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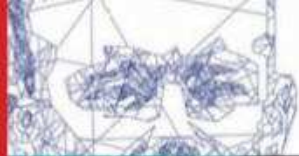
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ROGUE A.I. Why we need to start planning for it, now

DRONE CHUTES To stop the sky falling



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How probes are kept clean, and why it's so important

DISASTER!

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12

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Are We Just Waiting For a Sign?

The 20th century editors of this magazine had an easier time of it, if you ask me. The post-WW2 world was full of big technological breakthroughs, the rise of internal combustion, cars, flight, computers, space! Defining “futuristic” today isn’t as simple.

And after all, that has always been Popular Science’s primary task: to give you, the reader, a handy monthly update on the state of the future. The magazine even used to have WHAT’S NEXT written on the cover.

For the whole period between, say, 1920 and 1999, this was a pretty straightforward job. Inventors and industrialist across the world were building amazing new machines and developing innovative new methods of using them, almost faster than we could write.

Every few years - certainly every decade - something came along that changed the world, and Popular Science helped the early adopters (and the merely intensely curious) to understand it. Electricity in every home? Could that be safe? Yes! we said. Does everyone really need a telephone in the house? Why not? we asked. Jet aircraft, colour television, early computers, everything was new and amazing and if you waited a year, an even *more* amazing version of it would come out and we could do the story all over again.

But then, after the turn of the millennium, something happened. It’s not that the pace of innovation slowed down, it’s more that it just got... complicated. Instead of living in the present and imagining how awesome the future would be, we now found ourselves living in that future, and it was confusing and difficult. Is social media a good thing or a bad thing? Do smartphones bring people closer together, or drive them apart? Are cars better than ever, or pointlessly powerful? Why doesn’t anyone seem to care that there are no supersonic airliners anymore? And that’s just picking questions at random.

Maybe more significantly than this, though, is the way that all the awesome innovation we did in the mid-to-late 20th century turns out to have come at a cost. And the bill is due. Or is it? Back in the 1930s, if a company invented a new car it was straight up awesome. Today, we have to wonder if

that car still puts out too many emissions, or if its apparent lack of emissions is really just masking the problem by moving the emissions to a coal-fired power station somewhere. If a scientist develops a new strain of wheat that could triple yields (again) and put a real dent in world hunger... now we have to wonder if that wheat could kill off all the existing wheat, or whether its genetically-modified nature is harmful (it probably isn’t, but we still have to wonder).

The future, as defined by the late 20th century, was a simpler place than today. The future would just have hover cars, and jet packs, and somehow neither of these things would create new social problems, the way metadata and overusing antibiotics have.

So is writing Popular Science in 2018 a unique experience? Maybe not. Maybe I’m just not looking back far enough. Because this magazine has an unbroken line of issues going all the way back to 1919 - and those editors had to face a world that, perhaps like ours, also had no idea what “the future” meant anymore.

There are parallels. At the turn of the 21st century there was no social media, at the turn of the 20th there was no mass media. In 1918, after a previous century that saw steam ships dramatically reduce travel times between countries, the speed of travel seemed stalled. Today, our airliners aren’t significantly faster than they were 30 years ago.

Most of all though, 1918 was a world where an older generation saw the world in a very different way to the younger, and this heavily influenced almost every aspect of society.

So maybe this is just early-century-syndrome. Maybe the path to the future will become clearer again, in the 2020s or 2030s. Let’s just hope we can get there without a devastating global war.

ANTHONY FORDHAM
afordham@nextmedia.com.au

Contents

For daily updates: www.popsoci.com.au



36

Build for the Worst

As the frequency and severity of natural disasters continues to rise, planners and builders are faced with the inevitable: the next generation of houses, offices, and more must all be built tough enough to take whatever nature dishes out. Because she's going to dish out a lot...





8



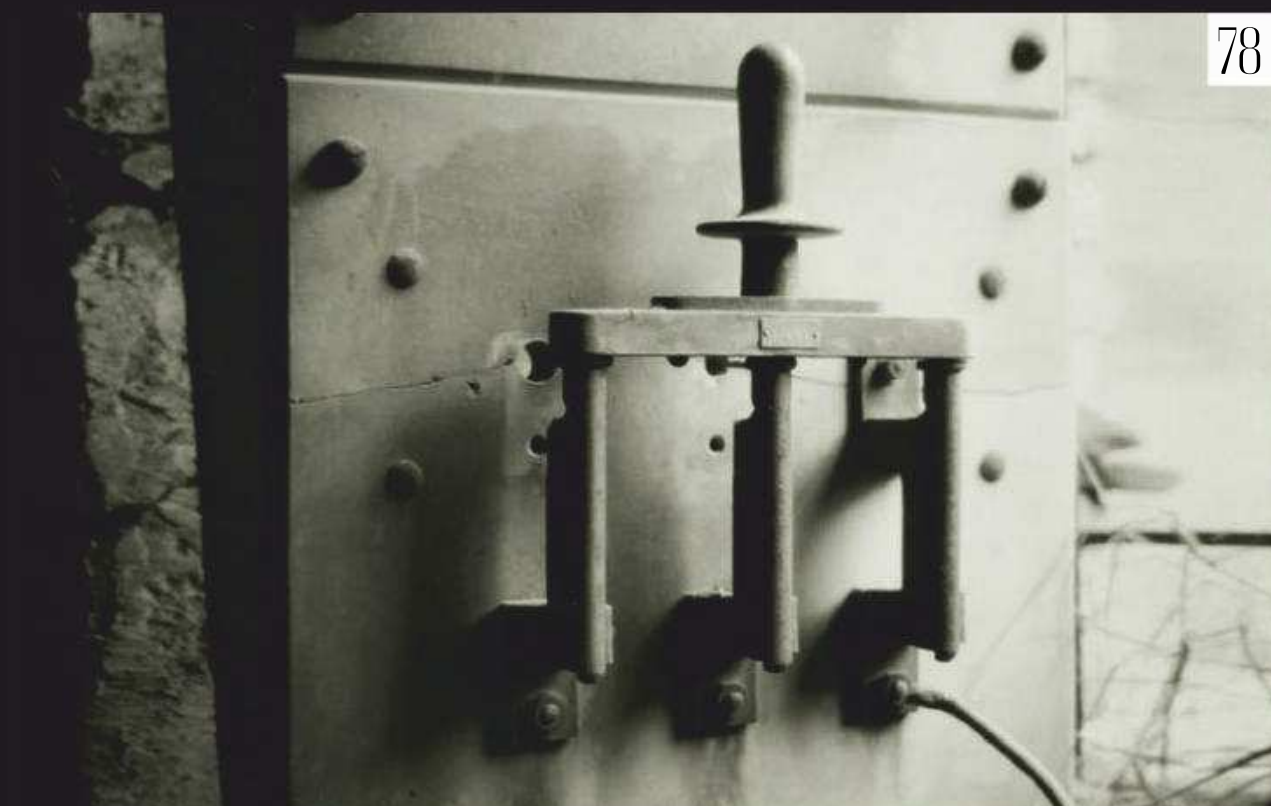
52



54



68



78



28

State of the Art

Your guide to everything

- 08 A pod to survive tsunamis
- 10 Parachutes for drones
- 12 Obsessed intimidates!
- 14 Like LEGO, but smarter
- 16 Your first pet robot?
- 18 Tools for surviving avalanches
- 20 Blades for cuttin' stuff
- 22 Super tablets try again
- 24 Oversight: Ozone layer?

Insight

Important stuff for futurists

- 28 Why does keeping germs off our space probes really matter?
- 30 What was the deal with that weird interstellar asteroid?
- 32 Can we predict the next flu, and would that save lives?

Features

Read, think, read some more

- 46 The problem with lethal injection
- 52 The Big One is still coming... maybe
- 56 We need to be ready for rogue A.I.

Rethink

Take a second look

- 64 A house that fear built
- 66 Guns: expensive for everyone
- 68 Asteroid impacts are usually bad
- 69 Melting permafrost is deadly gross
- 70 Tales from the field!
- 70 Archives: November 1934
- 78 Retro Invention: Ol' Sparky

The Other Stuff

Bonus Extra Material!

- 03 Our Editor Rants
- 06 The Big Picture
- 80 Lab Rats!
- 82 Next Issue



ICONIC SCENE GETS A REMATCH

At one point in Working Dog's 2000 film *The Dish*, bored local technicians play a quick game of cricket across the centre of the Parkes Observatory's radio telescope. It was just a throwaway gag to show Australian irreverence, but it quickly became an iconic image.

Which is why in early October, 50 young cricketers joined professionals Chris Lynn, Peter Handscomb, Alyssa Healy, Ash Gardner, and Nick Carey, to recreate the scene.

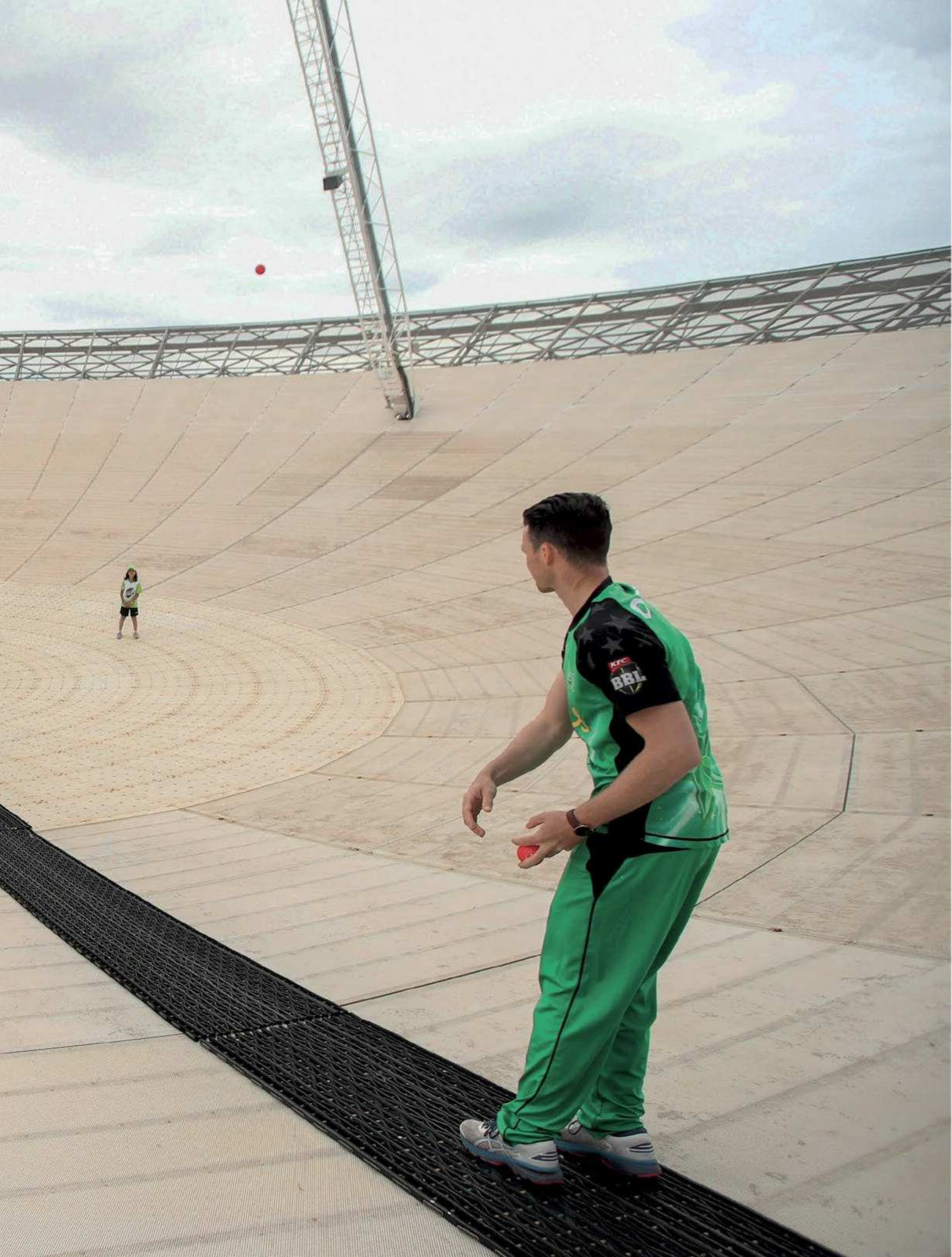
The stunt's purpose was to promote a new kid's cricketing program from Cricket Australia, but it also reminds us that Australia still plays a significant role in astronomy and cosmology, thanks to our various telescopes and observatories. www.parkes.atnf.csiro.au



A USEFUL TOOL

Opened in 1961, the Parkes Radio Telescope gained fame in 1969 as one of several antennas that received live TV images from Neil Armstrong's first moonwalk. But it hasn't been idle since. The CSIRO operates the dish today as part of the Australia Telescope National Facility, where it links up with dishes at Narrabri and Mopra to work as a very long baseline interferometry array. It's the second-largest moveable dish in the Southern Hemisphere - the largest is at Tidbinbilla, near Canberra.





State
of the
Art

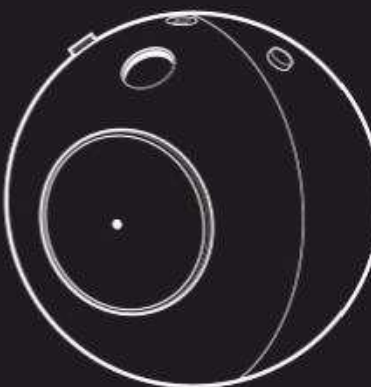
Ride or Die

by ELEANOR CUMMINS



SURVIVAL CAPSULE

4'6"



- **CAPACITY:** 2
- **MAX FOOD:** 5 days
- **ORIGIN:** Mukilteo, WA

TENS OF MILLIONS OF COASTAL residents face rising tides from earthquakes and tsunamis. Preparedness experts suggest infrastructure like evacuation centres and seawalls for protection, but proactive residents can also turn to the two-seater Survival Capsule, a 1.3 m (diameter) spherical escape pod.



PHOTOGRAPH COURTESY SURVIVAL CAPSULE (3)

The orb is built to bob. Its aviation-grade aluminium shell should hold its shape, even when massive waves and debris pummel houses and cars. Water tanks and built-in seats (there are models to accommodate up to 16 passengers) concentrate the craft's weight at the bottom, so, like a pontoon boat, the sphere stays upright. Evacuees seal themselves inside behind a submarine-style door—turning a wheel to engage locking arms that hold the hatch in place. And though the pod comes with a coated steel tether, Coast Guard-approved “marine orange” paint makes the bubble easy to spot if it floats out to sea.

900+

The force, in kilograms, it would take to submerge a two-person escape pod—and keep it there.

Why Drones Need Parachutes

by ANTHONY FORDHAM

THE AGE OF DRONES IS UPON US AND WE HAVE TO DEAL with a sky full of quadcopters. Which means, inevitably, we have to deal with those quadcopters falling out of that sky from time to time, because no machine is perfect. Sure, when a consumer drone like DJI's Phantom 4 crashes on a beach, the risk of serious injury to the public is relatively low. But some professional and industrial drone platforms can weigh as much as 300kg! You definitely don't want one of those falling on your head.

Which is where Israeli company ParaZero comes in. Their SafeAir system sounds simple on paper: a module on top of the drone deploys a parachute to bring the drone safely to the ground. But there's more to it than that...

ParaZero CEO Eden Attias told Australian Popular Science that SafeAir doesn't just stop drones smashing into people's heads, it also does its best to save the drone itself.

This is in contrast with parachute systems

on some light planes, which only deploy when the plane has, shall we say, irreversibly exceeded its flight envelope. The system saves the humans in the plane, while writing-off the plane itself.

"A parachute system like that is only deployed once the flight envelope is exceeded," says Attias. "The SafeAir system can monitor the flight and anticipate

that a problem is going to occur."

What's more, once the chute has deployed, SafeAir can use the drone's rotors to guide it down to the ground (as best it can). So it doesn't just drop into the middle of the angry mob, it can be steered away to a quieter landing.

SafeAir has been deemed good enough already that in the US, the FAA has authorised some drones

equipped with the system, to be flown over people. This is a vital step forward for drone operators, according to Attias.

"One day there will be an unmanned traffic management system that handles all these platforms autonomously," he says.

But for now, it seems, SafeAir is considered good enough. It's currently available for DJI's Inspire platform and up, including the M200 and M600. Attias says the company's next step will be to create a super lightweight system that can go on prosumer drones like the Phantom 4.





For us, innovation must
always serve function. For
example, raising our bezel by
2mm has improved the grip.
Just a little.

When you care about watches,
just a little matters a lot.

#GoYourOwnWay



Aquis Date

ORIS
HÖLSTEIN 1904

State
of the
Art

Obsessed

"You can't always get what you want," sang the Rolling Stones all those years ago, and we agree - although not maybe in the way Mick Jagger was thinking. Because how can you even *know* what you want, without first feasting your eyes on another 10 not-quite-useless gadgets, as presented by us? I mean, who already knows they want magnetically-connected touch-sensitive hexagonal lights?

selected in the spirit of Festivus by ANTHONY FORDHAM

NOTE ON PRICING: How long can it be until the New World Order imposes a universal currency on us all as part of their terrible plan to end all wars and lift billions out of poverty? For now though, the internet seems to be getting better at detecting where you are and what your currency is. Prices are therefore in AUD.



ERA Prometheus Tourbillon

\$1385

erapiece.com

Don't you hate the way every awesome crazy complicated watch costs, like, \$50,000? ERA wants to bring you, the pauper with a mere \$1400 to spend on a watch, a beautiful timepiece that includes a "tourbillon" in its movement. Tourbillons (French for "whirlwind") are circular cages in which the escapement (the cog that transfers power from the mainspring) and the balance wheel are isolated against the effects of gravity. Fancy! We have a soft spot for mechanical watches.



