM SUBVERSION OF A SCIENTIFIC TOOL TO FRINGE CURIOSITY TO NICHE HOBBY TO MAINSTREAM MEDIA TO MULTIBILLION DOLLAR INDUSTRY. THAT'S VIDEOGAMING IN A NUTSHELL. NOW, AS REVENUES CONTINUE TO ECLIPSE HOLLYWOOD BOX OFFICE AND OWNING A GAMES CONSOLE IS AS NORMAL (AND NECESSARY) AS OWNING A TV, THE GAMES INDUSTRY IS SET TO HARNESS NEW TECHNOLOGIES AND TAKE US... WHO KNOWS WHERE.

STORY BY ANTHONY FORDHAM

Star Citizen aims to be a space sim of unprecedented scope and detail.

THE GAMING INDUSTRY evolved much faster than legislators could keep up. As politicians scrambled to decide how to deal with a form of entertainment that let children blow virtual limbs into bloody chunks, even the nomenclature got confusing: Until the rise of the PlayStation and Xbox, "gaming" meant pokies and betting on horses.

Indeed, from the mid-1980s until today, videogames went from beeping novelties to a multibillion-dollar industry that acts like part Hollywood, part the music business, part book publishing, and part something all its own, like nothing else..

Many non-gamers still can't get their heads around where games fit. Is a videogame like a digital version of Monopoly, a sort of logic-puzzle thing where mechanics of gameplay scratch an intellectual itch? Well it can be. Or is a videogame like a movie where you are the main character and you have to make moral choices, and it lets the worst of us indulge every psychopathic tendency? Well, it can be that too. Or something completely different.

For last the 30 years or so, games have evolved along technological lines. Faster hardware has allowed designers to make games look more realistic. Some (like the latest version of id Software's Doom) play more or less the same as games from the early 1990s. Others use the internet to create new kinds of team-based competition, allowing e-Sports athletes to demonstrate amazing skill to legions of adoring fans.

WHAT IS A GAME?

As of 2017, even lumping all these things under the one name - "videogames" - seems inadequate. The difference between virtual trading card game Hearthstone and the latest instalment of the Call of Duty franchise is much greater than the difference between Call of Duty and a Hollywood action blockbuster. Call of Duty: Infinite Warfare even has an easily-recognisable (if still somewhat oddly digital) Kit Harrington in a leading role.

The last year saw some important milestones for this diverse industry. Pokémon Go - which ran on multiple smartphone platforms - was free to download but still made \$1.2 billion via in-app purchases. So-called "AAA" titles on the Xbox One and PlayStation 4 sold in enough numbers to generate billions too. Virtual reality headsets got plenty of press, and despite being derided as no big thing by naysayers, still struggled to get built fast enough to meet pre-orders.

What 2016 showed perhaps was a blurring of lines between different types of game. It used to be you fired up a singleplayer

shooter or logged in to an online environment like World of Warcraft.

With the major consoles each packing their own online marketplace and infrastructure, games are now often "always online" and entering a multiplayer session involves simply travelling to a specific location. Leaderboards update automatically, and games like Forza Horizon 3 use the performance of human players to dynamically create AI opponents - and your own profile can become someone else's ally or nemesis, without any action on your part.

GROWING A BACKBONE

Of course this kind of deeply integrated online functionality all but requires a game to be a major title, from a major studio. If an independent PC developer wants to do something similar, they have to create connected systems from scratch.

That is, until now. Amazon has announced a new system called Lumberyard. It's not just a so-called "graphics engine" for programming games, it also gives (relatively) straightforward

access to Amazon's increasingly dominant cloud services. So creating the next big cloud-connected craze is now a matter of reading the manual and then using Amazon's systems to do what you want.

This is an important step forward for games, especially on open platforms like the PC. Whether it just delivers Amazon a monopoly and leads to stagnation remains to be seen.

However, Lumberyard has as its graphics backbone a system called CryEngine. This was developed by a bunch of German programmers to help them make their own games, and the first version was nothing that unusual.

The second version however, built for a sci-fi shooter called Crysis, was extraordinary. Crysis may not have been that amazing a game, but its graphics certainly were amazing, and pushed PC



Nintendo's latest console, the Switch, continues the one-time industry giant's trend of focusing on radically different form-factors rather than raw power. The Switch is both a mobile platform and a console, and will be home to the usual Nintendo favourites including Zelda, Mario etc. In a world where tablets cost \$200 or even less, the \$469 Switch is likely to face an uphill battle.



Horizon: Zero Dawn is due out in 2017 for PlayStation 4.

OPEN TO IDEAS

Software systems like CryEngine and others have been made possible by continuing advances in PC hardware. For a platform that, even today, is mostly used to run boring productivity software or crunch numbers, it might seem odd that PC is where the "next generation" of gaming is born, over and over.

The PC is of course an open platform, and there are very few roadblocks to building a chunk of hardware to stick into PC's highly modular architecture.

Different consortia focus on different areas for standardisation, but at its heart the PC is an architecture for moving data around a system at extremely high speed.

With the development of bus architectures that measure data throughput in gigabits per second, other hardware pioneers realised this could be used to the advantage of games.

Key to PC's success as a gaming platform is the GPU. The Graphics Processing Unit is a sort of mini-PC (it has its own CPU, its own memory etc) that plugs into a larger

hardware to the limit.

Since then, CryEngine has been further developed and licensed to a wide range of developers. It was used for the initial development of Star Citizen, a vastly ambitious space exploration and combat game that has raised over \$100 million in crowdfunding. (In late 2016, Star Citizen's developer announced it was moving to Amazon's Lumberyard.)

Other examples include Epic's Unreal 4 engine, and the Unity engine, which can also be used for mobile games.

VIRTUAL REALITY

The history of VR, in some ways, mirrors the history of videogames in general. Early experiments did the best they could with limited technology, but couldn't break through into the mainstream in numbers that would start to drive economies of scale.

Current VR headsets use technology originally invented for other purposes: small LCD displays from smartphones, accelerometers and gyroscopes from the same, other sensors from TV remotes etc.

Using the Oculus Rift or HTC Vive shows the potential of VR in a way older, bulkier systems could not. But it's still like looking into a cartoonish world through a snorkelling mask covered with mosquito netting. It needs more.

VR right now is where games were in the 1990s. Back then, everyone with half a brain saw the potential, but it took the invention of graphics-specific hardware to make the next leap.

Within the decade, VR headsets will dramatically shrink in size and weight. OLED displays are already paper-thin, and equipping a system with two 4K panels should eliminate the "screen door effect" seen on today's first gen units.

The hardware behind the headset will need a boost too, to be able to generate two 4K images on the fly. But this is just a matter of time.

What VR really needs now is compelling content. Today's systems still suffer from a "demo mentality" and rely on the novelty of VR to keep people plugging in. Again though, the same was said of the first high-powered "graphics accelerators" that made modern games possible.

But the most compelling evidence that VR will be huge by the 2030s? The number of people who say it will never amount to anything. We've seen how that kind of prediction turns out before...



The Oculus Rift is the first consumer VR, but has already been copied by everyone from HTC to Sony and even Google.

system and works exclusively on the kind of floating-point calculations required to render highly complex graphics in real time.

Companies come and go in the graphics card industry, but for now US company Nvidia dominates (with AMD a close second). Each year Nvidia releases an updated graphics architecture that allows PCs to generate more complex and detailed graphics at higher resolutions.

Late in 2016, Nvidia released the GeForce GTX 10 Series of graphics cards, including the flagship GTX 1080. These GPUs provide gamers with a significant leap forward in power and performance, while remaining at more or less the same price as the previous generation.

The existence of tech like the GTX 1080, which can render a detailed scene at 4K resolution and keep doing it at 60 frames per second, in turn inspires developers to push their own artistic envelope.

NEW KIT, NEW GAMES

The pace of generational change on the PC is more or less yearly, and depending on how serious you are has an entry cost of \$1000-\$2000 (or more). The consoles - pretty much now limited to Sony's PlayStation and Microsoft's Xbox - are much cheaper, but gamers must wait longer for hardware upgrades.

The original PS4 and Xbox One now lag far behind a top-shelf PC in terms of raw power, but since they run on TVs with mostly 1080p resolution (a good gaming PC now has a 1440p or even 4K display) games still look pretty good. It's just when you see a PC-exclusive title running alongside a console game that you realise, for instance, *Destiny* ain't all that.

Consoles, not being modular, can't update their hardware every time a new CPU comes out, and until now "next-gen" consoles have appeared every 5-7 years. This might be changing. Microsoft and Sony both released updated versions - the Xbox One S and PlayStation 4 Pro - that go some way to addressing (limited) 4K video playback and somewhat improved graphics.

Elsewhere we see games being released with companion mobile apps, games being promoted via elaborate real-life treasure hunts and clues left scattered around the internet, and of course via codes printed on the sides of wrappers and drink bottles.

All of which is to say that, like movies and music, games are now just another thing that "everybody" does. They are part of "the media". Games have achieved total cultural relevance.

THE BEYOND

So what of the deeper future? For an industry, media and art form that iterates year-on-year and usually produces something radically different once every six months or so (albeit often a flash-in-the-pan novelty like *Pokémon Go*), what will gaming look like in, say, 2027?


It's likely that the barriers between platforms will continue to erode. In the 1990s, games had to be developed for a specific platform, be in PC or Nintendo or Sega (remember them?). Today, major titles are already simultaneously launched on PlayStation, Xbox and PC. And mobile games must support both iOS and Android to have a hope of success.

As hardware power continues to leap forward, and companies like Amazon create universal platforms and online backbones for developers, the machine you run your games on will become less relevant than the online service you subscribe to.



Pokémon Go didn't last that long, but it made \$1.2b. Welcome to the global village.

"Games will continue to drive information technology in important ways."