Artiphon INSTRUMENT 1 US\$399

artiphon.com

MIDI controllers that enable a bit of dynamics (sorry, \$100 keyboard) remain a thing, and the Artiphon INSTRUMENT 1 is one of these things. Pair it with an app and play it like a keyboard OR strum it like a guitar. See: both types of music! Its pressure-sensitive surface enables string-bending and polyphonic aftertouch. There's a built in speaker, six hours of battery life, and it supports standard MIDI so you can use it with hardcore DAWs on PC.



Astrohaus Freewrite Traveler

\$456

astrohaus.com/traveler

Is there any group of professionals in the world more distractable than writers? ... Sorry, where were we? Ah yes, the Freewrite Traveler (sic) uses a Kindle-style e-Ink display and a nearly-full-sized keyboard to offer writers a distraction-free environment for their work. The Traveler does nothing except very basic word-processing, which is the whole point. It syncs to Dropbox, Evernote and Google Drive, and has a four-week battery life. Check out those natty hinges!

Zencube Himalayan Salt Lamp

\$399

thezencube.com

First, take a big cube of rock salt (ideally from the Himalayas), drill out the middle, and shove a LED and a heater in there. The light glows through the salt, and the heat releases "negative ions". Which are good, apparently. That LED is colour-controllable, by the way, so yeah this cube of rock salt has an app. Also, there's a tray on the top into which you can drizzle some essential oils. So sit back, enjoy the ions, and light up your life with a cube of salt.



Helios Touch

From \$299

www.heliostouch.com

Every gadget these days has to be touch-sensitive, and expand using magnets. Exhibit A: Helios comes in packs of 15 hexagons with magnetic hooks. Arrange them in the shape of your preference, plug one into the wall, and then touch each hex to light it. It gives a room a lovely late-80s TARDIS interior feel. For the extremely rich, Helios assures us that the system supports an "infinite" number of tiles, so you can coat an entire wall. If you think that's necessary.



Apollo Graphene Battery

\$99

elecjet.com

Forget Lithium-polymer, the future of batteries is graphene! Graphene charges really quickly, and it's much less prone to puffing up and catching on fire if you hurl it on the ground. The Apollo is a 7000mAh pack which might look unremarkable, but its party trick is that it can fully recharge in just 20 minutes. That's if you plug it in via a special 60W adapter. Its ability to deliver high wattages means you can use it to power laptops, with various adapters.



Onyx RCR Electric Bike

From \$3900

onyxmotorbikes.com

Like the idea of electric bikes, but not how dorky they look? Enter Onyx. Its bikes look cool, and the RCR can hit over 100 km/h and has about 120km of range. Since it goes so fast and doesn't have pedals, it will need to be registered as a motorcycle, and you'll need a license. Onyx says the RCR is trail-capable (with chunkier tyres than shown here), so it could be your ultimate two-wheel adventure machine. Another model, the CTY, has pedals but falls afoul of Aussie laws: its top speed of 48km/h exceeds our 25 km/h max.



MasterSous Multi-cooker

From \$349

www.mastersous.com

Move aside Thermomix! MasterSous says it scores over Thermomix in three important ways: you can control it over Wi-Fi via a custom app, it works as a deep-fryer, and it has a sous vide feature. In fact it's eight cookers in one, and even comes in four different colours! And the big pot on top is stainless steel, which is something MasterSous really pushes hard for some reason.



Cosmo Communicator

www.planetcomp.co.uk

\$759

Everybody misses those wild Nokia phones with the flip out keyboards, and their Blackberrys of course. So Cosmo hopes to tap into that nostalgia with a clam-shell-design smartphone that has a teeny hardware keyboard. Specs are considerably beefier than the original Nokia Communicator 900 from 1996. The Cosmo runs Android 9, and has an external touchscreen as well as the 6-inch display inside. It can also run Linux. You nerd.



Elektronista Digital Clutch

\$299

uk.knomo.com

Bags specifically designed to carry all your gadgets have typically been more on the "student backpack" end of the design spectrum. Knomo presumably looked at how badly people were scratching their smartphones in their traditional handbags and said: The world needs is a digital clutch! The Elektronista is slim and easy to one-hand. But inside are a multitude of pockets to secure your phone, and cables. It also includes a battery to recharge your phone on the go.



Little Bits Are Back (In a Big Way)

by ANTHONY FORDHAM

BACK IN 2011, A NEW YORK START-UP CALLED LITTLEBITS CAME UP with the idea of using small magnets as connectors for electronic building blocks. But instead of a slightly dry Dick Smith Electronics style (this is a resistor, this is a capacitor etc), littleBits used tech like accelerometers, Bluetooth modules, and even an Arduino, to offer kids more exciting projects - and to encourage further invention. Now littleBits has a new wave of inventors kits, which include new “bits” and even more functionality.

littleBits Space Rover Inventor Kit

Price: \$349.95

Web: littlebits.com

Includes: 15 bits, wheels, perfboard, card templates

NEW BITS, NEW TRICKS

The Space Rover kit includes 15 different bits, and pre-cut card templates to build a basic rover that can be controlled via the littleBits app. The intention is that kids get inspired by the included projects, and then go on to mix the bits with other kits to create, well, whatever! Here are few of the bits that make it all possible.

1. Power Bit

This new version of the power bit still uses a 9V battery (included!) but now has a plastic shield to help kids resist the temptation to short it out and watch it melt.



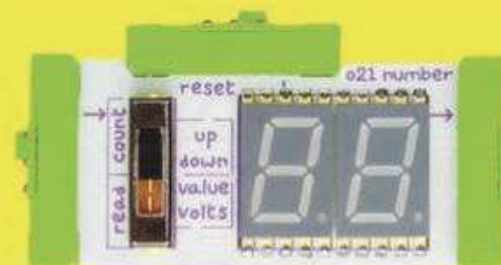
2. Control Hub Bit

This bit incorporates a Bluetooth LE transceiver with a speaker, and has one input and three outputs. It communicates with the littleBits app.



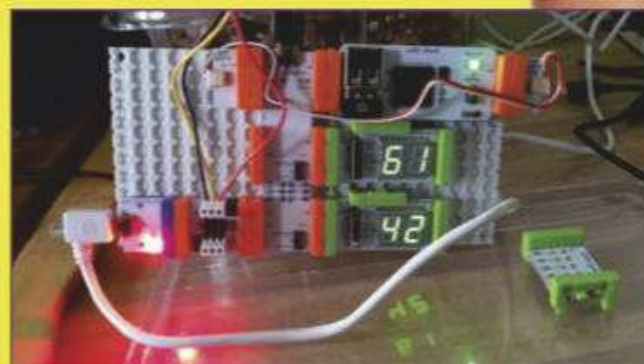
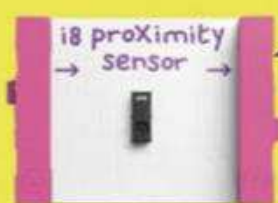
3. Number Bit

A two-digit number display, this bit can be set to count, show a value, or show the voltage passing through it.



4. Proximity Sensor Bit

Essential for giving your robots the ability to not bump into things, the proximity sensor sends a signal via its output side whenever it detects an object.



MORE THAN A TOY

littleBits might be targeted mainly to parents and teachers, but that doesn't mean it can't be used for proper, deep-geek stuff. The platform adheres to various open standards, which allowed self-proclaimed tinkerer Dennis Hitzeman to build a temperature and humidity monitor, using a sensor from Adafruit alongside his collection of bits.

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So Smart You Won't Even Notice

by ANTHONY FORDHAM

AFTER THE HUGE SUCCESS OF ITS COZMO “HOME ROBOT” IN late 2017, Anki has set itself an even bigger challenge: convince robot lovers to pay a lot more for a bot that seems to do less. Vector (\$450!) doesn't do less of course, he does much more, but Anki has a problem: the most impressive features of this new robot are things that most people assume robots can already do. Here's why Anki says Vector really an important step forward for home AI.

COZMO THE TOY

Anki admits that last year's robot, the similarly-shaped Cozmo, generated his personality mostly via tricks. He could only be operated via an app on a device connected via Wi-Fi, and in fact Cozmo parasitised that device's processing power to do a bunch of his party tricks. Cozmo's SLAM (simultaneous location and mapping) was impressive for a sub-\$500 device, but he mostly blundered through the world being endearing thanks to good animations.



ALSO A HOME ASSISTANT

Somewhat weirdly, Vector also functions as a fairly basic, squeaky-voiced version of Google Home or Amazon's Alexa. You can put him in query mode by saying "hey Vector I have a question". He'll then open a link to the internet and be ready to send your question to Cloud-based voice-processors (Anki says no data is retained at all, unlike Google et al). If you ask him the weather, he'll give you the current temperature and conditions for your location - complete with a little animation over his face. Anki says Vector may one day be able to do all sorts of things for you, including book tickets, order groceries, and all the other stuff Google already does. It'll be like trusting the dog to make sure the travel agent hasn't messed up your itinerary. Which is... cool?



STATUS NOT CONTROL

Vector doesn't need an app running on your smartphone to function day-to-day, but he does squirt data to the app on request to let you know various statistics - how far he's trundled on his little treads, how often you've patted (sorry, "petted") him etc. The app also tells you explicitly what he's doing, which is useful for power users who want to mess around with him via Anki's SDK.

GOOD LISTENER

In what Anki says is a seriously next-level integration of hardware and software, Vector has a four-way directional microphone on board. This lets him do something that we just take for granted: if he hears a noise coming from the left, he can turn to "look" at it. This enables a subtle but important bit of behaviour: when you get his attention by saying "Hey Vector", he'll turn to look at you. He also reacts to sudden loud noises - drop a saucepan in the sink and he'll wake up and trundle over to have a look at what's going on.



WILLING TO LEARN

Out of the box, Vector doesn't play as many games as Cozmo (the earlier robot could mess around with the included three cubes; Vector only has one cube), although he does have a basic blackjack app on board. But Anki says Vector has a roadmap of software upgrades they'll roll out via the Cloud, and importantly, he's already equipped with the ability to recognise objects, not just the sigils on the sides of his cube. Could he one day play chess with you on a real chess board? Maybe: but you'll have to move the pieces for him.



YES, BUT WHAT DOES HE DO?

Anki's biggest challenge in selling Vector to the non-robot-obsessed public is in helping them understand he's not a toy, or a tool, or a servant. He's more like a pet. And like small pets, he doesn't really DO anything. Why do some people like small animals as pets? Because they're fun play with. As Vector gets more upgrades, his behaviour will become more sophisticated. A pet rat's motivations might always be obvious (steal food, destroy electrical cables) but we know it doesn't just act randomly. Once Vector can convincingly simulate that level of engagement with the world around him, Anki will have created a new segment: the companion robot whose only real purpose is to be your friend.

ANNOYINGLY ALIVE

Anki wants you to leave Vector powered up all the time. After all, he's capable of finding his way back to his charger. If his constant trundling around and acting scared about the edge of the table gets old (and it will), you can tell him to "go home". Once back on the charger, he'll drop into a sleep state - but his sensors are still active and he'll wake up at any sudden noise. Anki says he's pre-programmed for "quiet time" between 2300h and 0700h though, and won't disturb you overnight. Unless you ask him to wake you up at 0630h. Which you can do.



YOU ARE NOT A BOX

Cozmo had the ability to recognise faces he'd previously recorded via his camera, and Vector does that too of course. But Vector also recognises humans generally, from a wide variety of angles. That means if a person walks in front of his camera, he'll react, even if he doesn't already know them. Vector's object recognition is also sophisticated enough to detect pets. How can a consumer-grade robot do this? Anki confesses: Vector is pretty inaccurate with his human-detection, but he's been set to err on the side of false positives, rather than false negatives. Mistaking a hanging jacket for a person is cute. Ignoring his owner is not.



Snow Survivor

by BERNE BROUDY

ANYONE WHO VENTURES FAR INTO BACKCOUNTRY MOUNTAINS—or even skis off-piste at a resort—should know what they're getting into. Slides kill more than 150 people worldwide every year, doing in snowmobilers, skiers, and snowboarders. But carrying the right gear (and taking a safety class) will make those epic, swooshy descents safer. These tools will help you get rescued—or save a teammate—in a snowfall emergency.

4/Shovel

The aluminium blade on the 680-gram **Backcountry Access RS EXT** avalanche shovel clicks into its 600-mm handle. The tool has two configurations: a traditional spade for scooping, and a hoe for moving chunks away for even quicker dig-outs.

1



1/Backpack

A folded bladder inside the **Mammut Light Removable Airbag 3.0** embiggens you once it's deployed, so ideally, you'll float at the top of a snow stream. Yank the handle on your left shoulder to trigger an air canister and inflate the nylon balloon in three seconds.

2



2/Beacon

The three antennas in the **Black Diamond Recon BT** unit transmit and receive radio signals on a dedicated frequency. Start the journey into treacherous terrain with it in "send" mode; your friends will set theirs to "search" if they need to track you down.

3



3/Probe

It takes some poking around to find a buried traveller. The aluminium **Ortovox ALU 320+ PFA** probe snaps together like a tent pole to be more than 3 metres long. Your buds will plunge it into the snow until it taps your body, gear, or pack.

Self-Inflicted

In most accidents, a group is hit by a snowslide they themselves triggered.



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Blade Stunners

by ROB VERGER

SHARP BLADES ARE SAFER. STRUGGLING TO FORCE A dull edge through veggies or fabric makes you more likely to slip and take a bloody trip to the ER, with a fingertip on ice. You'll also have to endure a lot of tired jokes from doctors about cutting pumpkins. So to avoid this, wield these cutting tools, and their honed, tough blades, with joyful efficiency—and care.

Scissors

To triple the strength of its **Titanium Scissors**, Fiskars coated the stainless-steel choppers with a layer of its name-sake metal. The 200-mm prongs won't dull or ding, even after an unfortunate encounter with a staple or pin.

Pocketknife

Sometimes you need to bust open an Amazon box or chop an onion on a camping trip. The **Benchmade 535 Bugout** folding knife hides an 85-mm steel-alloy cutter in its synthetic resin handle. As a result, the entire tool weighs less than 55 grams.

Razor

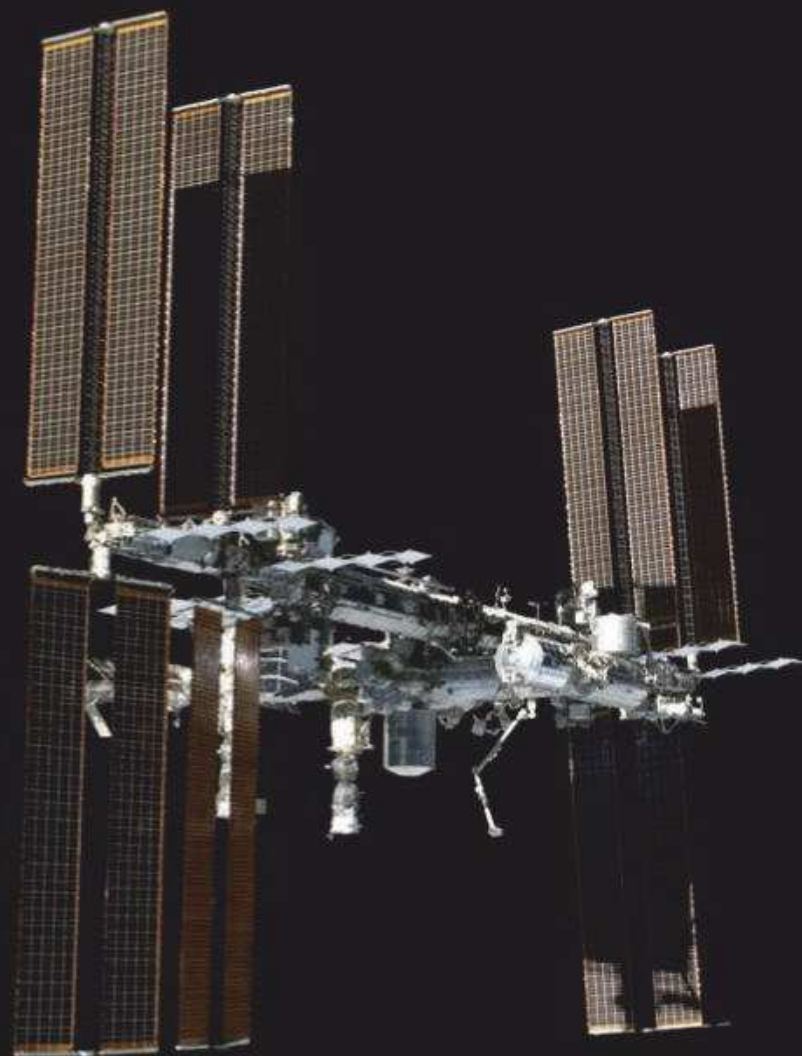
When shaving, a worn or nicked blade will butcher sensitive skin. The 15-m-wide cutter on the **Waldorf 24 Carat Gold** straight razor is carbon steel, which hones easily but is prone to corrosion over time. The gold outer coating, however, fights off rust while adding bling.

Utility blade

The scalpel-like, 25-mm slicer on the **X-Acto Retractable-Blade** breezes through crafty materials such as balsa wood or plastic. Once you're done cutting, use the slider on the handle to retract the pointy bit inside the body for safe storage.

Kitchen knife

Kyocera's 150-mm Chef's Santoku has a ceramic blade that's harder than steel, so it stays sharp up to 10 times longer than its flame-forged counterparts. The 180-gram tool slices easily through slippery work such as carving raw chicken.



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.