There's a good chance games could end up like subscription television. You will use a powerful hardware device - and by 2027 it will probably be your mobile phone - to subscribe to a game service. It seems likely that PC's Steam platform will survive the decade, and Amazon is just going to get bigger and bigger. An "exclusive" title will be less about what hardware supports it, and more about who is paying for the multiplayer servers.

Until now innovation has been ultimately pushed by advances in the ability of machines to render graphics. Networking has been an important addition, but even in 2017, graphics rule. At some point, hardware will be so powerful (perhaps even assisted by online systems that take some of the rendering load) that the way a game looks will be an entirely artistic choice - we're very close to this point already.

And let's not understate the significance of augmented- and virtual-reality. As 2017 begins, the headsets are bulky and expensive, and the content not especially compelling. But VR and AR are likely to

dramatically change our fundamental relationship with technology.

Today, your TV occupies prime lounge room real-estate, an along with its various bits and boxes, sits like a kind of shrine to technology, dominant even when it's off.

A set of lightweight AR glasses each will still let the family slump on the couch and watch a movie projected (invisibly to any other observer) on the wall. VR will let hardcore gamers lose themselves in fantastic worlds... without the need for a desk full of computer bits.

The industrial design of a current model OLED TV is already super-minimalist, a bare thread of unobtrusively-coloured metal or plastic around that huge, black rectangle of a screen.

So in the decades to come, physical design of tech will become less and less relevant. User interfaces will be the new focus.

How you interact with the technology will become even more important than the physical technology itself.

What's all but certain though is that games - videogames, a term that sounds quaint every year - will continue to drive information technology in so many important ways.

You may not be a gamer. You may think the uncanny valley dead-eyed digital marionette version of Kevin Spacey's Call of Duty character debases his career as an accomplished actor. But it doesn't matter.

The day is coming when all you'll need is a smartphone, a pair of funny glasses, and a couple of odd plastic thumb-rings to do everything from watch a movie to save the universe. And it will be all thanks to gamers.

Kevin Spacey appears in Call of Duty as a creepy plastic version of himself.



A BROKEN INDUSTRY?

Just like music and film, the games industry has an uneasy relationship with the dirty business of making money. As technology has evolved to support games with incredible graphics, the amount of time and money required to make a game has increased dramatically.

Throughout the industry, veterans tell stories of developers going bust as soon as a game is published, of programmers pulling hundred-hour weeks to meet "crunch" deadlines, of smaller studios being pushed out of the market by the impossible cost not just of entry, but of staying in the industry in any meaningful way.

It seems counter-intuitive that an industry that seems to be getting

bigger each year can be so tough to make a buck in. But like film and music, it's only an elite handful of titles that make millions each year.

Some commentators believe the market is hugely overcrowded. It might take \$20 million to make a Call of Duty, but a decent indie game can cost less to make than an indie film. And thanks to digital distribution, publication is only a mouse-click away.

This city
is known for
its world-
building
factories,

LIFE MADE

BY
JOE BROWN

but it's actually
creating
something



far more
important
than silicon
and plastic.

IN CHINA

Shenzhen
is ground
zero for the
new culture of
globalization.

-
PG. 59

PHOTOGRAPHS
BY CHRISTINA HOLMES



YOU'VE PROBABLY BEEN TO A DOZEN JOINTS

like Frankie's: The varnished bar runs almost the length of the restaurant, an oaken finger indicating the cigar room in back. The brick walls are thick with beer logos and framed nostalgia. Twenty-somethings flit between high tables, flirting and munching on chicken wings. A guy you swear you've seen in so many other watering holes sits flanked by empty barstools, suit coat on a peg under the counter, self-contained with a Kindle and a glass of wine. Dim overhead lights halo the chalkboard beer list: a dozen brews on tap, including Guinness and a Kansas City saison called Tank 7 Farmhouse Ale. Tank 7 is strong, and the smiling bartenders will warn you about its 8.5 per cent ABV on your second or third pint. But hey, it goes well with Frankie's famous cheeseburger, a large, hand-formed patty topped with a healthy glob of cheese. "Best burgers in town! They get the fat-to-lean proportions just right!" Other reviews focus not on the burger, but on the atmosphere, which is Frankie's true specialty: "It has that Southern hospitality I miss" and "I walked into Frankie's and I was home." Home, in this case, refers to America. And



that's the trick of this place. Frankie's—for all its chicken-fried charm—is in Shenzhen, China. It's at the metaphorical and physical heart of this city's expat community.

It's a regular haunt for guys like Josh Bismanovsky, a San Francisco Bay-area native who is a couple of beers in and losing to me at *Big Buck Hunter*, strafing a simulated alpine stream with a tethered plastic shotgun. His forest of brown curly hair moves a beat behind his head as it snaps quickly to the right. He racks the plastic forend grip and fires at the screen; his shot connects, but with the wrong mammal. *Don't shoot the cow!* a pop-up dialogue box admonishes. Game over.

"I suck at this game," he says, drains his beer, and walks outside to smoke. The night is warm and heavy with typhoon rain, still power-washing the city streets after two days of relentless wet. Frankie's has a little frosted-glass awning out front though, and you can stay pretty dry if you stand under it.

Follow Bismanovsky's gaze as he pulls on his imported Japanese cigarette, and you might see Hong Kong. Not the famous jagged skyline, but the outskirts: the swampy green of the Mai Po wetlands and the bleak stretches of Lok Ma Chau, the buffer zone the Chinese government set up to separate the cultural anarchy of Hong Kong from the unsullied mainland.

Frankie's Bar and Grille, Guihua Road, Futian district of Shenzhen, Guangdong province, Mainland-and-don't-you-forget-it China, is just 15 metres from the Free Trade Zone. Small-fronted and easy to miss if not for the illuminated green-script sign, Frankie's sits among warehouses, at the end of a street crowded with parked

tractor-trailers. Opened only five years ago, Frankie's is nevertheless the alpha pub in a city of dog years.

Here time hurtles forward at an astonishing pace.

Deng Xiaoping created the city from bucolic nothing in 1980 as the pilot of his special economic zone project. These zones were meant to create safe places for Western companies to do business—and they worked. Even though China is not the boom-country it was two years ago, favorable trade policies and cheap skilled labour lure companies and entrepreneurs from across the globe to Shenzhen's nimble factories. Before the SEZ, there were some 30,000 people in the area. Today, Shenzhen's population is north of 10 million, and its port is one of the busiest in China. You already know this: Your iPhone is made here. Everything is made here.

But this is not a story about tech made in China; it's a story about lives made in China.

As of 2013, there were 22,000 permanent foreign nationals living in the city, and nearly eight million others visiting every year. The expats range from the manufacturing-industry vet with a house and a spouse to the fresh-off-the-plane Kickstarter romantic with a pocketful of pledge cash to the English teacher who can't tell a diode from a dinner plate. And because humans crave contact with others, a community of couldn't-be-more-different internationals, united by the allure of this new economic engine, is building something far more important than businesses: a new cultural reality.

There is, of course, a context for all this: epochal change. Just as warming seas intensify typhoons like the one outside, the ineluctable tide of human evolution is washing away borders. Change is a violent storm, and Shenzhen is landfall. The leading edge of this planet-shaping shift is here: Western economics, Western people, Western culture, all thriving inside a country whose government is powerful enough to lock down a billion people's Internet. No force, not even the thundering anti-globalisation roar of America's most recent presidential election, can stop this tempest.

And though we're still in the throes of it, you can al-

► You can buy almost anything electronic inside "The Market," aka SEG Electronics Plaza.

▼ The maker group meets over beers and lamb skewers talking tech till the break of dawn.





ready start to see what will grow when the chaos subsides. The foreign community in Shenzhen has the makings of a cultural power the world hasn't felt since the expatriate denizens of post-World War I Europe pounded absinthe together at Harry's New York Bar. They too ended up far from home thanks to savage economic forces, but they harnessed the energy of change and *made* things, things like art, literature, and music.

Walking the streets of Shenzhen, feeling the energy of the blurring world, you see those same archetypal characters snapping into focus. Entrepreneurs chasing dreams, artists seeking inspiration, landed gentry following the action, lost souls in search of a definition of self. And though there's no Shenzhen Hemingway (yet), the ingredients for one exist in the experimental spirit and easy access to almost any component of anything made anywhere in the world. If we haven't found our Shenzhen Hemingway (yet), perhaps it's because, expecting pages full of words, we're missing the sonnets of solder and wire. Today, for many of us, it's not a painting or a poem that captures the spirit of our time; it's a gadget

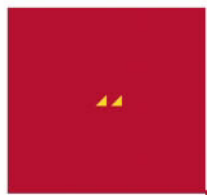
or an app. Or maybe Shenzhen's contribution is more subtle: precedent for a global community of creatives drawn not to the historic centres of art, but to the world's nascent economic hubs.

THE SHORT-TIMERS

MOST FOREIGNERS COME TO THIS TOWN to do the Shenzhen Shuffle: design, prototype, build, sell, ship, repeat. Thanks to the proximity to factories, hardware manufacturers of all sizes can get more done in a week here than they can in months back home. It's a life steeped in tech.

Then there are the supply chain tourists. They haunt factories for fun. They build things, sure, but often their products scratch creative itches more than they break open new markets.

This community of couldn't-be-more-different expats is building something far more important than businesses.



I was like
“Well, I don’t
really know
anything
about either
country, but
China’s on
the other
side of the
world.”

SCOTTY ALLEN: I guess I’m the first one here
JACOB: White guy walking in now
SCOTTY ALLEN: Also, there’s no Tsingtao and at least one waiter speaks very passable English. What city is this and what did you do with Shenzhen?
ALEX C-G: Only Bud there now. If you come next door, there’s Tsingtao here
CHARLES PAX: How cold?
ALEX C-G: At Lamb Place now. Bud is smoking cold

Lamb Place—aka 大汗碳烤羊腿 if you speak Chinese, or DanHa Grill Lamb Leg if you want to get literal—is a quick block off one of Futian’s main drags. It’s jammed with young Chinese people unwinding amid the humidity-thickened smoke of lamb crackling on small grills set in the centres of the closely packed tables. Even with the bumping crowd, it’s not hard to spot the half-dozen white dudes shoved into the farthest table from the restaurant’s entrance.