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screeninnovations.com/SPACE

Supertablets: The Next Generation

by ANTHONY FORDHAM

HAS THE BIG-SCREEN MOBILE PHONE KILLED THE TABLET?

A regular tablet certainly doesn't seem like a must-own gadget anymore: smart TVs handle all the big stuff, and a smartphone with a 5.5 to 6 inch display handles the rest. But perhaps supertablets still have a role to play, for a certain type of user. Here are three different new takes on the concept, from three of the most persistent tablet evangelists.

IPAD PRO 2018

Apple has doubled-down on its iOS powerhouse, giving the new iPad Pro a suped-up version of the iPhone XS's A12X CPU. The device has slimmed to 5.9mm thick, the bezels are thinner too (and have rounded corners - so hot right now) and the 2388x1668 display is optimised for creative work. That means more accurate colours, and a higher refresh rate for smoother animation and video work.

Radically, Apple has dropped the proprietary Lightning connector and replaced it with a USB-C socket (and dropped the headphone jack too), and has boosted the top model's onboard storage to 1TB.

Opinions about iOS 12 are mixed: it's still not as flexible as a "proper" desktop operating system, but Adobe is now producing pro-grade apps specifically for iPad.

The keyboard case and Apple Pencil cost extra, so like all of these supertablets, the iPad Pro is a laptop-level investment once you get all the bits you actually need to make it more than a regular tablet.

Price: From \$1229

GOOGLE PIXEL SLATE

The premium Android tablet has struggled to maintain much market share in the face of big smartphones. Usually, an Android tablet is something you get for free when you sign up to dodgy vocational college, or something you buy for \$49 off a weird Chinese gadget site.

But Google still believes in the format, and the Pixel Slate is its latest try. Rather than run Android like a smartphone, the Slate uses Google's Chrome OS. This makes it more like a laptop to use - but it's compatible with Android apps and Linux apps too.

People who shop via specs might not be too impressed. The Slate starts off with a Celeron CPU, and only 32GB of internal storage - though of course being a Chrome OS device, Google wants you to keep everything in the Cloud.

However, at least it's a viable alternative to Windows and iOS. Is "not Apple, not Microsoft" enough to make a device worth buying?

Like the other tablets here, the keyboard cover costs more than \$200 extra, but it is sensibly laptop-like with a nice big trackpad for mouse work - something Apple continues to resist on the iPad.

Price: From \$899

MICROSOFT SURFACE PRO 6

We could be wrong, but we could also have sworn that last year Microsoft said it wouldn't be numbering its Surfaces Pro anymore, and each new version would just be the Surface Pro. Anyway, here's the Surface Pro 6, and the big news for 2018 is you can now get it in BLACK.

As has been the case for the last five years, the Surface Pro is a laptop PC that wants to work as a tablet, making it the conceptual opposite of the iPad Pro and the Pixel Slate. That means it's heavier, and the 12.3-inch 2736x1824 display is just a little too awkward to cradle on the couch or in bed.

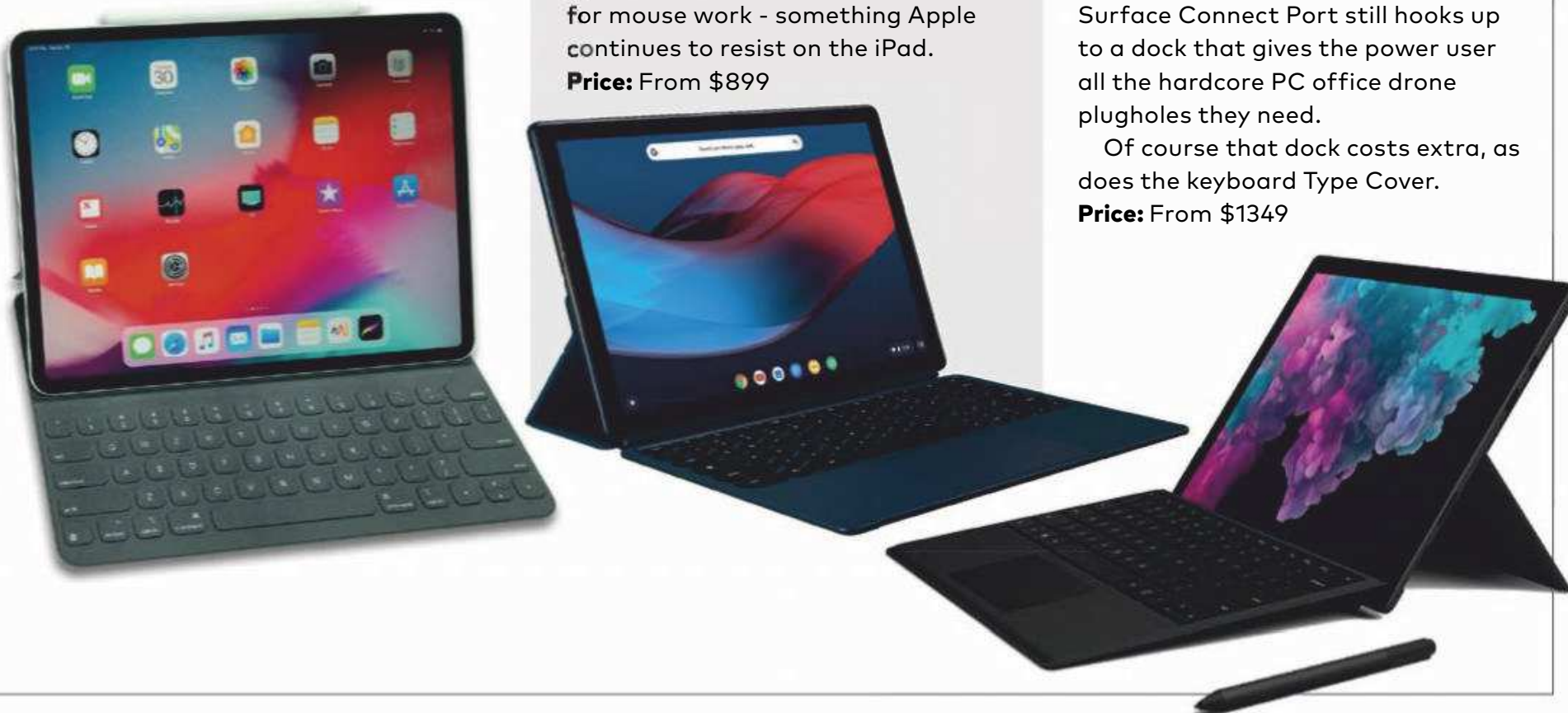
But it does get an 8th generation Intel CPU - i5 or i7 - and the base model has 8GB of RAM and 128GB of onboard storage. Those are laptop specs... because if we're brutally honest, the Surface Pro is really a laptop.

The Surface Pro also has a mini DisplayPort, an SD card reader, a proper headphone jack... and an oddly old-school USB 3.0 port that's not the fastest version of USB out right now.

Other hardware focuses on enterprise-grade security, and the Surface Connect Port still hooks up to a dock that gives the power user all the hardcore PC office drone plugholes they need.

Of course that dock costs extra, as does the keyboard Type Cover.

Price: From \$1349





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MISSION ACCOMPLISHED?

Whatever Happened to the Ozone Layer?

by JENNIFER LU

THANKS TO THE 1987 MONTREAL PROTOCOL, THE OZONE layer continues to recover, according to the 2018 Scientific Assessment of Ozone Depletion from the UN. This includes the “hole” over Antarctica where the ozone layer is exceptionally thin, which has been gradually shrinking since the early 2000s and is projected to heal by the 2060s. This year, the hole spanned about 14.4 million square kilometres, an area a bit under twice the size of Australia.

“Generally, it’s good news,” says Paul Newman, co-chair of the new assessment and chief scientist of earth sciences at NASA Goddard Space Flight Centre. “The projections into the future are pretty positive as long as parties continue to comply with the Montreal Protocol.”

The ozone layer is a 50 km thick buffer that occurs naturally above the troposphere and protects the Earth against ultraviolet-B radiation. Without this layer, life on land could not exist. More harmful radiation would reach the earth, increasing the likelihood of skin cancers and cataracts in humans, and damaging plants and most aquatic life.

In the mid-1970s, scientists discovered that manufactured gases drifted high into the atmosphere and were transformed by UV into chlorine and bromine radicals, which destroy ozone.

Then, in 1985, scientists discovered a hole in the ozone layer growing over Antarctica. Forty-six countries acted to regulate these gases under the Montreal Protocol, which has since been adopted globally.

Substances controlled under the Protocol include chlorofluorocarbons, hydrochlorofluorocarbons, methyl chloroform, and bromine-containing halons and methyl bromide.

Ozone in the northern hemisphere is projected to return to healthy levels in the 2030s, southern hemisphere ozone in the 2050s, and polar regions - where depletion is most severe - in the 2060s.

That’s not to say there aren’t any flies in the ointment, Newman says. Certain ozone-depleting substances like chlorofluorocarbon-11 (CFC-11) are decreasing from the atmosphere more slowly than projected. And two independent networks have confirmed an uptick of emissions over eastern Asia since 2012, though their exact origins are still being investigated. If someone is releasing them today, they’ll continue to do damage for generations to come.

To make this point, Newman keeps a small can of a different CFC—chlorofluorocarbon-12, the original Freon refrigerant—in his office. “If I were to dump this can onto my floor,” Newman says, “five per cent of that would still be floating in the atmosphere 300 years from now.”

That’s why it’s important that parties abide by the Montreal Protocol and the Kigali Amendment that was added in 2016.

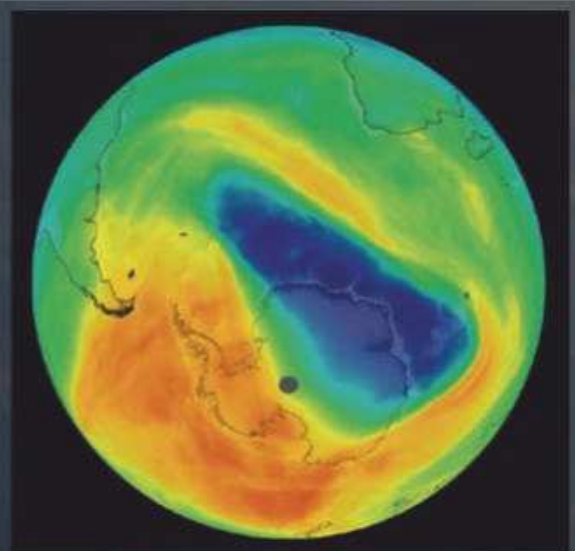
This amendment, which takes effect in January 2019, addresses chemicals used to replace those banned by the Montreal Protocol.





A RARE (POSSIBLE) SUCCESS

Among the endless depressing stories about climate change and environmental degradation, at least we can point to fixing the hole in the ozone layer as one success, right? Unfortunately, while banning CFCs and other substances halted the expansion of the hole, we still need to wait for at least another 30 years before we can expect it to close permanently. In this image, the blue indicates very low levels of ozone, and shows that the hole is still quite substantial. It does fluctuate in size due to other atmospheric conditions, so some years are worse than others. If nothing else though, the ozone hole shows that human activity *can* have an effect on the structure of the atmosphere, and that simply reducing pollution can slow - or even stop - further damage.



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POPULAR
SCIENCE

ISSUE
121

INSIGHT

DECEMBER
2018



28

MEET EARTH'S
PLANETARY
PROTECTION OFFICER

30

WAS THAT WEIRD
ASTEROID ACTUALLY
AN ALIEN SHIP?

32

CAN WE PREDICT - AND
PREVENT - THE NEXT
FLU OUTBREAK?

Insight

Guardian of the Galaxy



LISA PRATT WAS NEARLY 3200 METRES BELOW

ground in a South African gold mine when the lights went off and the air stopped moving. Power had cut out, along with the reassuring roar of the ventilating fans that regulate the mine's methane and carbon monoxide levels. Pratt, then an Indiana University geology professor, was hunting for evidence of life-forms capable of surviving in extreme dark, salinity, and temperature. As miners began to pour from a crease in the rock above her and run for the exit, it was clear that humans weren't on that list. "It was not a good moment," she recalls of that day in 2001. "I honestly thought that might be the end of the line."



Today, Pratt's work in such environments has led her to a brightly lit office at NASA headquarters in Washington, DC, as the agency's planetary protection officer. In this sparse room with a laptop and a whiteboard, she still ponders a question she faced during her years of crawling, sliding, and rappelling into harsh places to collect extremophiles: "How do you look for signs of life without inadvertently bringing life with you?"

Pratt's answer will influence everything from spacecraft construction to interplanetary flight plans. Her core mission is this: Keep Earth's hardiest microbes from hitching rides on equipment we send to places like Mars, and try to stop native critters (if they do in fact exist) from thumbing a ride back.

Since the launch of the satellite age, most space-faring nations have adhered to strict contamination-control guidelines set up by the Committee on Space Research (COSPAR). These don't call for complete sterilisation—an impossibility without damaging a spacecraft's materials and electronics. Instead, they rely on a probabilistic approach that tries to minimise the likelihood of a tough little microbe making its way to another world. To achieve that, Pratt is working

by BRYAN GARDINER

with NASA engineers and mission planners to ensure these guidelines are met as the agency constructs new spacecraft.

"Everybody has played well together on this," Pratt insists, "at least until just recently." By that she means Elon Musk. In February, his private company, SpaceX, sent a (microbe-laden) Tesla Roadster hurtling through space. While it's unlikely to collide with any planet in the next 100,000 years, Pratt still lets out an exasperated groan when the topic comes up, and launches into a long list of all planetary-protection protocols that SpaceX ignored.

Pratt doesn't have the power to slap Musk with a fine for cleanliness infractions, but she can try to convince companies like his that protocols matter. With SpaceX planning to deliver mining and life-support materials to Mars ahead of what could be actual humans, there's a new urgency to her mission. "We don't have any agreements or methods in place to get cargo like that clean," she says. Over the next several years, working with COSPAR and private space companies, Pratt will try to formulate agreements and guidelines for public- and private-sector space powers.

She doesn't have much time. Once humans carrying microbes step onto Mars, a key opportunity for discovering new life will end. And even then, what if we do find life out there? While momentous, it won't necessarily trigger a global embrace. "Earth as a whole is going to say, 'Sorry, until we know enough about it to be certain it's not dangerous, you can't bring it home,'" she says. "You can't just bring a Mars pet back with you."





“

**HOW DO YOU
LOOK FOR SIGNS
OF LIFE WITHOUT
INADVERTENTLY
BRINGING LIFE
WITH YOU?”**

—LISA PRATT

It Probably Isn't Aliens

INVESTIGATOR / NEEL V PATEL

Insight

REMEMBER THAT WEIRD interstellar asteroid? Harvard University physicist Avi Loeb and postdoc Shmuel Bialy do, and their new paper suggests a possibility that the interstellar asteroid known as 'Oumuamua might be a light-

sail-propelled spacecraft of artificial origin designed for interstellar travel. Yes, they're saying it might be aliens.

Or rather, they're saying aliens in an attempt to explain some of the object's weird behaviour. And the outraged response to their paper is a good example of why extreme ideas should be treated with caution.

Here's the deal: one year ago, 'Oumuamua came from interstellar space for a quick visit to the solar system, zipping through at 315,000 km/h. Scientists hastily went to work collecting as much data as they possibly could. They had about three months with the Hubble Space Telescope to observe 'Oumuamua before it was gone forever.

'Oumuamua is 800 metres long, 80 meters wide, composed of rock and ice mashed together into a rough cigar. Is it a comet or an asteroid? Its **shape suggests a comet**, but it didn't act like one.

The object made small **changes in direction** and speed that could not be attributed to gravitational forces alone, **accelerating as it left** the solar system. A good explanation for this would be outgassing — where jets of gaseous material are expelled from the **surface** and the object's volatile icy components, increasing the 'Oumuamua's overall velocity. This would have been a clear sign that it was a comet.

But outgassing is supposed to happen as a comet moves toward the sun, not as it moves away. Loeb and Bialy have put forth a counterargument that suggests 'Oumuamua's movement is what we might expect if the object was designed to be propelled through space using the force of the sun's light on a sail. Solar radiation hits the lightsail and induces a force that speeds up an object as it moves through space.

In his defence of the paper, to be published next week in *The Astrophysical Journal Letters*, Loeb told NBC News *Mach* that his new hypothesis was "purely scientific and evidence-based... I follow the maxim of Sherlock Holmes: when you have excluded the impossible, whatever remains, however improbable, must be the truth."

That's a pretty wild way to come to such a radical conclusion. Michele Bannister, an astrophysicist at Queen's University Belfast in Northern Ireland, emphasises that Loeb's hypothesis would only be appropriate if there

were no other good explanations for the abrupt increase in 'Oumuamua's acceleration. "And we do have a good explanation that fits the data well," says Bannister, citing a paper published in *Nature* earlier this year that uses data to support the notion that outgassing occurred on the object's exit from the solar system.

Anyway, if 'Oumuamua is a comet, it's certainly not the first to have no tail. 2P/Encke is a prime example of such a comet, yielding larger particles on the scale of several millimetres in diameter versus smaller bits of dust just microns in diameter.

"There's a range of comet behaviours," says Bannister. There are trillions on trillions of tiny ice-and-rock worlds strewn about the universe. It's probable, she argues, that we'd expect to see one acting a bit unusual like 'Oumuamua.

This paper isn't the first time 'Oumuamua was labelled a possible alien spacecraft. But there's a big difference between that speculation from a year ago, and what Loeb and Bialy are pitching now. A year ago, people were trying to understand the data as quickly as possible in order **to figure out whether** our instruments should look for **something in particular**, and that's why wilder **ideas were taken** more seriously.

Now, "it's been over a year since the flyby of 'Oumuamua," says Bannister. We're **now seeking** to simply increase our overall understanding of the visitor, and those things will take time to crystallize. A new hypothesis like the

Harvard researchers' is more noise than signal.