The six men seated there met through WeChat, the ubiquitous Chinese communications app, and are united by membership in a well-known chat group called HQB_2016. The name is short for HuaQiang Bei (Twenty-Sixteen), the section of the Futian district in which they live, play, and eat. Lamb Place is in HuaQiang Bei, as is Jie En, the hacker-friendly short-term apartment block down the street.

“That’s where we all tend to wash up,” says Alex Curteon-Griffiths, a strong-accented Brit who came to China to work in Shanghai real estate. These days, he’s the product lead at SpaceGambit, an organisation dedicated to creating a spacefaring civilisation through open-source collaboration. Welcome to Shenzhen.

The HQB group fluctuates, but it’s usually around 75 members united by a common love: They make stuff, hence its more-common name: the maker group.

The members drift in and out of Shenzhen—some to find work, others because they don’t have to work—but when they’re in town, the group is an anchor. They get together over barbecue and beer “sometimes every other night, sometimes once a week,” and jaw on about current projects, the things they’re building.

Like Charles Pax’s temperature logger, which he built not to fill some screaming market’s urging desire, but because he wanted a temperature logger. “It’s what I do for fun,” he says. He put the device on Kickstarter to see if anyone else wanted one. They did; he’s sold about 200 of them at US\$165 a pop. “There are people doing automotive stuff, people brewing beer,” he says, excitedly, going on to demonstrate a future version’s modular circuit board—it’ll let you log anything, diligently plotting a graph on its monochrome screen.

Pax used to be the head of R&D at 3D-printing company MakerBot. Since cashing out in 2013, he’s split his time between Shenzhen and New York. Lately he’s been spending more time here. “A bunch of MakerBot people came to China,” Pax says, “and a couple of them stayed.” As he speaks, he’s unwinding one of his logger’s four wire probes from its spool. “I had come to visit them on vacation—to do some hacking stuff—and I made the decision that this is the place for me.” He wiggles the wire behind the label of one of the table’s many unclaimed beer bottles and powers on





1	2
3	4
5	6

1
Twenty-year-old CTO Nicky Öster Jenk is in town for only a few days. First stop: the Market.

2
Elsbeth Myers and Frank Teng met through Reddit's r/Shenzhen forum.

3
Zachary Hany is a CrossFitter and paper artist.

4
Culinary explorer Arrica Gilmer fears no meal.

5
Josh Bismanovsky: misfit, man-about-town, injection-moulding sales rep.

6
Julia Kaisinger loves cycling, hiking, the beach, and mealworms.

his machine. As promised, the beer is quite cold.

Guys—all guys—flow in and out of the group, meeting each other and discussing their projects. There's a South African media artist on an organised tour of the city and a Spanish engineer who recently road-tripped around Spain in a hacker van. Scotty Allen, an ex-Google who runs a big data startup called Appmonsta, is here to play in the expansive electronics bazaar down the road. It is a nerd pilgrimage.

"The Market," as the maker group calls it, is SEG Electronics Plaza; its concrete face suggests an electronics Abu Simbel, and what's inside commands similar reverence. It's a nine-storey tinkerer's paradise, where anyone can buy any part to make anything: gallon bags full of cellphone cameras, kilometres of wire terminating in any connector imaginable, whirring machines that will print you a circuit board. Drone shopping? Third floor, keep left. Need an HDMI cable? There's a booth on five that sells nothing but.

Across the street, up a great glass elevator: Hax, a hardware accelerator that funds promising projects with \$100,000 apiece (in exchange for a nine per cent equity, of course) and brings teams to Shenzhen for four months to all but ensure their success. In the loftlike offices, young engineers play ping pong, do laundry, hand-build prototypes, and mine Hax's China-savvy staff for knowledge about how to launch a successful startup.

Twenty-nine-year-old Julia Kaisinger is a Hax alum, an Austrian who has been in Shenzhen for a year and a half getting her company's home mealworm farms ready for production. Her team's Kickstarter raised \$145,000 from people who want to grow and eat their own bugs. (Hey, it's a very sustainable protein source.)

The storm outside is cranking again, and Kaisinger turns to watch the fat drops splash on the flat roof beyond Hax's kitchen window. "I always think, 'OK, in a few months, I'm gonna leave,'" she says. But who knows? Neither Kaisinger nor her co-founder are manufacturing specialists, but as the design lead, she's closest. She'll stick around town, close to the factory, until everything is running smoothly.

For now, Kaisinger has a good setup. She works out of Hax and found a cheap apartment online, using Google Translate to read the ads; she shares it with three other women—all Chinese. She's one Metro stop away from the office, because, during the week, she's almost always there. "I work a lot," she says. "Maybe, I don't know, 12 hours a day, minimum?"

You'd think Kaisinger would want to hit the town to unwind. Not really. "There are a few bars here that are OK, but I don't like the spirit of Coco Park," she says, referring to expat-heavy area where most of the clubs are. "It's a lot of male foreigners who give me the impression that they easily pick up Chinese girls." Shenzhen is a notorious meat market where Western men take advantage of local women. Kaisinger makes it sound creepier than a box full of worms.

On the weekends, she tries to get out of the city. "I mainly like doing outdoor stuff," she says. There are mountains, remote parks, and beaches within a short train ride. "I have a bike here," she says. "I go riding, hiking." Sometimes she'll take the train into Hong Kong, where the beaches are better.

THE LIFERS

IN SOME WAYS, SHENZHEN IS LIKE ANY other town. You move there for work; you get an apartment, make friends, and find a couple of spots you like to hang out. Restaurants. Bars. Next thing you know, several years have flown by and you've put down roots. It could be Cleveland. The difference is, of course, that this is not Cleveland. When living in China, you have the choice to immerse yourself in the local culture or hold onto your own.

Josh Bismanovsky represents the latter camp: very much a stranger in this strange land—even after spending more time in China than he spent in high school and college combined.

He graduated from the University of Colorado in 2006 and looked for work in the Denver area. "But there were just no opportunities for a communications major," he says. After a short stint at an Apple store and some motherly encouragement to get out of her house, he came to China for a six-month internship with a supply-chain management company called PCH. The internship ended, and he briefly considered returning to the US. Then he landed a job as a sales rep for a manufacturing outfit, and—a decade later—he's still here.

It's the day after our *Big Buck Hunter* outing at Frankie's, and Bismanovsky is nursing a hangover. To make it go

away, he's just ordered a 180-gram wagyu burger called the MBA. It wears a crown of fried cheese and over-easy egg, and costs the equivalent of \$18—10 times what a streetside bowl of noodles will run you. The belly, as the blind poet says, is a shameless dog.

Bismanovsky is modest about his Chinese, but it's clearly very good. You never see him repeating himself or looking up words, and the sentences flow with ease.

As does, by all appearances, his life. He lives in an \$1,100-a-month two-bedroom apartment in a nice high-rise—he's paying a bit below market because, Bismanovsky suspects, the landlord is happy to have a single foreigner there instead of a family of four. He works the same steady job he got after leaving PCH.

And though he's something of a China lifer at this point, Bismanovsky is culturally rooted in the US. He doesn't have many Chinese friends outside work, and he dates mostly Western women. "Unless they've lived overseas for some time," he says of the locals, "I find that we don't have anything in common."

Bismanovsky has a solid group of Western buddies from around the globe. They play basketball and got sick of video games together. Although most of his American friends have left Shenzhen, he does still have one left; they split an NFL streaming package and watch the live games late at night. "Nobody else likes it when we get together because we're super loud and obnoxious," he says. "All we do is talk about sports."

The burgers arrive, and Bismanovsky levers his into

How cold is that beer? This home-brewed temperature logger is on the case.

Burgers are kind of a big deal in Shenzhen. This one costs 10 times a normal local lunch.



his mouth. The MBA is taller than it is wide and, at first squeeze, it starts leaking meat juice and liquid yolk from the fried egg on top. The rain outside picks up, as if spurred by the burger to drum Shenzhen's theme music: a cadence of arrival, a beat of change.

The next day is bright and hot, the calm before another typhoon is expected to swat the region. In the blasting sun, Zachary Hany is impossible to miss—even across a broad plaza. His skin is a shade of white you wouldn't think possible to maintain in Southeast Asia. The light bounces off his shaved head like a watch face.

Hany, a muscular six feet, is big even by American standards. A fast walker, he's tough to keep up with as he navigates the stairways and hidden turns of the multilevel shopping complex. Though the plaza where we met could have been plucked from any modern city, Hany guides us to unmistakably mainland China.

Water from the previous days' rain, though dried in open areas by the strong sun, still drips steadily down the concrete columns that support the mall above. We walk into a restaurant with pictures of Hong Kong action stars on the wall, and Hany does the ordering. The server is visibly startled by his Chinese fluency.

An Illinois boy who grew up mostly in Germany, Hany came to China with the Peace Corps in 2000, after finishing his master's in environmental engineering. "I could have gone to either Jamaica or China, and I was like, 'Well, I don't really know anything about either country, but China's on the other side of the world.'"

He's been here ever since, living the past 13 years in or around Shenzhen, hustling to knit together a living. "I work on a few projects here and there, just pulling together what I can, hoping," he says, trailing off.

As if to defy his imposing appearance, Hany is a gentle and genuinely nice guy. He's also very obviously lost in the world. He's American, but he grew up in Europe; he went to school in the States, but then he almost immediately left the country again. Where is home for a guy like that? What is he still doing in China?

With his engineering background and formidable bilingualism, Hany could likely land a lucrative job here; he's uninterested. Even without one though, he's "not in fear of starving to death." You can live cheap in Shenzhen. And even though he was recently evicted from his apartment, he scored a room in a friend's place in exchange for helping out the guy with a project.

The standard Shenzhen path might not be Hany's chosen course, but there is still a good reason for him to stick around town. Though Hany wouldn't describe himself as one, he's kind of an artist.

Hany calls it "design stuff," but he's talking about papercraft—worlds beyond the cut snowflakes you might be imagining. "I'm fascinated with paper engineering and pop-ups," he says. Engineering is the key word there. Hany designs complex networks of shapes in CAD and realises them with a computer-controlled laser-cutter. Many projects are aesthetic: detailed geometric lattices and sharpened fractals that explode along their radii like crystal supernovae; filigreed lanterns that glow with carefully concealed LEDs. Stare at them long enough, and you'll see a whole universe in their iterated facets.

The practical side of his paper passion is building realistic pop-up worlds for tabletop games—the ones

in which miniature metal figurines do battle. The simulated rock and timber of his sturdy paper creations almost look real (as real as the orcs, anyway), and yet collapse down, for easy storage. He has a Facebook page, a booth at the annual Gen Con tabletop gaming convention in Indiana, and, from the buzz in the forums, a waiting market.

When he's not at home ("I would describe myself as 'slightly reclusive'" and not working out (he used to be a certified CrossFit instructor), Hany is likely playing those same games. He and his friends, mostly Westerners, set up at each other's houses, at bars, restaurants—wherever.

He dreams of selling his collapsible constructions someday; he has vague plans for a Kickstarter. But, he says, "life gets in the way." A veil of melancholy falls over his face. Soon, he says, "I'll get my head straight."

The server forgot Hany's noodles—a simple but delicious tomato-and-beef concoction that you unfortunately couldn't find in America—but he doesn't seem bothered. He smiles calmly at the server, casually accepting the apology in his flawless Chinese.



THE ADVENTURERS

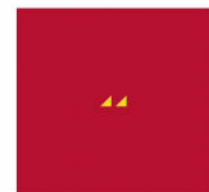
DON'T TELL DENG XIAOPING, BUT THE tech industry isn't the only force that draws people to Shenzhen. As with any global city, some just land here, drawn by opportunity or wanderlust. Many teach English, recruited by well-funded international schools tasked with teaching the children of American or wealthy Chinese families. Often these expats are not in search of the next Shanghai or seekers of new artistic truths. That doesn't mean they're any less important to the cultural fabric of the city.

"Shenzhen was the only option they gave me," says Elspeth Myers as she sips coffee in the booth of a restaurant called Linen Tea Dessert in Nan Shan. Linen Tea looks like the kind of place you'd go after church: white tablecloths and a lot of banquette seating.

A 23-year-old education consultant, Myers works for a company that helps well-heeled Chinese kids get into American colleges. "I just wanted to come anywhere," she says. By "anywhere," she meant anywhere in China. Myers took every Chinese language class the University of Wisconsin could offer, and is close to fluent.

Her boyfriend, Frank Teng, finishing off a bowl of noodles next to her, quit his job at *Make* magazine to drink from the Shenzhen fountain of fortune—but didn't quite succeed. "Hardware is a lot harder than I thought," he says, laughing at the pun. Now Teng, 25, works for Myers at the education company and spends his free time studying.

Though the two of them are both in education, they avoid the local teacher scene. It's not their vibe. "The ma-



Most foreigners come to this town for the Shenzhen Shuffle: design, prototype, build, ship, sell, repeat.



▲ 大汗碳烤羊腿 or "Lamb Place," as the foreign crowd hails it, serves a mean skewer.

▼ The imposing facade of SEG Electronics Plaza, a temple to technology.



jority are guys who are maybe a little socially awkward or just can't get a job back home," Teng says. They are more interested in the local women than the local culture. It's the crew Kaisinger spoke about. "There's a name for them," Teng says: "LBH, loser back home."

Arrica Gilmer is a teacher, but she's no LBH. "My only request is chicken feet," says the 30-year-old from Pueblo, Colorado, as she sits down to brunch in a heavily gilded dim sum restaurant. Typical of large banquet halls, there are no windows. If there were, they'd be getting hammered with still more rain; the second typhoon of the week is making its way north, just minutes from hitting town.

Tall and athletic and dressed in workout clothes and a knit cap, Gilmer came to Shenzhen a year and a half ago, after chaperoning a high school trip to Costa Rica. "I came back and I was like, 'I need to travel,'" she says. She gave herself a year to get out of the country, but within six months had made it to Shenzhen and secured a job here, teaching English to Chinese students.

Gilmer, an African-American woman, hasn't caught any static because of her race. In fact, she says, people seem to see her as foreign more than they do black, lumping her in with an amoebic group of teachers and tech bros.

She's actually had more trouble at the gym. "Being an athletic person wasn't a bad thing at home," Gilmer says. She power-lifts, and didn't think it would be a big deal to go to the gym and throw some weight around. It was. "It's not really what the culture embraces for women," she says. People stare.

This bothered her, until she met her friend Stephanie, an athletic woman from northern China. "She's really helped keep me sane on days when I feel like a monster because I'm doing things that the boys are doing," she says.

Outside work and the gym, Gilmer's life in China revolves around food. It's her main source of entertainment. Sure, she and the other teachers hit the bars—Frankie's is a favorite—but Gilmer is mostly interested in exploring delicious new flavours she couldn't find back home. She and Stephanie comb Shenzhen in search of the best post-workout meals.

And while many Westerners have, shall we say, difficulty with hardcore Chinese food, Gilmer straight-up seeks it out. "I'm pretty sure I had poop the other day," she says, more embarrassed to talk about it than revolted by the experience. "I was eating some duck, and I grabbed this one piece—I thought it was liver. It looked kinda different," she says. Honestly, who can identify cooked duck faeces? "I was like, maybe it's some kind of organ—and I like organ—so I didn't think anything of it. Then I bit into it, and I was like, oh, God, no. That's not something you're supposed to eat."

Gilmer swallowed it—whatever it was—and went back in for another piece. "You can't be a punk when eating in China," she says. She laughs, and the chicken feet arrive. Gilmer tucks right in.

THE STORM PICKED UP NOTICEABLY DURING DIM sum, so my photographer, Christina, and I hustle back to the hotel to grab our luggage. It's our final morning in Shenzhen, and we have flights out of Hong Kong. As soon as we walk in, though, we realise we're not going anywhere. The borders, the concierge tells us, are closed. He stands, palms forward, in front of the door.

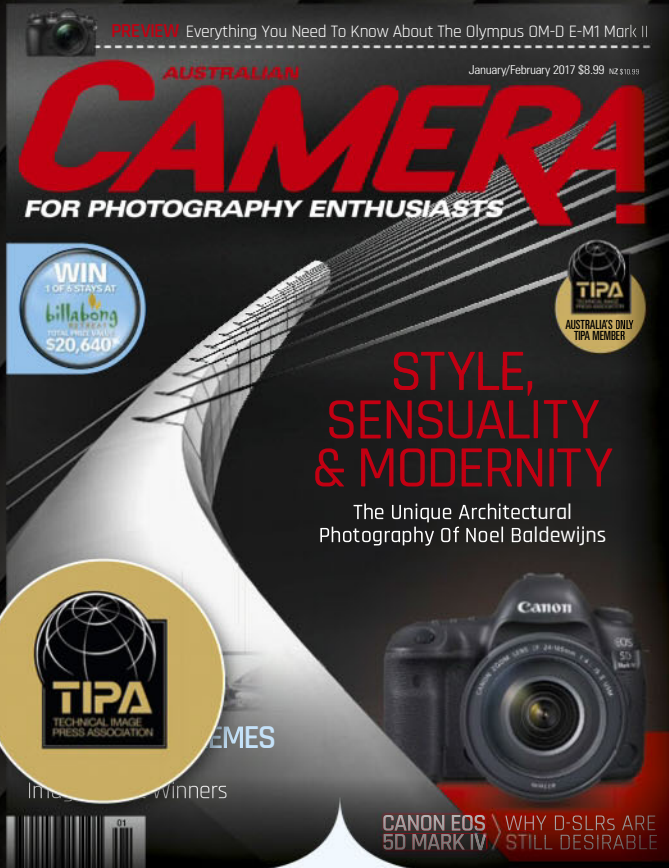
Nowhere to go, we grab a table by the window in the hotel's 26th-floor bar. Raindrops chase each other down the broad sheets of darkened glass. Yet, from 90 metres above the street, the storm looks insignificant. The scale of this city is so massive, someone would have to build a bigger wind to disturb it.

In search of some evidence of storm, our eyes set upon a broad green swath, a park stretching from the convention centre's imperial front to the ultramodern civic centre. It's a marvel: a meticulously planned urban refuge, criss-crossed with pathways and shaded benches, punctuated with water fountains, arching bridges, and open spaces for exercise. Robert Moses' most tender dream. Impressive just by virtue of its features, this public work has a defining feature that trumps all the others: It runs atop the roofs of all the structures between the two municipal buildings. It's a sky park.

You could find a public work like this only in a city that sprang forth from some urban planner's omnipotent head. In the short history of this urban landscape, those buildings have always been malls. Their roofs have always been greenspace. There is no old convention centre, bulldozed. This suite of structures is the very crystallisation of Shenzhen: huge, new, deliberate.