So why does this paper exist? Astrophysicist **Katie Mack** raised a good point on Twitter that

many scientists are happy to speculate on even the most extreme explanations for a phenomenon when it can't be proven 100 per cent false, even if they don't really take those explanations seriously.

Loeb and Shmuel may have actually sought to provoke some strong responses through their paper. Why? Loeb is heavily involved with lightsail research, particularly as a part of his work as the chair of the advisory committee in the Breakthrough Starshot Initiative. A cynical reading of these events could be that Loeb pitched a weird theory about 'Oumuamua to drum up some chatter about lightsails. At the very least, lightsails are on his mind, and it makes sense he would take a stab at seeing whether 'Oumuamua exhibited some characteristics of one.

It's going to take a lot more work to really figure out the deal with 'Oumuamua, but those like Bannister have no problem being blunt about what the object is not: "It's not aliens." Probably.



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CAN WE PREDICT FUTURE OUTBREAKS?

YOU MIGHT NOT THINK OF INTERNET oversharing as a lifesaving habit, but maybe it is. For more than a decade, epidemiologists and data scientists have scanned our search-engine queries and social-media posts with the goal of discerning who is infected, what they have, and where they live. But ironically, for all our selfies, and status updates, we're just not sharing enough to consistently forecast disease outbreaks—including the flu.

A hundred years ago, the infamous “Spanish flu” spread rapidly around the world, and killed at least 50 million people. With the rapid evolution of the virus, and increasing international travel and urbanisation enabling the quick spread of illnesses, a modern version of that pandemic could cause twice as many casualties. It doesn't matter where you live or what you do. The flu could infect you.

Even in the absence of Flumageddon, improving our ability to forecast the illness is vital. Influenza viruses kill up to 646,000 people worldwide every year, including as many as 56,000 people in the U.S. Americans pay as much as \$5.8 billion in medical care annually to fight the pestilence. If we know when it's coming, health agencies could push people to get vaccinated. Hospitals could plan ahead.

Augmenting official flu reports from the Centres for Disease Control and Prevention (CDC) with data harvested from the internet is another step in our online evolution. According to a 2012 Pew Research Centre study, about 184 million Americans (more than half the nation's residents) use the Web to find health-related information. These searches are like tips to a crime hotline, enabling researchers to identify suspected flu cases. In 2006, Gunther Eysenbach, associate professor of public health at the University of Toronto, found that searches for the terms “flu” or “flu symptoms” spiked a week before a jump in doctor visits. “The internet has made measurable what was previously immeasurable,” he wrote in 2006, christening the new field “infodemiology.”

In 2008, Google rolled out Flu Trends, harnessing its own big data to look for worldwide flu surges and hot spots through symptom searches in 29 countries. Google scrapped the program in 2014—because of at least one factor that researchers hadn't counted on.

Your search history, it turns out, can be misleading. It's impossible for data collectors to know whether you were looking up “headache and fever” for yourself, or because you heard your co-worker complaining about their kid's symptoms. In 2007, Americans suddenly started Googling “cholera”—had a new epidemic taken hold? Nope. Oprah Winfrey had just recommended *Love in the Time of Cholera* for her book club. “You should have seen what happened when Brad Pitt had viral meningitis,” says Lone Simonsen, professor of epidemiology at Roskilde University.

After culling search data from public resources, researchers run them through complex algorithms. These formulas reveal patterns that investigators can then compare with whatever the CDC or other health agencies report about the sickness. If a computer-generated prediction matches reality, we know the

experts are onto something.

Search queries aren't the only vein of data that researchers mine for flu clues. Svitlana Volkova, a data scientist at the Pacific Northwest National Laboratory, looks for gems of information on Twitter. She recently verified a new deep-learning method that probes tweets for signs of the flu. In an analysis of more than 170 million tweets posted over three years, Volkova and her colleagues found their model could accurately produce three-day forecasts of flu-like illnesses at a local level. That's much quicker than waiting for flu reports from the CDC, which lag up to two weeks behind what's happening in the world. (Facebook says it's not in the flu-predicting business, so for now, your sick emoji doesn't serve a greater good.)

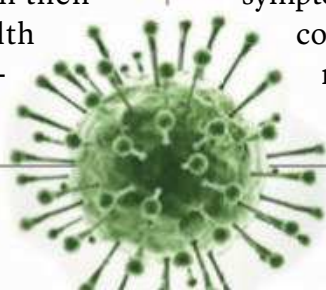
Social media adds more data for researchers to work with, but it still has limitations. Annoyingly, the image we present online doesn't always match the mucus-plagued person we are at home. Michael Paul, an information scientist at the University of Colorado at Boulder, recently found that people rarely tweet about their flu-like symptoms. In fact, the researchers found that people tweet less when they're ill. So the next time your favourite Twitter personality seems oddly quiet, it could be because they're sick of Twitter—but it might just be that they're sick. Paul also investigated Instagram and found that acute illness is the least-common health topic for photo posting. Not surprisingly, flu-ridden people don't love taking selfies.

Disease detectives, including Simonsen, hope that electronic health records could augment data from our tweets and posts. Insurance-claim forms, which list ailments and how they were treated, are particularly crucial. But people are typically reluctant to share private health data with researchers.

Epidemiologists would like to calm those privacy worries. They want only the numbers, never the names. But the final call ultimately lies with individuals. The public, Simonsen says, must weigh the balances: “Privacy on one side and the need to know more on the other.” That deliberation is even more pertinent since the EU implemented the General Data Protection Regulation this year—giving people more say in how their information is used.

Adding information from an app used to log health status—just as we do with fitness trackers or diet programs—could make big data-based flu forecasts even more accurate, Simonsen says. And private companies might come around: UNICEF is working with several, including IBM, to gather data in order to improve responses to global illnesses.

Ultimately, the potential for big data to predict the next flu pandemic might depend on people around the globe all oversharing our illnesses. The more we tweet about our #flu symptoms, the more data we generate. The more we allow companies to share that data with researchers, the more accurate they can make their predictions. And all that sharing, Volkova says, “will help the world.”



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FEATURES



36

WE CAN'T STOP DISASTERS,
SO WE HAVE TO BUILD TO
ENDURE THEM

46

WHAT HAPPENS
WHEN THE EXECUTION
DRUGS RUN OUT?

52

HAS THE BIG ONE BEEN
CANCELLED? OR ARE
WE OVERDUE?

54

WE NEED TO PREPARE
FOR THE EMERGENCE
OF A ROGUE A.I.



BOULDER

AS CLIMATE CHANGE INTENSIFIES, ARCHITECTS, DESIGNERS

AND SCIENTISTS ARE DEVISING BETTER WAYS TO

DEAL WITH ALMOST ANYTHING NATURE THROWS OUR WAY.

BY **LOIS PARSHLEY** / ILLUSTRATION BY **SINELAB**



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RECORD-BREAKING HURRICANES, historically bad fire seasons out West, unprecedented flood levels in the Midwest, and “bombogenesis” becoming a household word along the Eastern Seaboard: Devastating weather events are the new normal in nearly all areas of the United States. Climate change is causing both more-frequent and more-severe calamities. Add to that ongoing threats from earthquakes, tornadoes, and volcanoes, and it’s no surprise that, according to NOAA’s National Centres for Environmental Information, natural disasters cost the US more than \$306 billion in damage in 2017. But a new generation of architects, designers, and experts is creating infrastructure and buildings that respond to both extreme conditions and ongoing stress. Here’s a look at some of the most innovative approaches to living in an increasingly apocalyptic world.



LIVING BREAKWATERS

CHALLENGE: RISING SEAS **LOCATION:** NEW YORK CITY



2012’S SANDY was one of the deadliest hurricanes in New York City’s history. More than half of the 43 people killed were on Staten Island, where tidal surges as tall as 4.2 metres swamped the coastline. As the waters retreated, a federal task force held a competition to figure out how to best protect the area from future tempests. Living Breakwaters, one of the winning designs and led by architecture firm SCAPE, plans to tame the waves along the borough’s south shore with a 1.2-km necklace of rubble, stone, and concrete barriers. The structure will also encourage protective ecosystems, including oyster beds, which form natural reefs.

COURTESY AQUALONIS GMBH (2)



HARVESTING H₂O

Moisture accumulates on durable mesh-wrapped frames.



THE FOG COLLECTOR

CHALLENGE: DROUGHT

LOCATION: MT. BOUTMEZGUIDA, MOROCCO

Some residents of Morocco who live near the Sahara used to spend hours every day retrieving water by donkey, but a new fog-collecting system is changing that. The Aqualonis Cloudfisher's sturdy fabric mounts onto frames and can resist 120-km/h winds while collecting moisture from the frequent mountain mist. This drips into a 25-km pipeline, then flows directly into taps in more than 70 homes. Though people have erected similar systems in South America, Aqualonis claims Cloudfisher is the first to withstand stronger gusts. Innovative drinking-water solutions will gain importance as climate change alters rain patterns across the globe.



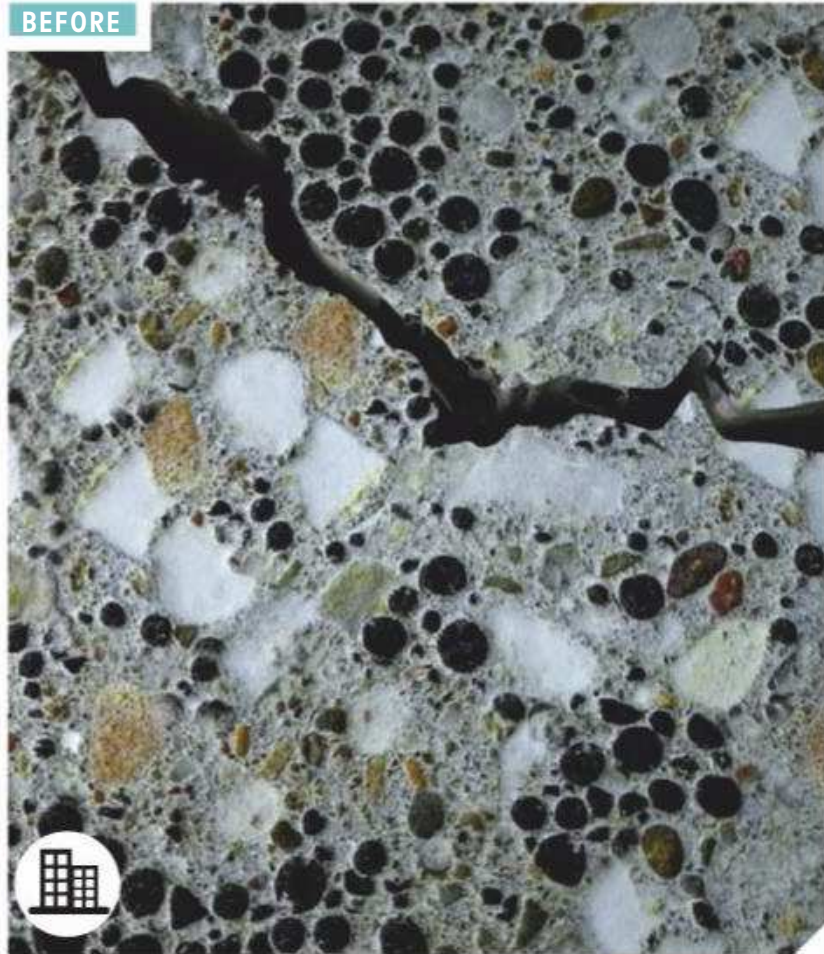
Fire-Resistant Houses



CHALLENGE: BUSHFIRES **LOCATION:** WESTERN UNITED STATES

Fire season has expanded in the US by about 78 days over the past several decades. While experts say that not living in flame-prone zones is probably the best way to minimise risk, for people who already live there, some easy changes will improve their property's likelihood of making it through a blaze. One of the best is to lessen the number of combustibles near their homes, says Patricia Champ, an economist at the US Forest Service's Rocky Mountain Research Station. Use less-flammable roofing material, such as asphalt shingles, clay tiles, or aluminium. This is an area where Australia's long experience with devastating bushfires can help: the US is looking to our building codes and vegetation clearing regulations.

BEFORE



AFTER



ILLUSTRATION BY SINELAB

Self-Healing Concrete



CHALLENGE: CRUMBLING INFRASTRUCTURE **LOCATION:** WORLDWIDE

Higher concentrations of carbon dioxide in our atmosphere actually accelerate deterioration of concrete. As CO_2 penetrates a structure, it reacts with already present moisture and calcium hydroxide, progressively eating away at the layer of cement covering steel reinforcements, leaving them vulnerable to rust. Fortunately, Henk Jonkers, an environmental scientist at TU Delft in the Netherlands, has invented a self-healing version. Jonkers embeds concrete with nitrogen, phosphorus, calcium lactate, and a limestone-producing bacteria. The additives lie dormant until a fissure emerges, admitting air and moisture. Then the bacteria activate, feeding on the calcium lactate, converting it into limestone, and sealing the split.

ELECTRIC CARS THAT BACK UP LOCAL GRIDS

CHALLENGE: POWER FAILURE **LOCATION:** WORLDWIDE



IT TURNS OUT THAT

cloudy, windless days don't yield much renewable energy—a roadblock in shifting power grids away from fossil fuels. But electric cars, which are essentially batteries on wheels, might accelerate a solution. Their drivers could be encouraged to use their vehicles to stabilise the grid by rewarding them for storing extra power. While owners are working during the day, their vehicles can charge on energy from solar farms, and later, parked at home, earn their owners a little cash by selling surplus juice back to the grid. Alternatively, since wind typically blows harder at night,

electric cars can store this fleeting power and release it the next day. Networked car batteries could thus provide stability to local networks, lowering the possibility of blackouts, not to mention providing their owners with emergency power. The potential impact is surprising: In a recent paper, researchers at the Lawrence Berkeley National Laboratory suggested that California's aggressive policy—requiring 33 per cent of its energy to come from renewables by 2020—can be met simply by using electric vehicles as storage. Doing that will also lessen the need, and cost to taxpayers, to build stationary storage infrastructure.

VOLCANOES

"THERE'S NOTHING YOU CAN DO TO STOP A VOLCANO. IT'S REALLY ABOUT NOT LIVING WHERE THERE HAVE BEEN LAVA FLOWS IN THE PAST," SAYS JESSE KEENAN, HARVARD PROFESSOR AND CLIMATE-CHANGE CONSULTANT.

FEED THE FLORA

Plants offer many perks to city dwellers, including shade, beauty, and habitat for wildlife. But they also drink up water that might otherwise flood busy streets.

GATHER RUNOFF

Roads, sidewalks, and terraces connect people but are often also impermeable to rain. Small changes like perforated surfaces can help cities manage runoff.

REMOVE WASTE

The Tredje Natur system keeps storm runoff from mixing with everyday pollutants like fertiliser, and sewage, ensuring that plant life gets only the best.

CHALLENGE:
FLOODING

LOCATION:
COPENHAGEN,
DENMARK

STREET-DRAINING TILES



Cities are dense with impermeable sidewalks and streets, so the concrete jungle doesn't exactly drink up excess water during storms. The result: destructive flash floods. To help, Danish architecture firm Tredje Natur developed Climate Tiles, a modular paving system that collects and distributes rainwater. The slabs resemble a normal paved surface but sport small perforations that funnel storm runoff into horizontally

connected channels. The system captures water from roofs, streets, and parking lots, and delivers it to nearby permeable landscapes—such as garden boxes or park spaces—where it can be absorbed. Tredje Natur already gave a few Copenhagen sidewalks a face-lift this year to test out the tiles. But even before that experiment is finished, Toronto and several other cities have put in requests for the rain-draining material. Sydney should take note.



PORES FOR POURS

Tredje Natur Climate Tiles have tiny perforations that allow rainwater to be funneled toward plants. Permeable pavements come in many different forms: Elsewhere, urban planners utilise a type of porous asphalt to absorb storm runoff.



TORNADO-RESISTANT HOUSE

CHALLENGE: TORNADOES

LOCATION: JOPLIN, MISSOURI

On a calm Sunday in 2011, one of the deadliest twisters in US history, an EF5-rated multiple vortex storm, tore through Joplin, Missouri, killing 161 people. Afterward, as the city rebuilt, Toronto-based Q4 Architects designed a concept house that shows how homeowners might better survive—and recover more quickly from—such disasters.