But you can't plan everything. Life will always find fissures in your concrete. In Shenzhen, the green shoots of a new culture are drinking in the storm of globalisation to overgrow any tower of glass and steel. You think the city is rising, but it's just a base. %s

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Replace a Shattered Smartphone Display

FOR A DEVICE WE CARRY EVERYWHERE, it's remarkable how fragile the average smartphone is. At least, if you insist on hurling it to the ground, screen-first. Or, you know, dropping it from hip-height onto something like a bedpost or corner of a coffee table. With horror you turn your phone over to see that dreaded tracery of cracks... or worse. SOP is to take the phone down to that weird kiosk that appeared overnight in the middle of your local shopping mall (and will disappear after the weekend) and pay a disinterested guy \$200 for 15 minutes work. Or you could do it yourself. While some phones remain stubbornly unfixable, others are surprisingly straightforward. All follow this basic method.

by
LINDSAY
HANDMER

+SMARTPHONE REPAIR

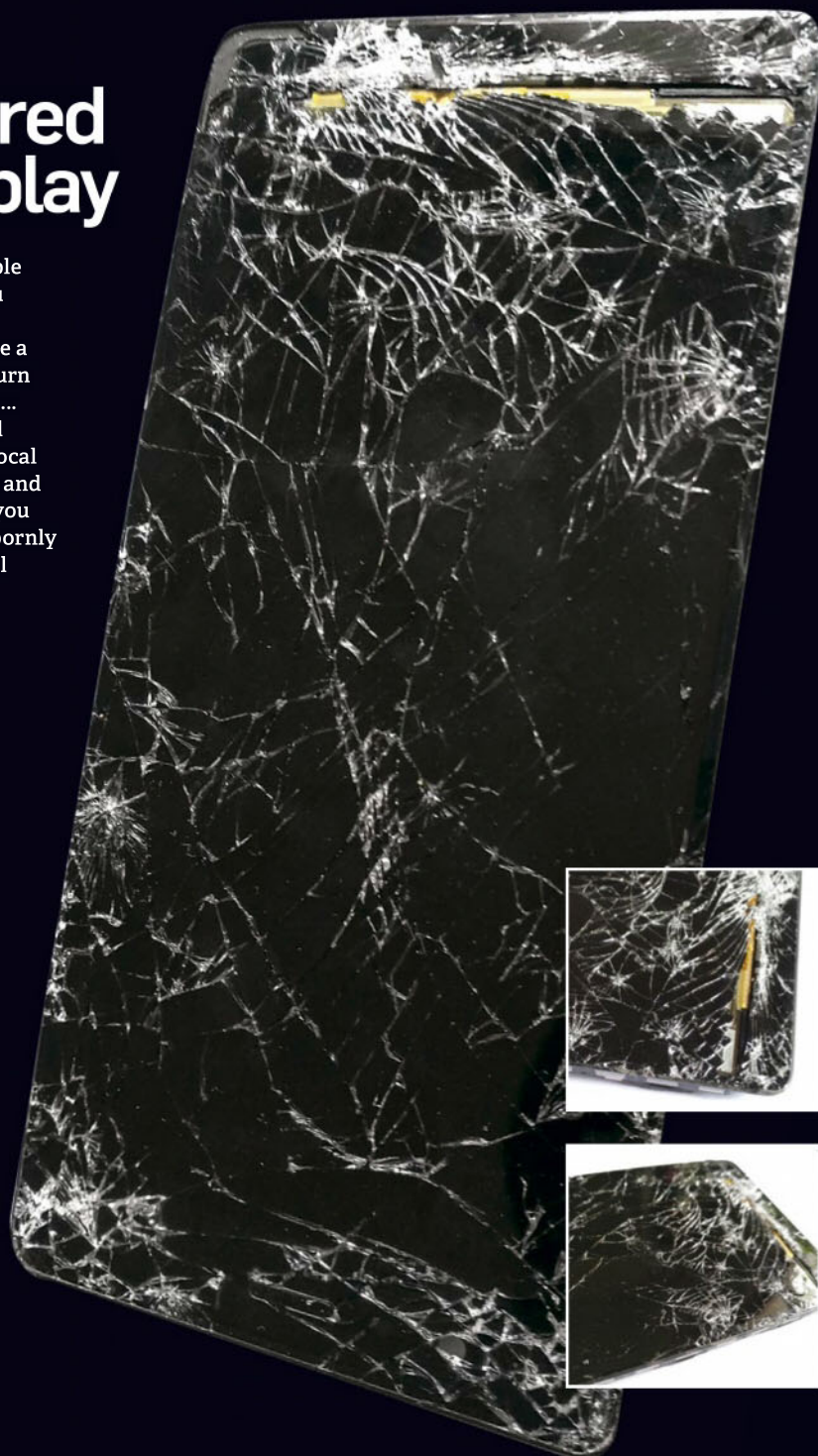
Before we begin, not that while cracked screens are a universale experience, occasionally other parts such as cameras or charging sockets go bad. In our case, a Huawei P9 was left on the roof of a car (pro tip: don't do this) and flew off at 80 km/h. The trip through the air didn't hurt the phone, but hitting the tarmac at some percentage of 80km/h kind of did.

Impressively it still worked, despite the touch panel being a mess of glass shards. Some shops were willing to try repairing it, but wanted around \$250, presumably in fingertip-danger-money.

A quick Google search showed multiple teardown and repair videos, and loads of spare parts. While not every phone has parts or guides, most of the major ones do.

A good starting point is ifixit.com, or simply searching the phone name and 'repair guide'. The photos in this guide are specific to the P9 but the principle is the same for most phones.

IRONIC TIP: The more expensive and powerful your phone, generally the more difficult it is to repair yourself. Sorry!



+TOOLS

The old screwdrivers in the third drawer down won't cut it for mobile phone repair. Instead, a bunch of odd shaped tools (called spudgers) are needed to help separate various parts.

Fortunately, it's possible to buy toolkits from eBay for as little as a few dollars.

For those with a (mostly) intact screen, suction cup spreaders are a great way to open the phone without damaging it. Typically, some screwdrivers are needed, and are often star bits - but once again these are available very cheaply online, or just buy a 72-piece (or more) electronics screwdriver kit so you have everything. For next time.

Some models of phone will need glue heated and softened, so a small hot air gun is needed (avoid the large 1000W+ ones). These cost around \$15.



+YOUTUBE REPAIR VIDEOS

While possible to do without, having a video of the process makes it a whole lot easier. Watch it through at least once before getting started, and have it available to watch and pause as you complete each step.

Be aware that the videos can make it look very easy, but these guys have a lot more experience, so take it slow. Some steps also show stuck-on parts being removed quickly, but they are often already-loosened to make the video faster. Make sure to remove the simcard and tray, and obviously power down the phone before starting.

+THE AFTERMATH

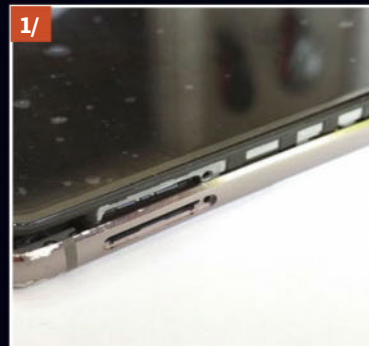
It's quite easy to accidentally miss plugging a cable in correctly, causing some functions such as a camera or fingerprint reader to not work. Just carefully pop the phone open again and check the cables. Any accidentally damaged parts can often be replaced cheaply - for example a new fingerprint scanner on a Huawei P9 costs \$10, while a camera is \$25.

SHOULD I EVEN START?

One of the great services iFixit.com provides is a repairability rating for most new smartphones (and some tablets). Before buying a replacement screen, you can check the repairability rating and get a quick idea of whether you're up to the task yourself. iFixit rates our P9 7/10 (straightforward but time-consuming to disassemble, but it has annoying pentalobe screws).

+THE PROCESS

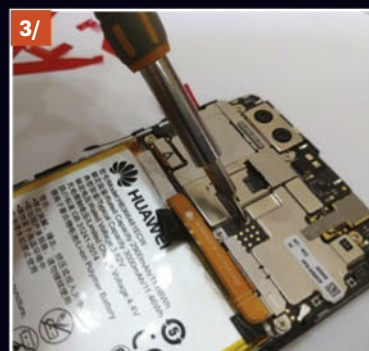
1/ OPEN A GAP: The method varies from phone to phone, as well as depending on the damage. In our case, the phone needs to be opened from the bottom, after two screws are removed. Suction cup spreaders are ideal, but won't work on a cracked screen. Instead, insert a spudger tool as per your guide (under the screen edge for us) and then slowly work all the clips free.



2/ DISCONNECT CABLES: In our case, there is a fragile ribbon cable that connects the fingerprint scanner on the rear to the phone electronics. Huawei made the process easy with a long cable, but some phones need to have it disconnected before the halves can be laid side by side. From there, follow your guide to disconnect the many ribbon cables and brackets.



3/ REMOVE THE HARDWARE: Step by step (follow your guide!) disconnect and remove parts such as the cameras, and motherboard. Many are stuck down, so be gentle and take it slow. Batteries are often glued in place, but some manufacturers (such as Huawei) use quick release pull-tabs. Be very careful when removing the battery, as it should not be bent or pierced, or it could catch fire.



4/ SWAP THE SCREEN: Before reassembly, it's important to plug in the new screen in to make sure it works. Look for dead pixels, and make sure the touch panel works over the entire surface. In our case, only the motherboard, battery and power switch was needed for the phone to power on. Our new screen came bonded to a replacement phone frame and includes replacement peel off tabs for all the parts that are stuck down. It's very important to ensure all these are used again so nothing inside the phone can move. Re-assemble in the reverse of the disassembly, to avoid missing any steps.