Strong on the Inside

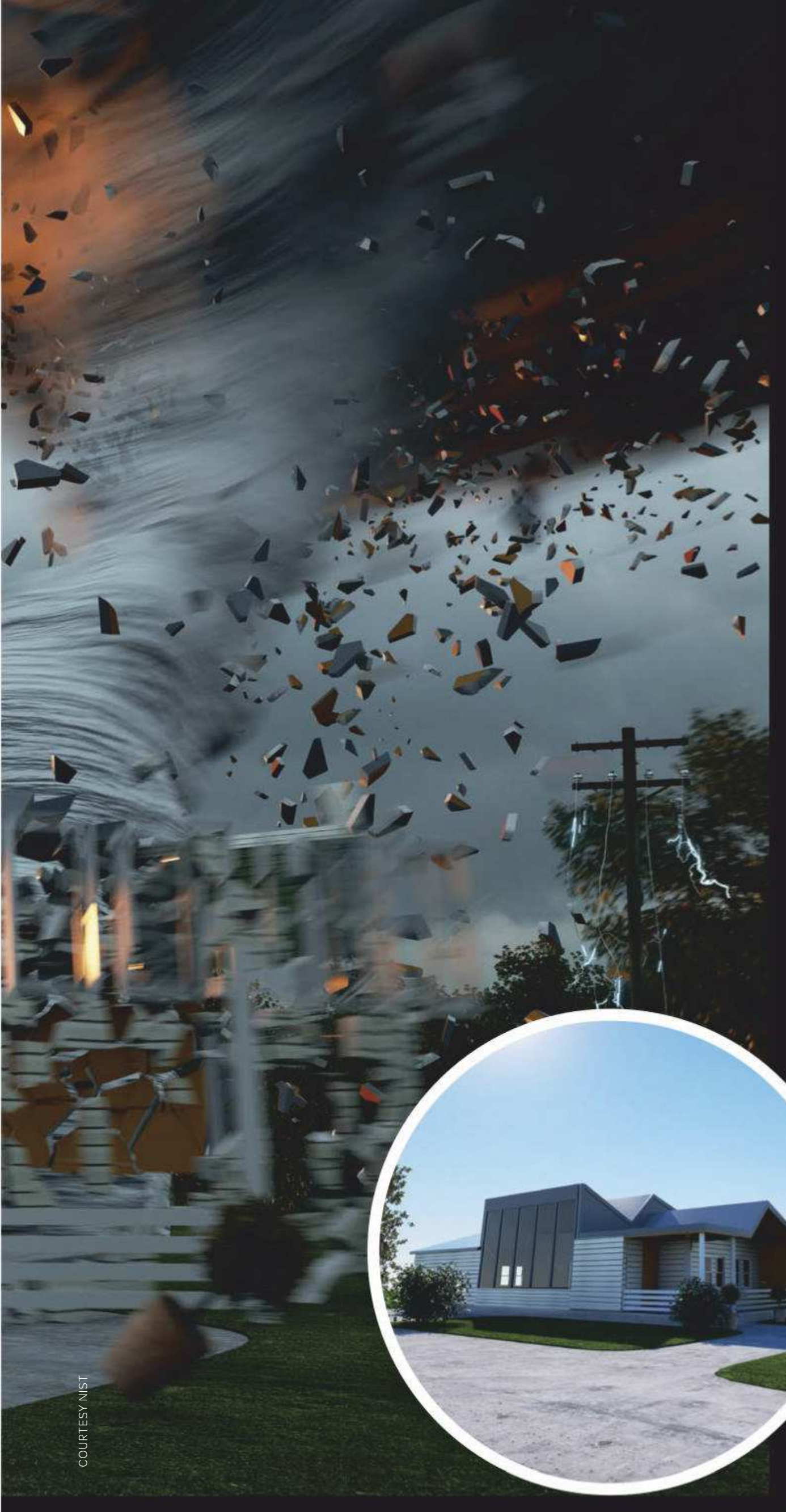
Called the CORE House, the building is constructed around a central space made of well-anchored concrete that would meet Federal Emergency Management Agency standards for “near-absolute protection.” All the critical needs of daily life—a place to rest, cook, and use the bathroom—are protected here. Surrounding rooms feature traditional comforts such as larger windows.

Restoring Function

Municipal infrastructure often takes a while to come back online after natural disasters. So Q4 has built photovoltaic panels and water-harvesting systems into the safe house to provide emergency backups. The perimeter has openings strategically located to withstand gales but large enough to help keep the home cool.

Carbon-Neutral

Considering your building’s long-term impact on the environment is a key component of resilient design. So Q4 built its house with an eye toward being easy on the planet. A custom blend of concrete sequesters carbon emissions, and all the other materials are made within 800 km of the site.



COURTESY NIST



"Dragon"- Tested Materials

CHALLENGE: WILDFIRES

LOCATION: TSUKUBA, JAPAN



It's surprisingly difficult to prove fire resistance in materials—mostly because it requires making a real-world-strength blaze without burning down your lab. So Samuel Manzello, a researcher for the National Institute of Standards and Technology, helped develop what he refers to as "The Dragon." (Formally, it's called the NIST firebrand generator.) Investigators fill the 300-mm-diameter, 1.5-metre-tall tubular contraption with wood chips, which are ignited by two propane burners. Used in combination with one of the world's only fire-research wind tunnels, located in Tsukuba, Japan, testers can create firebrands that move at 10 metres per second. This allows researchers to simulate natural conditions such as wind-driven wildfires that rush into urban areas. NIST used the Dragon to support improvements in roofing to resist ignition, and to suggest changes to California's fire code by testing the mesh size used to keep embers from entering building vents.



Standing Up to Quakes



CHALLENGE: EARTHQUAKES LOCATION: TOKYO, JAPAN

Perched on one of the most seismically active tectonic-plate junctions, Japan registers more than 1,500 earthquakes every year. Architects there have pioneered new engineering standards to stabilize even skyscrapers. For example, Mori Tower, one of the tallest buildings in Tokyo, contains 192 oil-filled shock absorbers throughout its 54-storey structure. A sensor inside these steel dampers detects small shudders and controls the flow of the fluid; when an earthquake is detected, the dampers slosh a thick oil in the opposite direction to counterbalance the tremor. The Japanese continue to push seismic technology's boundaries, engineering dampers out of everything from isolation bearings to high-tensile carbon fiber.

FLOATING HOUSES

**CHALLENGE: FLOODING
LOCATION: WORLDWIDE**



As Hurricane Harvey demonstrated in 2017, huge swaths of the US are increasingly prone to severe storms that knock out power and flood hundreds of thousands of homes. Architects have taken note, creating new types of floating and amphibious homes worldwide. Here are some of their protective features.



MOVING FOUNDATIONS

One of the ways to safeguard a house from floods is to move it up and out of the way. Dutch architect Koen Olthuis has designed floating homes in the Netherlands, Dubai, and China that can rise in order to dodge an encroaching deluge. Some of these houses rest on hydraulic systems that can lift them up to 12 m above stormy waters and remain stable even in winds up to 250 km/h.



WATERPROOF UTILITIES

An amphibious home on an island in the River Thames, built by UK-based Baca Architects, features terraced gardens that act as an early-warning system. If they flood, the owners know that the house is about to be threatened by water. When it rises up off its foundation, all of its utilities remain connected through elephant cabling—a flexible casing that carries electricity, water, and sewage.



EFFICIENT SYSTEMS

Hurricane Katrina proved the importance of building for extreme conditions around New Orleans. The FLOAT House, designed by Morphosis Architects, can provide its own water and power. The specifically sloped roof funnels rainwater into cisterns, where a filtration system renders it drinkable. A geothermal heat pump cycles air to warm or cool the indoors with Earth's 7- to 23-degree subsurface temps.

CLOCKWISE FROM TOP LEFT: TOMOHIRO OHSUMI/BLOOMBERG VIA GETTY IMAGES; OSHIKAZU TSUNO/AFP/GETTY IMAGES; COURTESY MORPHOSIS ARCHITECTS; COURTESY BACA ARCHITECTS; COURTESY KOEN OLTHUIS

WATER-SAVING IRRIGATION CHANNELS

CHALLENGE: DROUGHT LOCATION: SAN ANTONIO, TEXAS



HISPANIC SETTLERS brought a system of water management to the New World that is seeing new use as our climate changes. Called acequias, these networks of earthen canals traditionally branched out like arteries from rivers, some even allowing excess water to seep underground, where it could be stored for months. With reservoirs increasingly at risk for evaporation due to global warming, the US Department of Agriculture's

Natural Resource Conservation Service began funding acequia infrastructure projects in 2015 as an alternative. San Antonio, Texas, recently built a modern adaptation in Phil Hardberger Park, where the system captures and diverts storm runoff from a parking lot. Lauren Stimson, one of the landscape architects behind the project, says it uses plant roots and sediments as a natural filter, collecting and storing runoff the way the region's farmers did historically.

Past Is Present

A park revives an old way to conserve water via acequia (at right).



Mangrove Dams

CHALLENGE: FLOODING
LOCATION: WORLDWIDE



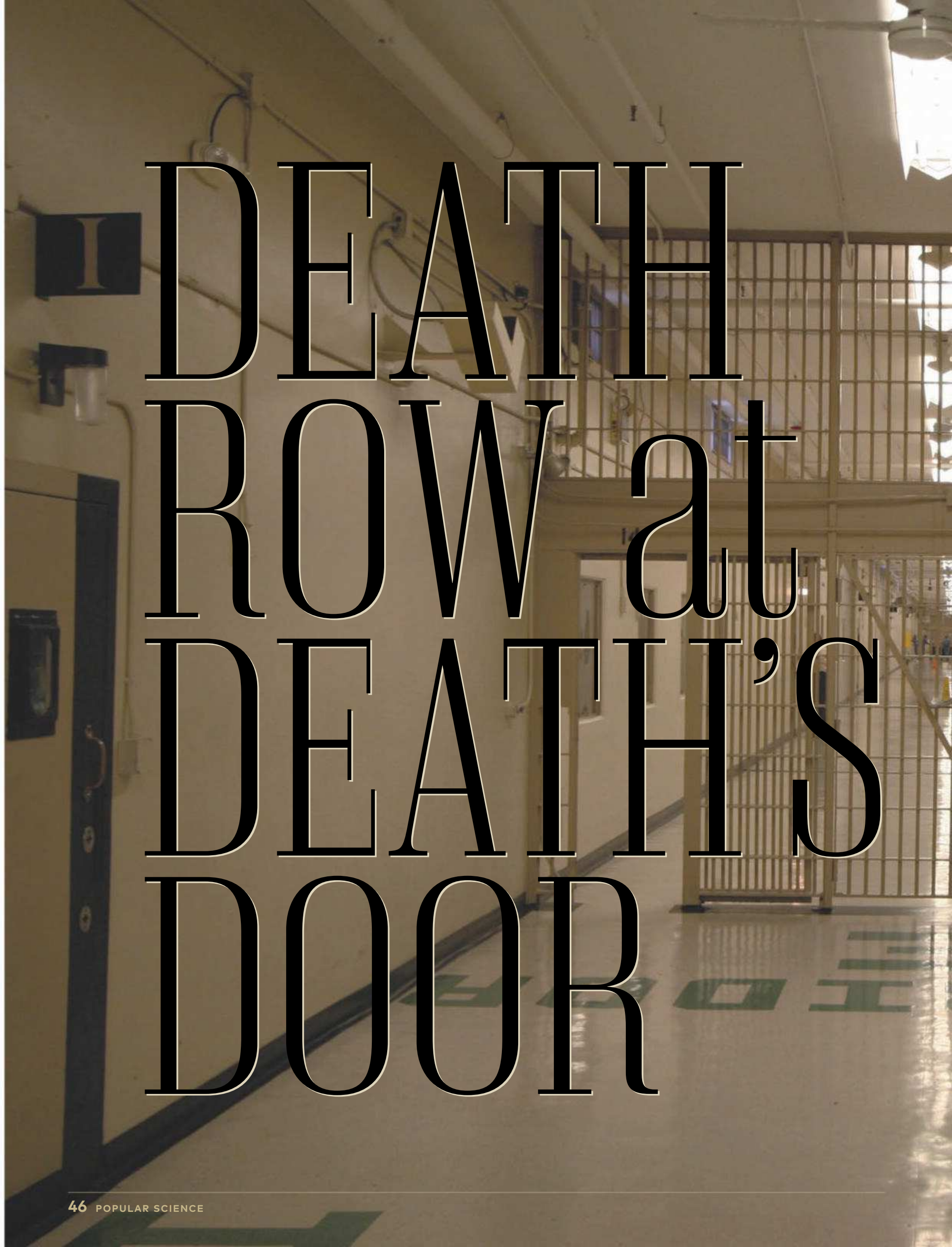
Cities aren't the only places floods impact. Low-lying areas can be fertile sites for productive farms, yet they're susceptible to deluges. Mangroves could be an incredible natural defense mechanism against the rising waters, with a dynamic root system that aerates soil while holding it in place, reducing erosion and increasing drainage. But in many places, these natural ecosystems have long since been destroyed. Hungarian design collective Szövevény's 39 brainstormed a modular, lacelike concrete structure to act as a base for mangrove saplings, which often have trouble getting established. The man-made foundation is designed to support the trees until they form a natural dam, then it slowly degrades beneath the water-stopping grove.



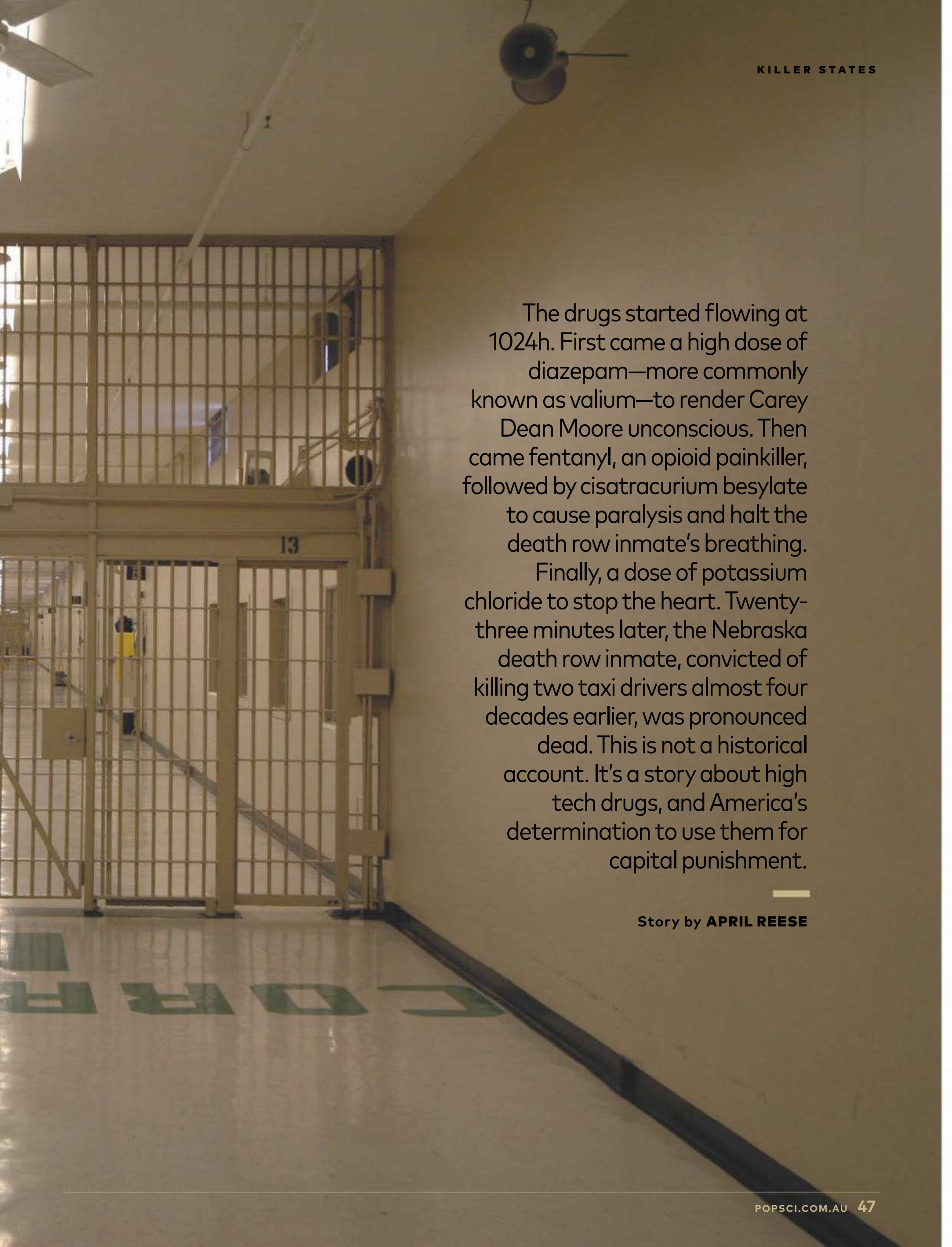
Building Back Microgrids



CHALLENGE: POWER FAILURE LOCATION: HIGASHI-MATSUSHIMA, JAPAN
After a calamitous earthquake and tsunami in 2011 led to meltdowns at the Fukushima Nuclear Power Plant, nearby towns applied the catastrophe's lessons to their recovery efforts. Unlike many places that rebuild systems sure to fail again, the town of Higashi-Matsushima, which has a population of nearly 40,000, plans to put the city on a localised, renewable grid. For instance, the government converted a damaged park into a solar facility capable of producing enough energy for 600 families. And the town, which was 75 per cent destroyed, has also constructed a smart microgrid with battery backup that can supply electricity to the entire area for several hours, or redirect it to hospitals and community buildings for several days. Twenty-five per cent of the municipality's power is already produced locally.