Manual

Less Is More

A Paper Centrifuge to Make Blood Tests Cheap

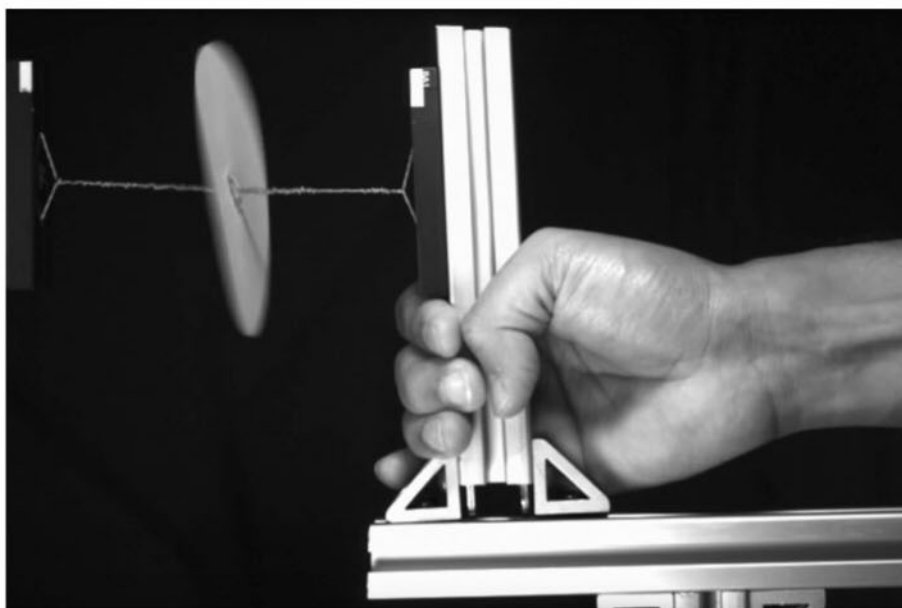
by
SOPHIE
BUSHWICK

BIOENGINEER MANU PRAKASH recreates expensive scientific equipment using incredibly cheap materials. This quest has led to a paper microscope with components that cost less than a dollar and a music-box-inspired lab-on-a-chip that could cost 4500 times less than comparable devices. His latest contribution to what he calls “frugal science” is a paper centrifuge powered solely by human hands.

To test a person for diseases such as malaria, HIV, and tuberculosis, scientists spin samples of the patient’s blood, urine, or stool in a centrifuge. Thanks to centrifugal force, the spinning motion separates cells of different weights — such as pathogens in the blood — from the rest of the sample. Researchers can then look at the separated cells under the microscope to identify the disease.


But a bench-top centrifuge, which whirls at around 20,000 rpm, makes for less-than-ideal field equipment. It’s bulky and heavy, costs hundreds (if not thousands) of dollars, and relies on electricity. Some researchers have tested out salad spinners or egg beaters as possible low-cost alternatives, but these options barely reach 1,200 rpm.

Instead, Prakash and his collaborators looked to a simple, ancient buzzer toy called a whirlingig for inspiration. Based on that design, they cut two circles out of paper, used Velcro to fasten tiny tubes of blood between the disks, and ran two strands of fishing wire through a hole in the circles’ centres. By connecting the twisted wire to two wooden handles and



pulling the handles apart over and over again, a user can spin the paper discs — and the blood samples sandwiched between them — at top speeds.

This “paperfuge,” presented in a new paper in the journal *Nature Biomedical Engineering*, can spin at up to 125,000 revolutions per minute (rpm). In the

paper, Prakash and his collaborators also explain how they separated malaria from samples of infected blood by spinning the device by hand for about 15 minutes. This demonstrates that the paperfuge could be a super-fast method of malaria diagnosis. Not bad for a device that costs about 20 cents to make. 



Snap the Night Sky on a Phone

YOU CAN'T STOP GAZING AT THE luminous full moon—you need to share this with Instagram. So you pull out your phone, aim at the heavens, and capture... a fuzzy white blob. The night sky is one of the hardest targets to snap on a phone. Why? A smartphone's camera lens is wide, and it automatically sets the exposure to capture the dark sky instead of the

bright objects in it. To up your phone game, try adding some additional technology. These tips will help you photograph celestial bodies near and far.

by
SOPHIE
BUSHWICK

1

► SHOOT THE MOON

Before you adjust the settings on your phone, fix the setting around it. Go to a dark area to avoid light pollution, clean the camera lens with a soft cloth to remove any smudges that might produce a glow effect, and use a tripod and a remote trigger to stabilise the phone. (Did you know you can use your headphone remote to take a photo?) On an iPhone, focus on the moon by tapping on it, and then swipe down to reduce brightness.

2

► TRACE STAR TRAILS

As Earth spins on its axis, the stars overhead appear to move in curves. The paths they follow are called star trails. Apps that let you customise your camera settings can take long exposures that will reveal them. The NightCap Pro app is particularly easy to set up because it has "star trails" as a preset mode. As you do for moon photos, minimise light pollution, keep the lens clean, and stabilise the camera.

3

► CAPTURE A PLANET

To nab bright planets such as Saturn and Jupiter, snap them on the eyepiece of a telescope and reveal details with stacking software. First, use an app like ProShot or Manual to take multiple photos in RAW format. Then combine the images with a computer program such as Deep Sky Stacker. This works best if you have a mount that holds your smartphone to the scope. Or hack one together with wood, a hose clamp, and some rubber bands.

Manual

Toolbox

The Modern Explorer's Survival Kit

WHO NEEDS A SURVIVAL KIT? You have a phone. Compass. Flashlight. Maps. Translator. Classic tools of exploration, all there under your uncalled thumb. But your phone is not a rain poncho or a power bar. It's time to think like a modern explorer, one as capable on an urban grid as on a dirt switchback. The items here will help you break away from your routine while letting you hang on to

your app-store comforts. Welcome to the Silicon Age of Exploration.

by
SARA CHODOSH
AND PETER HESS

1/ FOOD

Whether you're trekking the trails or the avenues, you've gotta eat. Powders and bars made from crickets pack protein, iron, vitamin B12—and less sugar than most granola. You won't even know you're eating bugs. *Chapul Protein Powder*, US\$39; *Chapul Bar*, US\$3

2/ POWER

Nothing says "rookie explorer" like running out of juice. This unit, with built-in Apple Lightning and micro-USB cables, lets you and two companions charge your devices at the same time. *Jackery Bolt 6,000 mAh Ultra-Compact External Charger*, US\$22.09

3/ BURNER PHONE

It never hurts to have two. If your phone is lost, stolen, or broken, a prepaid flip phone will give you a secure backup—and it doesn't even need a wireless plan. Throw one in your bag for that Jason Bourne vibe. *TracFone LGL237C 3G Prepaid Phone*, US\$14.99





4/ COMMUNICATION

Don't lose your friends to a mobile dead zone. The choc-bar-size goTenna turns phones into walkie-talkies, letting connected smartphones talk and text, via VHF radio waves, within a 6-km radius. Plus, it keeps your GPS online even without a signal. goTenna, US\$149

5/ FIRST AID

The price of exploring is blisters. With waterproof tape, you can protect your feet in any condition. Don't forget to sanitise your hands before and after treating your sores. Nexcare Absolute Waterproof Tape, US\$3.42; Purell Advanced Travel Size, US\$10.97 for pack of four

6/ WATER

Does the water in your city park or campsite fountain taste like metal? Improve your H₂O by drinking it from a bottle with a built-in filter. But this bottle won't stop all microbes, so boil water from a questionable source before filtering it. Bobble Classic 18.5 oz., US\$9.99

7/ NAVIGATION

Fiddling with your phone while biking is dangerous. Get hands-free directions by attaching this turn-by-turn navigation device to your handlebars. Download the app, pick a route, pocket your phone, and follow the light-up turn signals. Hammerhead One, US\$99

8/ RAIN PROTECTION

Whether you're stuck in a downpour or faced with a dew-slick park bench, you'll want reliable, stay-dry gear. And nothing beats the versatility, protection, and low price of a rain poncho. LOOGU Camouflage Waterproof Rain Poncho, US\$16.88

Manual

Cheap Tricks

The Sun Stove

YOU DON'T NEED A GAS STOVE TO cook a hot meal while you're out exploring. Lightweight flat-pack materials like cardboard can assemble into an oven that harnesses sunlight for heat. This solar oven, designed by high school student Brandon Spellman, can reach temperatures above 93°C.

by
THOM
LEAVY

+TOOLS &

MATERIALS

- Two cardboard boxes
- Box cutter
- Silicone adhesive
- 1-inch-thick foam insulation
- Black gaffer tape
- Scissors
- Eight 30-cm bamboo skewers
- Aluminium tape
- Sheet of glass or plastic
- Oven mitts

TIME 2 hours

COST \$30

DIFFICULTY ● ● ● ● ●



+INSTRUCTIONS

- 1/ Line the inside of one box with adhesive and foam insulation, and cover the insulation with gaffer tape.
- 2/ Cut duplicates of the first box's flaps from the second box. Tape the duplicates to the outer edges of the originals, doubling their surface area.
- 3/ Poke two skewers into each side of the box to prop open the flaps. Adjust their angles for maximum sunlight.
- 4/ Cut cardboard triangles to fit in the gaps between the flaps and affix them with gaffer tape. Cover the flaps with aluminium tape.
- 5/ To cook, lay the glass on the insulation and position the oven to catch the sunlight. It gets hot, so handle with oven mitts when it's cooking.

PHOTOGRAPH BY BRIAN KLUTCH

Recycle Plastic at Home

WHEN HUMANS MOVE INTO NEW TERRITORY, WE LEAVE waste behind, and one of our most harmful byproducts is plastic. Dave Hakkens wants to solve the planet's plastic problem with a build-it-yourself home recycling system that will make the material easy to reuse.

"With wood or metal, you can recycle it yourself," he says. There are already consumer tools that can cut,

bend, melt, and reconnect scraps of this material. The machines that process plastic for recycling, on the other hand, are not available in your average workshop.

So Hakkens decided to design those machines himself. His Precious Plastic system includes four appliances: One chops up and shreds clean plastic refuse into scraps. The other three heat and reuse that plastic by squeezing it into filament for 3D printers, injecting it into a mould to form small objects, or compressing it into a mould to make larger items.