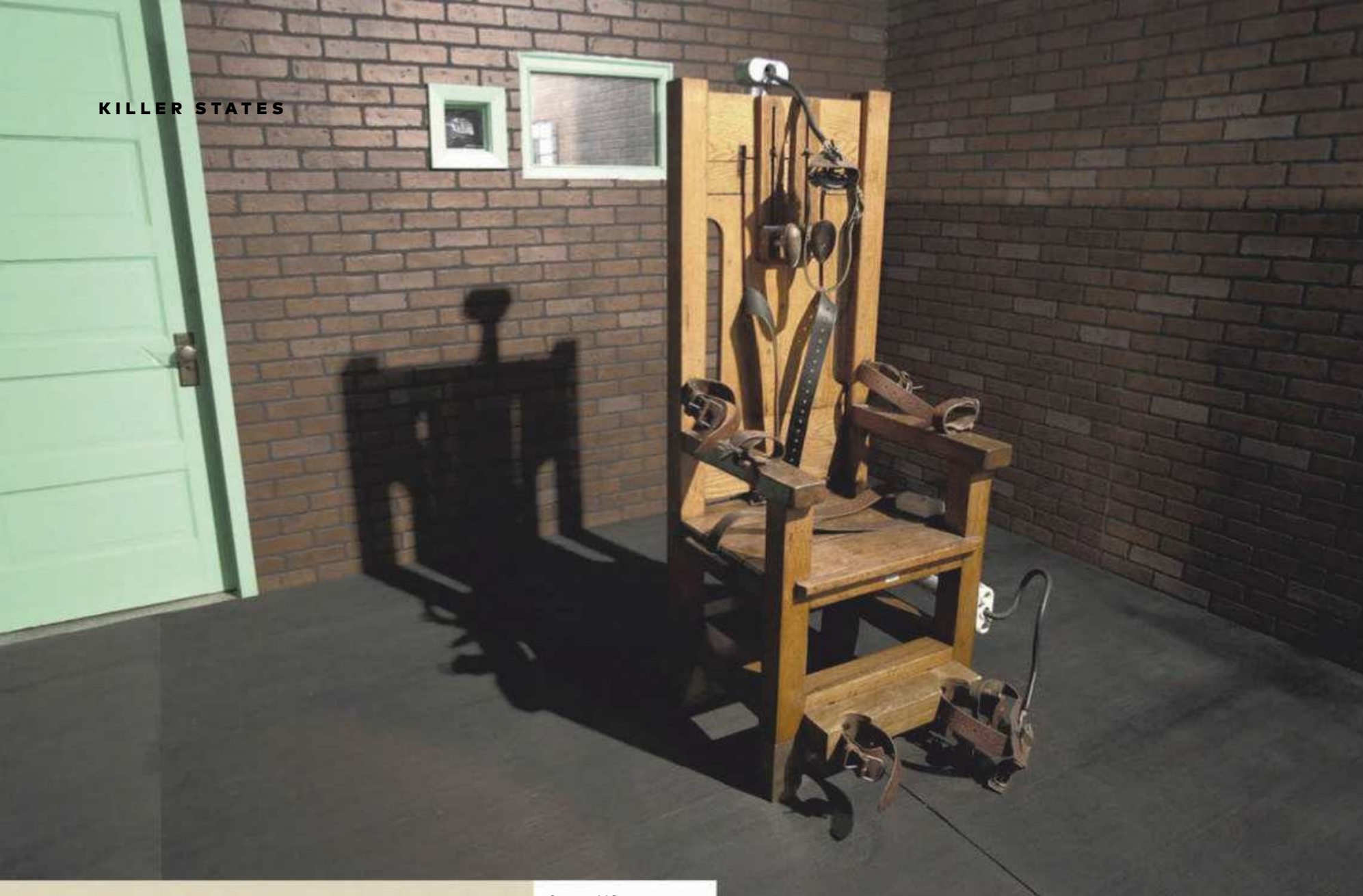
DEATH ROW at DEATH'S DOOR



The drugs started flowing at 1024h. First came a high dose of diazepam—more commonly known as valium—to render Carey Dean Moore unconscious. Then came fentanyl, an opioid painkiller, followed by cisatracurium besylate to cause paralysis and halt the death row inmate's breathing.

Finally, a dose of potassium chloride to stop the heart. Twenty-three minutes later, the Nebraska death row inmate, convicted of killing two taxi drivers almost four decades earlier, was pronounced dead. This is not a historical account. It's a story about high tech drugs, and America's determination to use them for capital punishment.

Story by **APRIL REESE**



Australia got over the urge to kill its prisoners toward the end of the 20th century. By 1985, all Australian states had abolished capital punishment, for all crimes. The Commonwealth abolished it in 1973. New South Wales was the straggler, because even though capital punishment for murder was ended in 1955, it was kept as a penalty for treason, piracy, and arson in naval dockyards.

Despite this, the last person to be executed in New South Wales was in 1939. The last execution overall was in Western Australia, in 1967.

In fact, not only has each state and territory abolished capital punishment, the Commonwealth passed legislation in 2010 that would prevent any state from *reintroducing* it. Absent a revolution, capital punishment in Australia, it seems, is done.

The situation in the US is far more complex. Some states have abolished capital punishment, others have restored it, and many Americans are adamant that state-ordered killing of the worst of the worst criminals must be allowed to continue.

In Australia, opposition to capital punishment was essentially grass-roots. Post World War 2, public opinion shifted from 67% for capital punishment in 1947, to 69% against it in 2005.

Opposition in the US faces a hard battle, in many states. But that's not the executioner's biggest challenge in 2018. The biggest challenge is finding the tools to do the job at all.

Some US states still offer the electric chair as an "option" to death row inmates. Its use is widely considered a "cruel and unusual punishment" as several prisoners have survived the process, only to die soon after.

GRIM INNOVATION

Carey Dean Moore's August 14 execution, the 16th in the US in 2018 alone, marked the first time most of the drugs involved—fentanyl, diazepam, and cisatracurium besylate—had been used in a lethal injection. Concerned that the use of substances intended for medicinal purposes for lethal injection harms their reputations, several companies have filed suit to keep their drugs out of the execution chamber.

When a state's supply expires, it can be next to impossible to procure more. That has led states to begin experimenting with combinations of drugs that have never been used for lethal injection before, increasing the risk that something will go awry. And even those alternative substances are increasingly difficult to get. The people might be calling out for blood, but it seems pharmaceutical companies don't want any of that blood on their own hands.

The dearth of drugs leaves capital punishment states with two choices: They can either suspend executions until they replenish their stocks, or they can go back to older, potentially crueller, methods.

OL' SPARKY

So far, most have opted for the latter. In South Carolina, for example, the state Senate passed a bill last northern spring that effectively replaces injection with the electric chair as the state's method of choice. Inmates have been allowed to choose between the two since 1995, but only one has chosen the chair (James Earl Reed, executed in 2008).

Had the bill been signed into law (it "died in committee," a feature of US politics that means it was neither signed into law or explicitly defeated), it would have meant that if there were no drugs available, the state would make the decision to electrocute—a method of execution widely accepted as being extremely cruel.

Most observers expect South Carolina's Senators to reintroduce the bill in the next legislative session. After all, the state is out of drugs—the last of them expired in 2013—so if the people of South Carolina remain determined to exact vengeance upon their worst criminals, it seems

likely they'll accept the only alternative: any death row inmate scheduled for execution will die by the electric chair.

ULTIMATE PENALTY

America really believes in capital punishment. Five US states still include the electric chair as an option. And three states—Oklahoma, Mississippi, and Utah—allow death by firing squad, though only Utah has ever used it. How long ago? June 18, 2010. A little after midnight on that day, Ronnie Lee Gardner was strapped to a metal chair, had a paper target pinned to his chest, was surrounded by sandbags, and was then shot with four bullets. The shooters fired from the adjacent room, through narrow rifle ports, so they remained invisible to those watching Gardner die. Gardner himself was hooded. He was guilty of double-murder, but had spent 25 years on death row. A commemorative coin was given to prison staff who participated in the execution.

Utah is a bit of an exception though. Most capital punishment states want to get the job done quickly, quietly, and if at all possible, humanely. Lethal injection was considered the ideal solution, but as drugs run out, other options - short of abolishing the death penalty - must be explored.

Oklahoma and Alabama are switching to what studies suggest is a painless form of asphyxiation, via nitrogen hypoxia. And incredibly, two states, Washington and Delaware, still have hanging on the books, though there hasn't actually been an execution by hanging in the US since 1996. (Australia's last hanging was in 1967, in Victoria.)

DEATH WITHOUT SUFFERING

"States are looking at all their options," says Robert Dunham, director of the Death Penalty Information Centre.

Many of these "options", some centuries old, were largely abandoned years ago as society's tolerance for them soured and lethal injection became available in the late 1970s, after the US Supreme Court reinstated the death penalty in 1976. "The reason [states] use lethal injection is that the public thinks other methods are cruel and unusual," Dunham says.

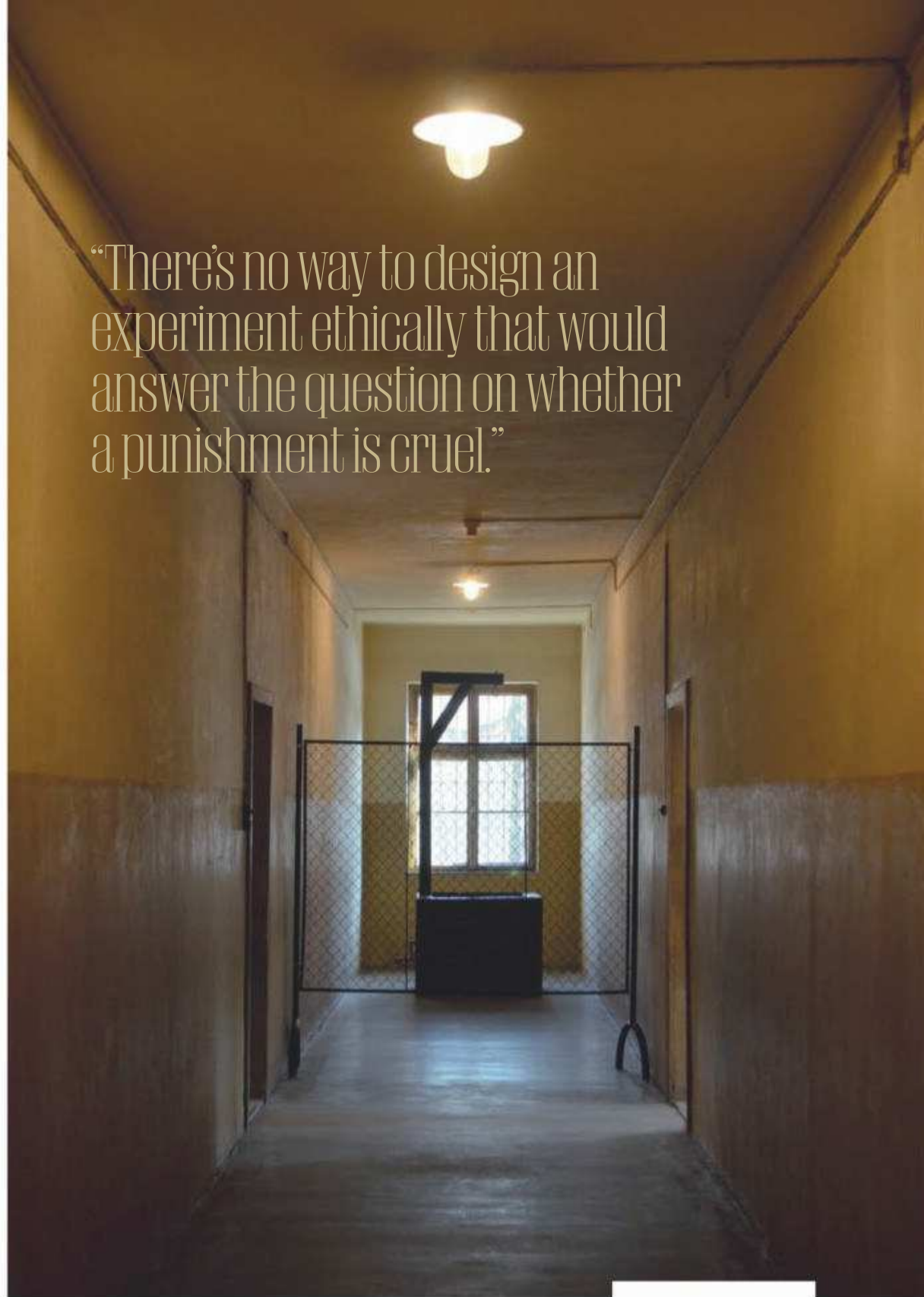
But the push to keep the execution chamber stocked with lethal injection drugs may be misguided. While death by drug has become the execution method of choice in the past few decades—all of the 31 death penalty states use it—injection is more likely to go wrong than any other method, according to the Death Penalty Information Centre.

"It's always been problematic," says Deborah Denno, a law professor at Fordham University who studies execution methods. "That said, it's gotten worse."

While media witnesses reported no complications during Moore's execution—his chest heaved and then went still, they said, and his face turned first red, then purple—no one can say how painful his death truly was. And this isn't unique to new drugs; it's inherent to the method.

Injection masks any suffering, says Joel Zivot, a professor of anaesthesiology and surgery at Emory University who has studied autopsies of executed inmates. "It will look as though an inmate will fall asleep and then be dead," he says, but "things are on fire on the inside. That's been the problem with lethal injection, because it's been specifically designed for public view. The skin is hiding what is beneath it in terms

"There's no way to design an experiment ethically that would answer the question on whether a punishment is cruel."



of toxicity to the tissues."

The truth is that no one really knows for sure which method of execution is the most humane (or, as 67 per cent of Australians might put it, least *inhumane*), and there's no reason to think lethal injection is superior. "There's no way to design an experiment ethically that would answer the question on whether a punishment is cruel," Zivot says. "I do know lethal injection is cruel. I know this because of the way the chemicals are being used and the effect of it. I've studied a series of autopsies, and I've seen organ failure. I've seen many inmates whose lungs have filled with fluid [making it impossible to breathe], and an enlargement of the heart and liver."

The heightened controversy over lethal injection has not stopped states from favouring the method; those that still have the drugs, or manage to find them, continue to use them. Some reportedly have resorted to creative ways to ensure it remains an option.

Shielded by statutes that exempt them from

Hanging is not considered an ethical form of capital punishment. Apart from the cruelty, there are the associations: this portable gallows sits in a corridor at Auschwitz.

In a 2015 death penalty case, Supreme Court Justice Sonia Sotomayor suggested death by firing squad may be preferable to lethal injection.

Freedom of Information Act requests for documentation, state corrections officials may be importing drugs from overseas, or buying them from unlicensed sources. That's according to capital punishment opponents, who says their suspicions are hard to investigate because the secrecy laws make it difficult to verify supply chains.

"States that want to carry out executions are trying through whatever means they can to obtain drugs to be used in those executions," Dunham says.

How successful they are will determine whether they stick with lethal injection or turn to other methods, he adds. Many states that can't get lethal injection drugs see alternate methods as their only choice; in their view, suspending the death penalty isn't an option.

That's the feeling among many lawmakers in South Carolina, which has 36 people on death row, but no means of carrying out executions now that the drugs have run out.

WAITING FOR A REFILL

South Carolina has executed 282 people since 1912 (the year it switched from hanging to the electric chair), but has not carried out an execution since 2011. That uncertainty has led prosecutors to seek life sentences instead—and that means, for capital punishment supporters, justice is no longer being served.

"I don't really like the electric chair, but ... I think if we're gonna have the death penalty in South Carolina we're going to have an obligation to fulfil it, and an obligation to the families that when we say they'll get justice they will," says Republican state senator and former prosecutor William Timmons, who introduced the bill that would restore the electric chair as the state's primary execution method.

Even if the South Carolina bill becomes law, whether the public has an appetite for electrocution in 2018 remains to be seen. Reports of prolonged, painful deaths in the electric chair still linger in the public memory, Denno says. "I personally don't think electrocution is going to go anywhere. There's a botched history and also a racial history."

But there's one antiquated execution method shunned by society that may be worth revisiting by death penalty supporters, she says. It's the one that Utah last used in 2010.

"The evidence suggests firing squad is the most humane," says Denno, who examined the method in a 2016 paper in the *University of Michigan Journal of Law Reform*. "People

think they are the most barbaric, because it doesn't have a sort of gauze over it like lethal injection, no pretence over it being anything but killing somebody. But it's such a direct method."

In her dissent on a 2015 death penalty case, Supreme Court Justice Sonia Sotomayor suggested death by firing squad may be preferable to lethal injection.

"In the future . . . some inmates may suggest the firing squad as an alternative," she wrote, adding that "such visible yet relatively painless violence may be vastly preferable to an excruciatingly painful death hidden behind a veneer of medication."

Yet the assumption that lethal injection hews most closely to the US Constitution's 8th amendment prohibition on "cruel and unusual punishment" continues to prevail in most states.

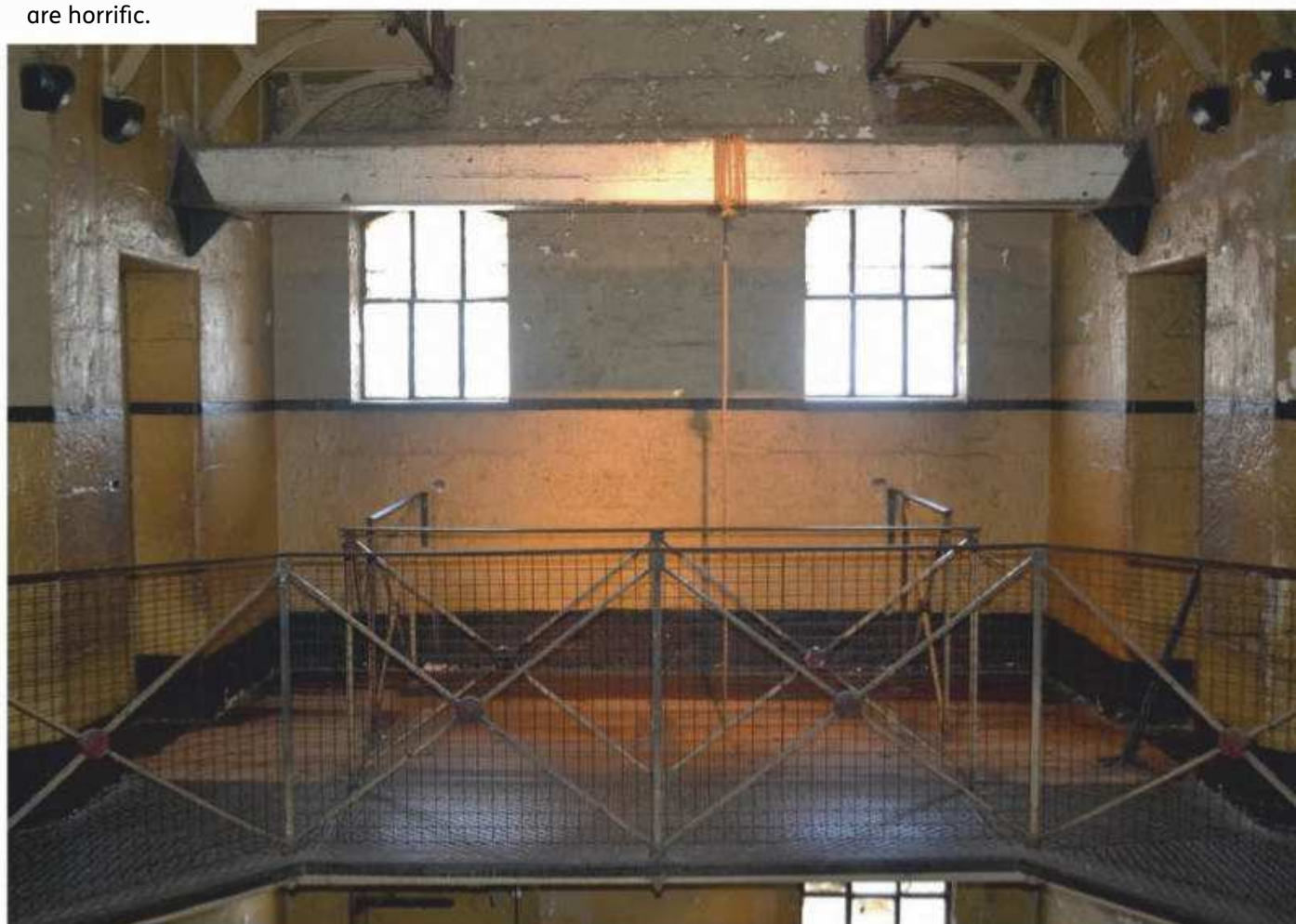
THE END OF DEATH ROW?

Meanwhile, Timmons, who is running for Congress, says if he wins South Carolina's open 4th District seat, he will introduce legislation to require the federal government to provide lethal injection drugs to states, noting that federal prosecutors successfully sought the death penalty for Dylann Roof, who fatally shot nine African-American parishioners in a Charleston church in 2015. "I do hope to try to fix this problem nationwide."

If he succeeds in reopening the supply chain for lethal injection drugs, it's likely states will abandon alternative methods. But some capital punishment policy experts predict that the death penalty's days are numbered anyway.

A Pew Research Centre survey conducted last April and May showed

Done properly, hanging can be a quick method of execution, especially if the neck is broken. The problem is that botched hangings are horrific.





Most states in the US that practice lethal injection strap the prisoner down in front of an observation window.

an uptick in the share of Americans who favour capital punishment, but over the long term, public support for the death penalty—and the number of actual executions—has dropped.

About 54 per cent of Americans favour the death penalty today (as did 54% of Australians back in 1993), up from 49 per cent in 2016, but that's far fewer than in 1996, when 78 per cent supported capital punishment. Support for the death penalty in the US hasn't been this low since 1972.

While it depends on the specific case, the families of the prisoner's victims may be invited to witness the execution. The US focuses heavily on "getting justice" for victims of certain types of crime.

DEATH US DOES PART

Nebraska's recent political wrangling over the death penalty is illustrative of just how conflicted the public and lawmakers are over the practice in the 21st century.

In 2015, the state Legislature voted to repeal the death penalty. Republican Governor Pete Ricketts vetoed the measure; lawmakers then overrode his veto. Determined to keep capital punishment in place, Ricketts and his family put \$400,000 of their own money toward a campaign to

reinstate the death penalty, and last November, voters approved the ballot measure.

This, perhaps, is the core difference between Australia and the US when it comes to state authorised killing. As late as 1995, a majority of Australians - 53% - still approved of capital punishment as a penalty for murder.

But the government didn't reinstate the death penalty. Sometimes it can feel like there's an unspoken understanding among our politicians - don't raise the issue, don't take it to referendum, because it might just get voted back in. And our MPs do seem to agree on at least one thing: Australia is not a country that executes criminals.

As for the US, with public support for the death penalty slipping overall, Denno thinks it's only a matter of time before capital punishment goes the way of the noose.

While 31 states allow the death penalty, few of them have carried out an execution in the last five years. And legal action is further curbing capital punishment's sweep: Earlier this month, the Washington Supreme Court struck down the death penalty, saying it was imposed "in an arbitrary and racially biased manner."

"It's very clear," Denno says, "that there will be a time when this country no longer has a death penalty."


But for now, US states that put convicted criminals to death have a difficult choice to make: Go to ever-greater lengths to keep using lethal injection, despite the controversy over the pain it inflicts, or revisit the killing machines of the past—and potentially face a public outcry that may just hasten the practice's demise. Opponents of capital punishment will just have to wait... and hope.



IT WILL BE OUR FAULT

Seismologist **Lucy Jones** is on a crusade to prepare us—and our infrastructure—for the next Big One.

BY MARY BETH GRIGGS / ILLUSTRATIONS BY KYLE HILTON



On a sweltering day in Pasadena, California, geologist Lucy Jones stands above a steep, dry riverbed overlooking Los Angeles County. To the southwest, LA sprawls out to the Hollywood Hills. Jones, whose demeanour is as sunny as the sky, sees an abundance of disaster.

"Here's your Southern California issue," she says, pacing the trailhead that leads to a quarry below. "You've got earthquakes that push up the mountains. That traps the rain, but then erosion brings [the mountains] back down." In other words, the quakes build them up and the rains wash them away. Jones points to what looks like a healthy bush in the ravine. It's actually a willow tree, nearly up to its leafy crown in two metres of dirt. Rubble and soil slid there after a 2009 bushfire burned 160,000 acres, destroyed more than 200 buildings, displaced more than 10,000 people, and

denuded these slopes. With nothing to hold back the earth, storms sent slurries of rock and mud downhill, further ravaging the landscape.

Fires, earthquakes, and landslides are interconnected forces that shape this topography. They are as intertwined as the web of geological faults that lie beneath LA County. The biggest of those, the San Andreas, is never far from Jones' mind. No one knows when it will move, but this tectonic boundary one day will—and shake all of Southern California to its foundation. Experts predict it will kill at least 1,800 people; rupture 966 roads, 21 railroads, and 32 aqueducts; down 141 power lines; damage 300,000 buildings; and leave millions of survivors cut off from critical resources.

Jones wants people to understand that it doesn't have to be a complete disaster, not if we

listen to her and her experts. Through her namesake Dr. Lucy Jones Centre for Science and Society, she tries to persuade officials and community organisers to prepare for the worst. Her fixes range from the simple, such as attaching furniture to walls, to the complex, including retrofitting homes with wall braces, bolting office buildings to their foundations, and even installing shock absorbers, called base isolators, that will keep a structure from shaking too much.

Such adaptations can be expensive but will add up to more-resilient communities. "We have to accept that it's going to cost some money for a common good," Jones says.

Jones is not new to this line of work. For 30 years, she toiled as an LA-based seismologist with the United States Geological Survey. There, she served as a calming voice to her fellow Angelenos. Each time the city quaked, TV crews showed up at her office to have her explain what had happened. Strangers stopped her at the grocery store with questions. An AC repairman sent to her office was elated to meet her. "What makes her different from other technocrats is she can understand what people outside her discipline are telling her very quickly, and she can extract the stuff that you really need to know," says Keith Porter, a civil engineering professor at the University of Colorado at Boulder. "I can't think of five people who have the ability to distil information the way she does. She's up there with Stephen Jay Gould and Neil deGrasse Tyson."



Jones developed the skill of helping different communities understand each other early in her career. She was one of the first geologists allowed into China during the 1970s to study the dynamics of temblors there. Later, she began advising groups like the Federal Emergency Management Agency and municipal authorities in California on earthquake preparation. That requires navigating what in her mind is a demilitarised zone between politics and science. She must shuttle facts to politicians, avoiding her own opinions in order to help others shape policy.

"You have to get right up to the edge to help," she says. "As a citizen, I look at the information, and I know what I want my elected officials to do. But I'm not elected to do that."

In 2008, after city and emergency planners told her they needed help convincing people of the danger underfoot, she released the Great Southern California ShakeOut report. Drawing on

graphs, it depicted a Hollywood-worthy scenario: Buildings fall, highways buckle, gas lines erupt, power lines tumble, 1,600 fires burn, 1,800 people die, and 50,000 more are injured.

The vivid account galvanised the public and convinced 5.5 million people in Southern California to take part in a massive earthquake practice run. Her drills taught people to drop, cover, and hold on. (Last year, 18 million people around the world participated.) In her last years at the USGS (she retired in 2016), Jones worked with the LA mayor's office as it spearheaded landmark legislation requiring owners of vulnerable wood and concrete buildings to retrofit them so the people inside would be able to make it out of a seismic shake alive. More than a dozen other California cities have done the same or are trying to.

But escaping a building with your life, says Jones, is not enough. If our homes and offices stand, but we can't go back in because of dangerous cracks, where do you live and how do you work? It's a situation that could devastate lives as well as LA's economy. "Why is that acceptable?" Jones asks, incredulous.

So, in 2018, testifying at the State Capitol, Jones successfully encouraged California



from Pompeii's volcanic eruptions to Hurricane Katrina's wind and rain. As she travels from LA to places such as the UK and New Zealand—advising communities on how to get ready for hurricanes, tsunamis, floods, and earthquakes—Jones is determined to change one piece of infrastructure that requires no political action: human networks.

"Traditional preparedness messaging tends to be very isolating," Jones says. "It says: 'You're going to be on your own; nobody's going to be there to help you. You need to take care of your family.'" There's an implicit message that your neighbour might become your enemy. Jones says just the opposite is true, and you should start planning with others. "You have networks with parents at your child's school," she says.

"There are faith communities and social organisations. There's your network. They're a forgotten target on getting ready for an earthquake."

In other words, we're all in this together, which is why making sure schools, churches, city halls, and homes are strong is so vitally important now, while we still have time.

The effect of a magnitude 7.8 quake: Buildings fall, highways buckle, gas lines erupt, 1,600 fires burn, 1,800 people die, and 50,000 more are injured.

computer models and the expertise of more than 300 scientists in engineering, seismology, public health, and economics, the 300-page account simulated the effects of a magnitude 7.8 quake. Using animations, diagrams, and

lawmakers to pass legislation that would lay out strict standards for the habitability of all new construction. A state-appointed committee would draft the requirements. The group would have until 2022 to figure out a number of key factors: What level of damage is acceptable for a building to remain functional after a quake? And should such standards be mandatory or voluntary?

Jones has since busied herself promoting *The Big Ones*, a book she published this year about the lessons of past disasters,



CAN SUPER-
INTELLIGENT
AI ESCAPE
OUR CONTROL
AND DESTROY
US? SKYPE
CO-FOUNDER
JAAN TALLINN
PUTS MONEY
ON IT—AND
ON FINDING
A SOLUTION.

BY
**MARA
H V I S T E N D A H L**

ILLUSTRATION
BY
**LEON
D I J K S T R A**

"IT BEGAN THREE AND A HALF BILLION YEARS AGO IN A POOL OF MUCK, WHEN A MOLECULE MADE A COPY OF ITSELF AND SO BECAME THE ULTIMATE ANCESTOR OF ALL EARTHLY LIFE.

IT BEGAN FOUR MILLION YEARS AGO, WHEN BRAIN VOLUMES BEGAN CLIMBING RAPIDLY IN THE HOMINID LINE.

FIFTY THOUSAND YEARS AGO WITH THE RISE OF HOMO SAPIENS.

TEN THOUSAND YEARS AGO WITH THE INVENTION OF CIVILISATION.

FIVE HUNDRED YEARS AGO WITH THE INVENTION OF THE PRINTING PRESS.

FIFTY YEARS AGO WITH THE INVENTION OF THE COMPUTER.

IN LESS THAN THIRTY YEARS, IT WILL END."

JAAN TALLINN STUMBLED ACROSS these words in 2007, in an online essay called "Staring into the Singularity." The "it" is human civilisation. Humanity would cease to exist, predicted the essay's author, with the emergence of super-intelligence, or AI that surpasses the human intellect in a broad array of areas.

Tallinn, an Estonia-born computer programmer, has a background in physics and a propensity to approach life like one big programming problem. In 2003, he co-founded Skype, developing the backend for the app. He cashed in his shares after eBay bought it two years later, and now he was casting about for something to do. "Staring into the Singularity" mashed up computer code, quantum physics, and *Calvin and Hobbes* quotes. He was hooked.

Tallinn soon discovered that the essay's author, self-taught theorist Eliezer Yudkowsky, had written more than 1,000 articles and blog posts, many of them devoted to super-intelligence. Tallinn wrote a program to scrape Yudkowsky's writings from the internet, order them chronologically, and format them for his iPhone. Then he spent the better part of a year reading them.

The term "artificial intelligence," or the simulation of intelligence in computers or machines, was coined back in 1956, only a decade after the creation of the first electronic digital computers. Hope for the field was initially high, but by the 1970s, when early predictions did not pan out, an "AI winter" set in. When Tallinn found Yudkowsky's essays, AI was undergoing a renaissance. Scientists were developing AIs that excelled in specific areas, such as winning at chess, cleaning the kitchen floor, and recognising human speech. (In 2007, the resounding win at *Jeopardy!* of IBM's Watson was still four years away, while the triumph at *Go* of DeepMind's AlphaGo was eight years off.) Such "narrow" AIs, as they're called, have superhuman capabilities, but only in their specific areas of dominance. A chess-playing AI can't clean the floor or take you from point A to point B. But super-intelligent AI, Tallinn came to believe, will combine a wide range of skills in one entity. More darkly, it also might use data generated by smartphone-toting humans to excel at social manipulation.

Reading Yudkowsky's articles, Tallinn became convinced that super-intelligence could lead to an explosion or "breakout" of AI that could threaten human existence—that ultra-smart AIs will take our place on the evolutionary ladder and dominate us the way we now dominate apes. Or, worse yet, exterminate us... the way we exterminate apes.

After finishing the last of the essays, Tallinn shot off an email to Yudkowsky—all lowercase, as is his style. "i'm jaan, one of the founding engineers of skype," he wrote. Eventually he got to the point: "i do agree that...preparing for the event of general AI surpassing human intelligence is one of the top tasks for humanity." He wanted to help. When he flew to the Bay Area for other meetings soon after, he met Yudkowsky at a Panera Bread in Millbrae, California, near where he lives. Their get-together stretched to four hours. "He actually, genuinely understood the underlying concepts and the details," Yudkowsky recalls. "This is very rare." Afterward, Tallinn wrote a check for \$5,000 to the Singularity Institute for



Super-Ambitious

Jaan Tallinn, driven to save humans from their AI creations.

Artificial Intelligence, the nonprofit where Yudkowsky was a research fellow. (The organisation changed its name to Machine Intelligence Research Institute, or MIRI, in 2013.) Tallinn has since given it more than \$600,000.

The encounter with Yudkowsky brought Tallinn purpose, sending him on a mission to save us from our own creations. As he connected on the issue with other theorists and computer scientists, he embarked on a life of travel, giving talks around the world on the threat posed by super-intelligence. Mostly, though, he began funding research into methods that might give humanity a way out: so-called friendly AI. That doesn't mean a machine or agent is particularly skilled at chatting about the weather, or that it remembers the names of your kids—though super-intelligent AI might be able to do both of those things. It doesn't mean it is motivated by altruism or love. A common fallacy is assuming that AI has human urges and values. “Friendly” means something much more fundamental: that the machines of tomorrow will not wipe us out in their quest to attain their goals.

NINE YEARS AFTER HIS MEETING WITH YUDKOWSKY, Tallinn joins me for a meal in the dining hall of Cambridge University's Jesus College. The churchlike space is bedecked with stained-glass windows, gold molding, and oil paintings of men in wigs. Tallinn sits at a heavy mahogany table, wearing the casual garb of Silicon Valley: black jeans, T-shirt, canvas sneakers. A vaulted timber ceiling extends high above his shock of gray-blond hair.

At 46, Tallinn is in some ways your textbook tech entrepreneur. He

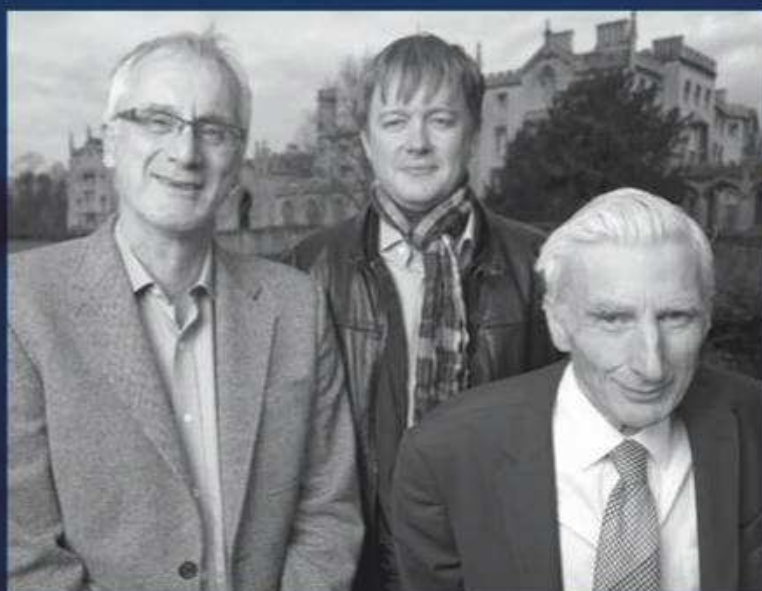
thinks that thanks to advances in science (and provided AI doesn't destroy us), he will live for “many, many years.” His concern about super-intelligence is common among his cohort. PayPal co-founder Peter Thiel's foundation has given \$1.6 million to MIRI, and in 2015, Tesla founder Elon Musk donated \$10 million to the Future of Life Institute, a technology safety organisation in Cambridge, Massachusetts. Tallinn's entrance to this rarefied world came behind the Iron Curtain in the 1980s, when a classmate's father with a government job gave a few bright kids access to mainframe computers. After Estonia became independent, he founded a video-game company. Today, Tallinn still lives in its capital city—which serendipitously is also called Tallinn—with his wife and the youngest of his six kids. When he wants to meet with researchers, he often just flies them to the Baltic region.