The machine designs are open-source, and Hakkens provides blueprints, instructional videos, and directions online. He suggests that builders recycle scrap material to build the machines themselves; in his videos, he picks through a junkyard and even cuts sheet metal from an old car door. Building one of the

four Precious Plastic machines costs between \$135 and \$215 and takes three to five days.

by
MEAGHAN LEE
CALLAGHAN

Use and Reuse

Hakkens' system compressed recycled plastic into moulds to create these containers.



COURTESY DAVE HAKKENS (2)

Go Ahead...

Ask Us Anything

► Have a burning question? Email it to latters@popsci.com.au or tweet it to @PopSciAU with #AskAnything

Q

CAN YOU FERTILISE MARTIAN CROPS WITH HUMAN POOP?

A

If humans ever settle on Mars, getting reliable food will be one of the major challenges they face.

"If you're ever going to have a tomato on Mars, you're going to have to grow it there," says Bruce Bugbee, a Utah State University professor who helps NASA develop life-support systems for astronauts in space.

Setting aside light and water issues, plants still need nitrogen to grow. Human faeces contains nitrogen as well as bacteria that break it down into nitrate, which plants prefer for growth. But lingering alongside those useful bacteria will be any bad bacteria the crew brought with them. If they dumped it all directly onto the plants, the harmful bacteria could thrive and proliferate and make humans sick.

To avoid this, says Bugbee, Martians will have to compost the faeces over several months to weed out the bad microbes. So it's possible to use human waste for fertiliser, but they'd better have a contingency plan for the first few months.



Archives

February 1977

Wind Power: A 40 Year-Old Tradition

by
ANTHONY
FORDHAM

ONE OF THE (MANY) arguments against moving to renewable energy at larger scales is that this technology is just still so new, y'know? It needs time to MATURE, it's ridiculous to force it on people so quickly. And all that.

But what this article from the February 1977 edition of Popular

Science shows is that wind turbines were well understood, and people like PopSci reader Steve Sieradzki were already looking at ways to improve and refine them.

Yes, Sieradzki's windmill only generates enough juice for his camping holidays, but that's not the point. The point is that wind turbines have been around long enough to have gone through

several generations of improvements, and the wind farms you see today aren't using experimental or "version 1.0" devices by any means.

One surprising detail in this article, as you'll read, is the paragraph where Sieradzki thinks his fold-down tower might be adapted to "large-scale applications" such as "in populated areas where there might be aesthetic objections to rigid towers."

And here was me thinking then-Treasurer Joe Hockey had come up with a new (and silly) objection to renewables, when he said, back in 2014, that he finds wind farms "utterly offensive." Turns out he was just channelling attitudes from the late 1970s. Which makes sense.

Meanwhile, and as if to hammer the point home, this article in February 1977 is part of a monthly series the magazine ran in that era, where it asked inventors to show off "projects PS readers have devised to conserve or replace fossil fuels."



Early turbines weren't exactly high-output

Remember, this is less than four years after the late-1973 oil crisis that saw pump prices spike. That was when ordinary people first began to realise that this stuff we keep sucking out of the ground might not, in fact, last forever...



This turbine was erected on Grandpa's Knob. Any questions?



THE FUTURE OF HOME ENTERTAINMENT!

February 1977

This is the 1970s so covers are all about the latest amazing electronic thing. In this case: LaserDisc! Here called videodisc so as not to show favouritism for any particular brand. Also in this issue: an usually high focus on boats. Lots of boat stories. No idea what that's about. Check the bottom right corner of the cover though: "TV picture simulated". Little did these editors know that high definition would become the norm... and with nary a videodisc in sight.

Stephan Sieradzki, Windmill on a boom

By EDWARD MORAN

Someday in the not-distant future, Steve Sieradzki hopes to take his windmill along on a fishing trip. A flexible tower similar to the one pictured here will be mounted on the roof of his van. When he arrives at his favorite fishing spot, he'll raise the 10-foot prop skyward and fill ballast tanks with water to stabilize it. The power generated - 400 watts in a 15-mph wind - will be used to cool the beer and cook the fish, he says - quite an energy-saving angle.

Although Sieradzki hasn't yet built this mobile

unit, he has created a novel DIY windmill at his Fairdeadling Mo., home. Unlike most rigs, it's not mounted on a fixed tower, but on a flexible boom that rises and falls with the wind - for safety, efficiency, and ease of maintenance.

Anyone who's ever handled a spinning windmill, from the tiny water-pumpers on the plains to the giant NASA/ERDA job at Sandusky, knows the importance of speed control: A rig can rip itself to pieces if the blades overspin in a strong wind. And faster doesn't always mean better when it comes to generating power...

..."Why not bring the prop down to the ground and solve both problems?" Sieradzki reasoned. So he designed a windmill on a boom like that of a hoisting crane and balanced it by counterweights, so that the prop is lifted to its maximum height and automatically adjusts to face the wind...

When the wind blows...

The leaning tower is almost vertical in winds up to a preset limit (say 25 mph), and the prop faces squarely into the wind. Above this limit, however, the wind overcomes the counterweights and pushes the boom over, downwind and closer to the ground. This tilting of the shaft reduces the area of the spinning propeller that faces the wind, thereby preventing rpm from exceeding dangerous limits. Pressure on the structure is also reduced, permitting lighter construction.

"Present rigid towers," the inventor points out, "must be designed to take the highest wind force for their area - a force that occurs rarely or never." When such a blast does come, Sieradzki's prop will be lowered to within 10 feet of the ground, where it will stay until reset at its operating height after the storm - a further protection to the equipment.

Built principally of recycled materials, the windmill-on-a-boom cost Sieradzki about \$75. He obtained the alternator from a junked car, and used shock absorbers from an old truck to cushion the boom and prevent it from slamming into the swing-limiting stops...

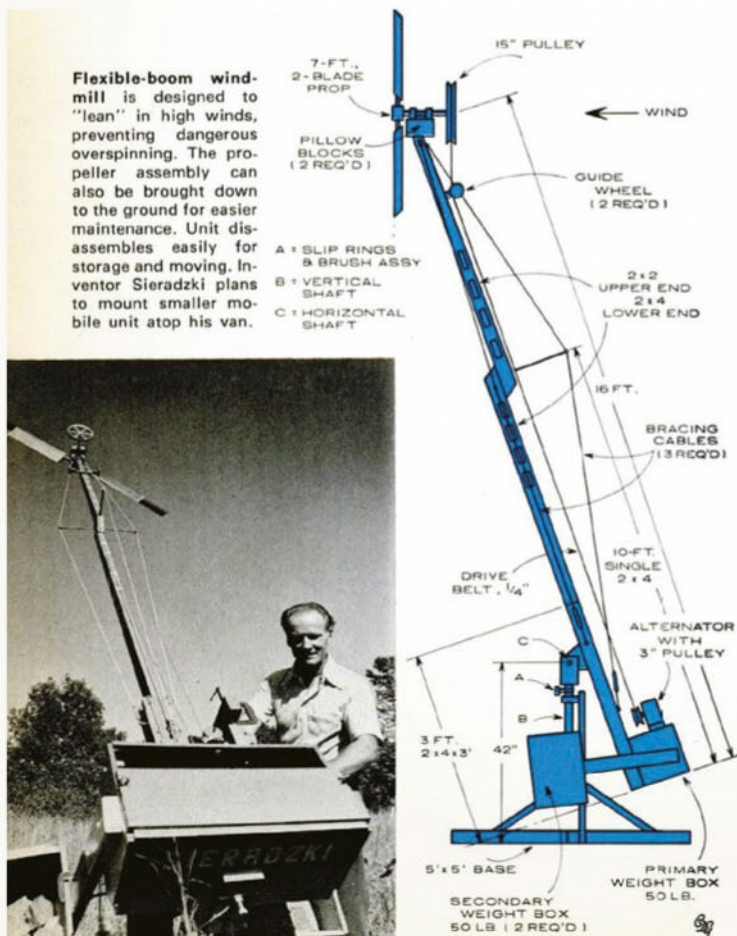
...A store-bought propeller can be costly; Sieradzki made his of 0.032" fiberglass sheet. It weighs but 3 1/2 lb, a boon because it keeps the rig from becoming top-heavy...

...One warning if you decide to build a windmill of this type: A prop spinning at 300 rpm is a lethal weapon..

Generating electricity

Sieradzki's primary goal was to test a novel design, and he admits that the power output of the device could stand improvement. By using a 5:1 stepup belt drive, he obtains 200 watts at 12 volts in a 15-mph wind...

...Steve Sieradzki plans to make further refinements of his concept (when he's not working on a solar-powered engine that also occupies his time). He thinks his idea can be adapted to large-scale applications, such as in populated areas where there might be aesthetic objections to rigid towers; he envisions an array of "invisible" windmills that could be deployed automatically at night of during high winds...



Then

Retro Invention

The Microbee

A computer built for Australian conditions

by
ANTHONY
FORDHAM

WAY BACK
IN THE DIM
MISTS OF tech
prehistory (the
1980s) the options

for a powerful home computer were pretty limited. The IBM PC was still a few years away, Apple had a crazy-expensive pricing structure, and the motley mix of kit computers in the market were aimed mainly at hobbyists.

Which is indeed where engineers Owen Hill and Matthew Starr (and a small team) initially pitched their new computer. It took advantage of the "S-100 bus", the first standard expansion bus for these newfangled "microcomputers" (ie a computer that can fit on a desk, instead of BEING the desk) and the Zilog Z80 CPU. And it made its first appearance as a kit, with instructions published in the February 1982 edition of *Your Computer* magazine.

Applied Technology, as the company was known, had already planned to offer a fully assembled version of the computer for a premium, but

made the fateful decision to bid for the NSW Department of Education's computer tender. They won, and the computer was subsequently sold in an iconic beige and black case. The name "Microbee" was supposed to give an impression of accessibility and friendliness.

Whether or not you encountered a Microbee in the 1980s depends heavily on which school you attended. Schools that dithered around until the end of 1983 probably ended up with the Apple IIe. But if the maths head teacher (or whoever was arbitrarily put in charge of the computer

labs) was pro-active, the school probably invested in a room full of Microbees.

Like all PCs from the time before "PC" became a recognised term, the Microbee's specs are kind of hilarious today. Somehow, it made do with a 2MHz CPU (your notebook probably runs at 2GHz, with multiple cores), and 16 or 32KB of RAM. It could display text on a green-only monitor at a crisp 512 x 256 resolution, and programs were stored on cassette tape.

Thanks to winning the school tender, Applied Technology was able to invest the cash in upgrades. More powerful

Microbees quickly followed on from the original, boosting CPU speed to 3.375MHz and screen resolution up to 640x264.

There was even a colour version, called the "32K Personal Communicator". Despite being theoretically able to display 32 different colours, mathematical vagaries of how RAM works meant only 27 colours were actually possible.

Anyway, this modest array of computing power was more than enough to run a basic word processor called WORDBEE and a basic programming language interpreter called, uh, MicroWorld BASIC. Interestingly,

Put a bee under your tree this Christmas.

Microbee K300

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to install the word processor, users had to plug a chip into a ROM socket. And you thought sideloadng was a pain.

Sadly, the Microbee ultimately became a sort of victim of its own success. The company ploughed all its cash into developing new models of the computer, and

like so many companies working in this area in the mid-1980s, they knew the IBM PC was coming. The Microbee Gamma was supposed to be the answer to the first true PCs, offering compatibility with various peripherals while also matching IBM's first machines in performance. But it was not to be.

Unfortunately R&D costs got ahead of Microbee's ability to make money. In the years to follow, the company was variously bought out, put in receivership, bought out again, revived, mothballed and eventually quietly faded away.

Some of its technology went into building task-specific computers (such as a diesel injection and engine

management system), but mostly the cheerful little abstract bee faded into memory...

...until the Microbee name was purchased by Ewan J Wordsworth, a self-proclaimed enthusiast and former Microbee employee. The brand now lives on at www.microbeetechnology.com.

au. While progress seems to be moving fairly sedately, there's information about new kit versions of the Microbee Classic Plus, as well as plans to release development boards that are Microbees at heart, while also

being compatible with Arduino shields and other contemporary prototyping systems.

While it seems obvious in hindsight that no small Australian brand could have weathered the onslaught of IBM PC clones that swamped the market in the 1990s and led to the computers we take for granted today, it's still somehow comforting to know that we had a go at it anyway.

And at the end of the day, having a go what being Australian is really all about? 🇦🇺

The name "Microbee" was supposed to give an impression of accessibility and friendliness.



By the beginning of the 1980s, everyone seemed to understand that home computers were now a thing. You could get a Commodore, an Atari, an Apple, a Tandy and any of a range of machines running an operating system called CP/M (which included the Microbee).

IBM was worried about its dwindling share of the mainframe market, and so decided to get in on this new microcomputer craze.

Key to making the IBM compatible PC the dominant platform of the next decade (and onward) was the decision to build it on a so-called open architecture. Anyone could build peripherals and upgrades that would simply slot into the PC and work right away. And even better, there was no restriction on what software could run on the PC.

IBM clones soon emerged, competition drove innovation, and the rest is more or less history. Including, ironically enough, the actual IBM PC. The last IBM-branded PCs were released in 2004, and Big Blue sold its personal computer business to Lenovo in 2005.

SOME ALTERNATIVES

The thing with computers in the early 1980s is that almost nobody ever had the same computer as you. There was so much choice. Here are a few.

BBC MICRO

Released: 1981

Price: GBP335

Like the Microbee, the BBC Micro was built, by Acorn, with government assistance (in this case the BBC) for education - specifically for computer literacy. It even had its own TV show.



COMMODORE 64

Released: 1982

Price: US\$595

This giant chunk of beige plastic was actually a robust machine that, thanks to its not-too-crazy price, colour and sound capabilities, became a favourite of gamers.



SINCLAIR ZX81

Released: 1981

Price:

GBP69.95

(assembled) While so many computers were prohibitively expensive in the 80s, Sinclair had a vision of a low-cost, basic machine. The ZX81 was super-successful, and was followed up by a colour-capable model called the ZX Spectrum.



ATARI ST

Released: 1985

Price: US\$999

(colour version) If you were a rich kid and didn't have a powerful Amiga, you probably had one of these. Apart from its gaming cred, the ST was used by musicians thanks to a built-in MIDI port.



AMIGA 500

Released: 1987

Price: US\$699

The Amiga 500 is interesting because it's a deliberate downgrade of earlier Amiga models to reach a wider market. It was one of the first truly mainstream gaming PCs.





Liquid Breathing Apparatus

For those times when life really sends you off the deep end

THE DROWNED RAT FLOATS IN THE aquarium full of pinkish fluid and manages to look extremely dead. Steve Gilman, lead engineer on Project Wetlung, pushes his face right up to the side of the aquarium and frowns.

"Hmn," he says. "Must have had some kind of condition, a congenital weakness, perhaps in the heart."

"Maybe," I say. "Or maybe your stupid goo doesn't work and the poor bugger just drowned."

Gilman shakes his head, then daintily plucks the rat from the aquarium and flings it into a nearby wheelie-bin. Pink fluid flies around the place and I try not to let any of it get on my latest skin grafts.

"The goo, as you call it, definitely works," says Gilman. "We had a rat in there for three days last week. And sure it died right away when we finally took it out, but the point is that the rat could breathe our unique oxygen-enriched superfluid."

"Yeah but WHY?" I say. "I don't understand what the point of murdering all these rats is! And I still don't understand why I'm here, because there is no way I'm going to try breathing that stuff myself. Hell, I'm not even sure I'm up for TOUCHING it." I feel a bit flushed.

"If you're quite finished," says Gilman acidly. "Of course I'm not going to ask you to breathe our unique oxygen-enriched superfluid. It's far too expensive to waste on specimens like you. Anyway I know your reputation. As if your lungs are currently operating to anything approaching a normal baseline right now. I heard

about that mustard gas party, so I did."

I shrug. "I don't have to defend how I choose to get high," I say. Gilman rolls his eyes at me. Then he goes back to his aquarium full of pink goo and starts poking around at all the complicated machinery attached to it.

"So why AM I here?" I demand.

It's a hot day, a ridiculously hot day in fact, and this warehouse has minimal insulation. This doesn't seem to bother Gilman at all. He's an odd sort of guy, all sweaty and clammy-looking. His eyes are really far apart, almost on the sides of his head and he never seems to blink. His skin is pale but also kind of greenish. In other words, he's a perfectly typical research scientist. But I do wonder why he's all the way out here in an abandoned warehouse rather than in the basement of the underfunded science faculty of a minor regional university.

Gilman fusses over his machinery, ignoring me. His nose drips.

"Hey!" I yell. "I asked you a question, what am I doing here?"

"What?" Gilman seems startled. "Oh yes, right. I need a second soul to balance the gateway."

"The what?" I ask. He just gestures at the large stone archway that sits incongruously in the middle of the warehouse, a little to the side of the aquarium's trestle-table. The archway looks like something from an archaeological dig, maybe reassembled here after being shipped from somewhere exotic in crates. It's covered in weird

hieroglyphs and I can see strange fish-like figures here and there.

Cables run from another pile of machinery up to the archway, and there's a bizarre almost steampunk-looking diving suit type contraption laid out on the floor. Ribbed black pipes hook this thing to a giant vat of Gilman's pink goo that sits next to the arch. Again, I wonder why the suit has so many damn legs.

"What exactly is that?" I ask, pointing, for the sixth or seventh time since I arrived.

"Life support," Gilman finally says, dismissively. He seems to be peering at a bunch of tattoos on his forearm, and then consulting in a giant old book he has sitting next to the aquarium. He mutters a couple of things, or maybe he's just clearing his throat. "Okay, right well I think the configuration is correct. You can sort of go over there and stand in the pentagram."

There's a pentagram chalked on the floor to one side of the archway. I sigh and stomp over. Gilman moves to another pentagram on the opposite side of the archway. He's carrying some kind of remote or actuator. He presses a big button. Eldritch fire crackles across the top of the archway, I feel a strange sort of tingle at the base of my spine, and then the archway fills with muddy water.

The water collapses onto the floor of the warehouse, revealing what looks like a badly mutated squid. It's about fifteen centimetres long. It writhes around for a bit, squeals, tries to raise itself up, and then expires like a deflated balloon.

"Ah," says Gilman. "Not entirely what I was expecting."

"What does all this crap even have to do with the pink goo?" I demand. Gilman fixes me with a terrible, haunted stare.

"Your world is doomed to find out, mortal," he intones. "But not until I've worked the kinks out. Here's your \$125, can you come back same time next week?"



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Viewable area of a 300 inch screen (1080P, height 3.74 m x width 6.64 m) is more than ten times greater than a 65 inch screen (1080P, height 0.81 m x width 1.44 m). Epson is the number one selling projector manufacturer according to surveys conducted by Futuresource Consulting Limited for the period from 2001 to 2015. Product features and specifications vary by model.

*EH-TW9300W Only.

MINOX

German.
Performance.
Optics.

MINOX BL HD Line

Comfortable. Lightweight. HD.



8x44 \$1149.00 10x44 \$1199.00



8x33 \$949.00



8x52 \$1349.00 10x52 \$1399.00

Excellent optical
performance
.....

High quality, high
performance HD optics
.....

Lightweight, compact
and robust housing
.....

High resolution,
neutral colour rendition
.....

Adjustable
eyecups
.....

Wide field
of view

MINOX BL HD binoculars are characterized by their distinctive lightweight design and open bridge, enabling a comfortable one handed operation. The BL HD series with its innovative anomalous partial dispersion HD glass provides an image free from disturbing colour fringes or glare.

minox.com

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