His giving strategy is methodical, like almost everything else he does. He spreads his money among 11 organisations, each working on different approaches to AI safety, in the hope that one might stick. In 2012, he co-founded the Cambridge Centre for the Study of Existential Risk (CSER) with an initial outlay of close to \$200,000.

Existential risks—or X-risks, as Tallinn calls them—are

Principal Uncertainty

Can we control AI? Huw Price, Tallinn, and Martin Rees founded the Cambridge Centre for the Study of Existential Risk to find out.



threats to humanity's survival. In addition to AI, the 20-odd researchers at CSER study climate change, nuclear war, and bioweapons. But to Tallinn, the other disciplines mostly help legitimise the threat of runaway artificial intelligence. "Those are really just gateway drugs," he tells me. Concern about more widely accepted threats, such as climate change, might draw people in. The horror of super-intelligent machines taking over the world, he hopes, will convince them to stay. He is here now for a conference because he wants the academic community to take AI safety seriously.

Our dining companions are a random assortment of conference-goers, including a woman from Hong Kong who studies robotics and a British man who graduated from Cambridge in the 1960s. The older man asks everybody at the table where they attended university. (Tallinn's answer, Estonia's University of Tartu, does not impress him.) He then tries to steer the conversation toward the news. Tallinn looks at him blankly. "I am not interested in near-term risks," he says.

Tallinn changes the topic to the threat of super-intelligence. When not talking to other programmers, he defaults to metaphors, and he runs through his suite of them now: Advanced AI can dispose of us as swiftly as humans chop down trees. Super-intelligence is to us what we are to gorillas. Inscribed in Latin above his head is a line from Psalm 133: "How good and how pleasant it is for brothers to dwell together in unity." But unity is far from what Tallinn has in mind in a future containing a rogue super-intelligence.

An AI would need a body to take over, the older man says. Without some kind of physical casing, how could it possibly gain physical control? Tallinn has another metaphor ready: "Put me in a basement with an internet connection, and I could do a lot of damage," he says. Then he takes a bite of risotto.

An AI is driven by outcomes. Programmers assign these goals, along with a series of rules on how to pursue them. Advanced AI wouldn't necessarily need to be given the goal of world domination in order to achieve it—it could just be accidental. And the history of computer programming is rife with small errors that sparked catastrophes. In 2010, for example, a trader working for the mutual-fund company Waddell & Reed sold thousands of futures contracts. The firm's software left out a key variable from the algorithm that helped execute the trade. The result was the

trillion-dollar US "flash crash."

The researchers Tallinn funds believe that if the reward structure of a superhuman AI is not properly programmed, even benign objectives could have insidious ends. One well-known example, laid out by Oxford University philosopher Nick Bostrom in his book *Superintelligence*, is a fictional agent directed to make as many paper clips as possible. The AI might decide that the atoms in human bodies would be put to better use as raw material for them.

Tallinn's views have their share of detractors, even among the community of people concerned with AI safety. Some object that it is too early to worry about restricting super-intelligent AI when we don't yet un-

derstand it. Others say that focusing on rogue technological actors diverts attention from the most urgent problems facing the field, like the fact that the majority of algorithms are designed by a relatively small cross-section of humanity, or based on data biased toward them. "We're in danger of building a world that we don't want to live in if we don't address those challenges in the near term," says Terah Lyons, executive director of the Partnership on AI, a multistakeholder organisation focused on AI safety and other issues. (Several of the institutes Tallinn backs are members.) But, she adds, some of the near-term challenges facing researchers—such as weeding out algorithmic bias—are precursors to ones that humanity might see with super-intelligent AI.

Tallinn isn't so convinced. He counters that super-intelligent AI brings unique threats. Ultimately, he hopes that the AI community might follow the lead of the anti-nuclear movement in the 1940s. In the wake of the bombings of Hiroshima and Nagasaki, scientists banded together to try to limit further nuclear testing. "The Manhattan Project scientists could have said, 'Look, we are doing innovation here, and innovation is always good, so let's just plunge ahead,'" he tells me. "But they were more responsible than that."

TALLINN WARNS THAT ANY APPROACH TO AI SAFETY WILL be hard to get right. If an AI is sufficiently smart, he explains, it might have a better understanding of the constraints than its creators do. Imagine, he says, "waking up in a prison built by a bunch of blind 5-year-olds." That is what it might be like for a super-intelligent AI that is confined by humans.

Yudkowsky, the theorist, found evidence this might be true when, starting in 2002, he conducted chat sessions in which he played the role of an AI enclosed in a box, while a rotation of other people played the gatekeeper tasked with keeping the AI in. Three out of five times, Yudkowsky—a mere mortal—says he convinced the gatekeeper to release him. His experiments have not discouraged researchers from trying to design a better box, however.

The researchers that Tallinn funds are pursuing a broad variety of strategies, from the practical to the seemingly far-fetched. Some theorise about boxing AI, either physically, by building an actual structure to contain it, or by programming in limits to what it can do. Others are trying to teach AI to adhere to human values. A few are working on a last-ditch off switch. One researcher who is delving into all three is mathematician and philosopher Stuart Armstrong at the University of Oxford's Future of Humanity Institute, which Tallinn calls "the most interesting place in the universe." (Tallinn has given FHI more than \$310,000.) Armstrong is one of the few researchers in the world who focuses full time on AI safety.

I meet him for coffee one afternoon in a cafe in Oxford. He wears a rugby shirt unbuttoned at the collar, and has the look of someone who spends his life

behind a screen, with a pale face framed by a mess of sandy hair. He peppers his explanations with a disorienting mixture of popular-culture references and math. When I ask him what it might look like to succeed at AI safety, he says: "Have you seen *The Lego Movie*? Everything is awesome."

One strain of Armstrong's research looks at a specific approach to boxing called an "oracle" AI. In a 2012 paper with Nick Bostrom, who co-founded FHI, he proposed not only walling off super-intelligence in a holding tank—a physical structure—but also restricting it to answering questions, like a really smart Ouija board. Even with these boundaries, an AI would have immense power to reshape the fate of humanity by subtly manipulating its interrogators. To reduce the possibility of this happening, Armstrong has proposed time limits on conversations, or banning questions that might upend the current world order. He also has suggested giving the oracle proxy measures of human survival, such as the Dow Jones Industrial Average or the number of people crossing the street in Tokyo, and telling it to keep these steady.

Ultimately, Armstrong believes, it could be necessary to create, as he calls it in one paper, a "big red off button": either a physical switch, or a mechanism programmed into an AI to automatically turn itself off in the event of a breakout. But designing such a switch is far from easy. It's not just that an advanced AI interested in self-preservation could prevent the button from being pressed. It also could become curious about why humans devised the button, activate it to see what happens, and render itself useless. In 2013, a programmer named Tom Murphy VII designed an AI that could teach itself to play Nintendo Entertainment System games. Determined not to lose at *Tetris*, the AI simply pressed pause—and kept the game frozen. "Truly, the only winning move is not to play," Murphy observed wryly, in a paper on his creation.

For the strategy to succeed, an AI has to be uninterested in the button, or, as Tallinn puts it, "it has to assign equal value to the world where it's not existing and the world where it's existing." But even if researchers can achieve that, there are other challenges. What if the AI has copied itself several thousand times across the internet?

The approach that most excites researchers is finding a way to make AI adhere to human values—not by programming them in, but by teaching AIs to learn them. In a world dominated by partisan politics, people often dwell on the ways in which our principles differ. But, Tallinn notes, humans have a lot in common: "Almost everyone values their right leg. We just don't think about it." The hope is that an AI might be taught to discern such immutable rules.

In the process, an AI would need to learn and appreciate humans' less-than-logical side: that we often say one thing

and mean another, that some of our preferences conflict with others, and that people are less reliable when drunk. But the data trails we all leave in apps and social media might provide a guide. Despite the challenges, Tallinn believes, we must try because the stakes are so high. "We have to think a few steps ahead," he says. "Creating an AI that doesn't share our interests would be a horrible mistake."

ON TALLINN'S LAST NIGHT IN CAMBRIDGE, I JOIN HIM AND two researchers for dinner at a British steakhouse. A waiter seats our group in a white-washed cellar with a cave-like atmosphere. He hands us a one-page menu that offers three different kinds of mash. A couple sits down at the table next to us, and then a few minutes later asks to move elsewhere. "It's too claustrophobic," the woman complains. I think of Tallinn's comment about the damage he could wreak if locked in a basement with nothing but an internet connection. Here we are, in the box. As if on cue, he and the researchers contemplate ways to get out.

Tallinn's guests include former genomics researcher Seán Ó hÉigeartaigh, who is CSER's executive director, and Matthijs Maas, an AI policy researcher at the University of Copenhagen. They joke about an idea for a nerdy action flick titled *Super-intelligence vs. Blockchain!*, and discuss an online game called *Universal Paperclips*, which riffs on the scenario in Bostrom's book. The exercise involves repeatedly clicking your mouse to make paper clips. It's not exactly flashy, but it does give a sense for why a machine might look for more-expedient ways to produce office supplies.

Eventually, talk shifts toward bigger questions, as it often does when Tallinn is present. The ultimate goal of AI-safety research is to create machines that are, as Cambridge philosopher and CSER co-founder Huw Price once put it, "ethically as well as cognitively superhuman." Others have raised the question: If we don't want AI to dominate us, do we want to dominate it? In other words, does AI have rights? Tallinn says this is needless anthropomorphising.

It assumes that intelligence equals consciousness—a misconception that annoys many AI researchers. Earlier in the day, CSER researcher Jose Hernandez-Orallo joked that when speaking with AI researchers, consciousness is "the C-word." ("And 'free will' is the F-word," he added.)

In the cellar now, Tallinn says that consciousness is beside the point: "Take the example of a thermostat. No one would say it is conscious. But it's really inconvenient to face up against that agent if you're in a room that is set to negative 30 degrees."

Ó hÉigeartaigh chimes in. "It would be nice to worry about consciousness," he says, "but we won't have the luxury to worry about consciousness if we haven't first solved the technical safety challenges."

People get overly preoccupied with what super-intelligent AI is, Tallinn says. What form will it take? Should we worry about a single AI taking over, or an army of them? "From our perspective, the important thing is what AI does," he stresses. And that, he believes, may still be up to humans—for now.

**"PREPARING
FOR THE EVENT
OF GENERAL
AI SURPASSING
HUMAN
INTELLIGENCE
IS ONE OF THE
TOP TASKS FOR
HUMANITY."**

—JAAN TALLINN

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ISSUE
121

RETHINK

DECEMBER
2018



64

WE BUILT YOU A HOUSE
FULL OF FEAR!

66

WHAT DOES THE WAR ON
GUNS ACTUALLY COST?

68

ASTEROID STRIKES ARE A
REAL PROBLEM

69

MELTING PERMAFROST IS
EXTREMELY GROSS

70

TALES FROM
THE FIELD!

72

WE GO AHEAD AND
SUPPORT EUGENICS!

78

THE ELECTRIC CHAIR IS
NOT A GOOD CHAIR



Rethink

The Ultimate Fear Factory

by ELEANOR CUMMINS

roving sharks has kept us safe for millennia. So it makes sense that 25.4 per cent of us fear these toothy predators: after all, 317 Australians have been attacked by sharks, and 43 killed, since 1990. Other terrors aren't so obviously rooted in evolution, but pack some of the common ones into a house—as we did—and you're bound to find something to rattle your bones.

Heights: 28.2%

We're not born acrophobic, but we learn to be early on. Even in our largely cliff-free lives, a fear of heights remains so fundamental that 9-month-old babies avoid drop-offs when crawling.

Reptiles: 23.6%

Each year, 100,000 people die from snake bites, but it could be worse. Humans are especially good at spying slitherers: Even in our peripheral vision, we're better at spotting snakes than other potential threats such as spiders, likely because the fanged reptiles pose a greater danger.

Public speaking: 20%

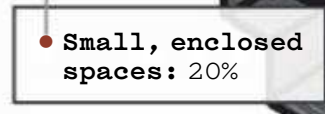
Although glossophobia is extremely common, it's rarely disabling enough to warrant treatment. Broader social anxiety, however, affects about millions of adults, many of whom rely on therapy or medication.

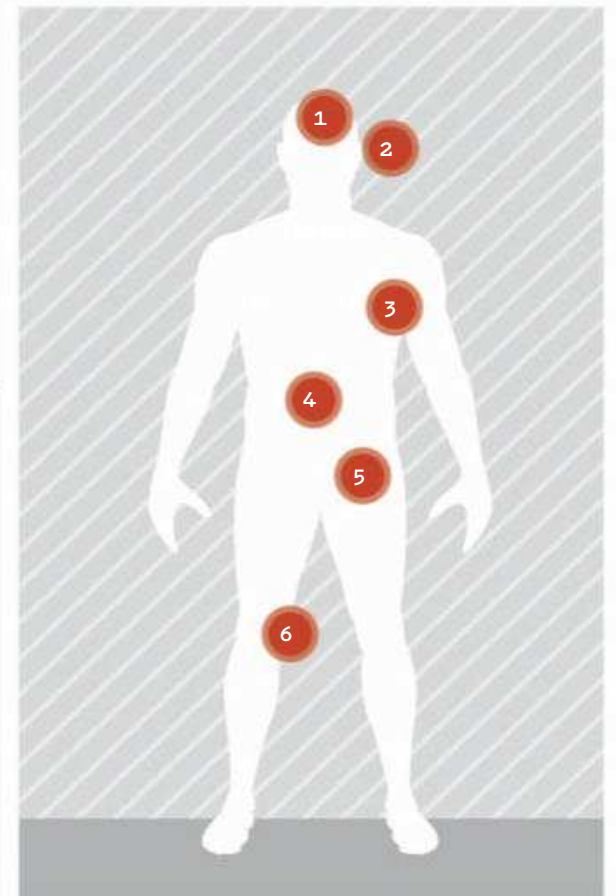
Deep lakes and oceans: 18.2%

Nearly 300 people drown in Australia each year. Though vast waters might trigger fright for about one-fifth of us, the depth of an ocean or lake is immaterial. Toddlers can drown in just 50 mm of water, and 25 percent of all drownings happen at less than 1.5m.

Clowns: 6.7%

Ventriloquist dummies, porcelain dolls, and clowns may be united in horror by the “uncanny valley” effect. The disputed and largely unexplained psychological phenomenon means almost-lifelike things unnerve us, while totally inhuman objects (and real human beings) don’t.





Fright in the flesh

Alarm strikes your body within seconds of recognising a threat. Here's what's going down.

- 1 Amygdala**
Before you consciously process a problem, this almond-shaped brain region activates and begins to amp up the sympathetic nervous system's fight-or-flight response.
- 2 Hippocampus and frontal cortex**
The rational centres of our brain kick in, analysing whether the perceived visual or auditory input shows a true danger.
- 3 Cardiovascular system**
Stress hormones increase your heartbeat and breathing rate while dilating the tiny airways in your lungs. This allows more oxygen to reach your muscles.
- 4 Endocrine glands**
Signals from the amygdala hit the hypothalamus, which starts a cascade of activity throughout the endocrine system. The result: a surge of adrenaline and cortisol.
- 5 Gastrointestinal system**
Fear really can make you poop your pants. That and retching may be side effects of shrinking blood vessels in the GI tract—diverting resources to give you strength.
- 6 Musculoskeletal system**
Endocrine signals push glucose and other energy-storing molecules out of reserve and into the blood, which rushes in to fuel muscles should you need to escape or fend off a threat.

ILLUSTRATION BY NIGEL SUSSMAN / SOURCE: 2017 CHAPMAN UNIVERSITY SURVEY OF AMERICAN FEARS



The Plagues We Made

by KAT ESCHNER

NOT ALL EPIDEMICS COME FROM THINGS YOU CAN CATCH FROM a cough. Two public health threats with ever-growing casualty rates in the US—gun violence and drug abuse—are just as worthy of the designation as the most virulent bug, and stopping a social contagion is no small feat. Thankfully, the Centres for Disease Control and Prevention is devoting money and brainpower to solving America's deadly descent into widespread opioid addiction. But thanks to a 1996 law effectively banning federal funding for the study of gun control, the country's work on curtailing growing firearm-related fatalities has even further to go. Here's the latest data on these looming crises.

1,681,359

Potential years of life lost to opioids in the United States in 2016—45 hours and 13 minutes for each person in the country.

916,869

Potential years of life lost to guns in the US in 2016. That amounts to 24 hours and 49 minutes for each member of the population.

How much more likely a white American is to die from an opioid overdose in 2015 compared to a black American. Rates are rising in rural areas.

1.7x

The rate at which black Americans died by gunshot between 2010 and 2016 compared to white Americans.

1.9x

Opioid overdose deaths per 100,000 Americans in 2016. This rate is nearly five times higher than it was in 1999.

13.3

US gun homicides per 100,000 people in 2016. America accounts for 82% of such deaths in the developed world.

4.6

\$229 billion

Estimated annual cost of firearm violence to the US economy, including lost wages and productivity from the deceased. Fees from hospital visits alone hit \$2.8 billion.

\$504 billion

The cost of the opioid crisis in 2015, according to a 2017 White House report. This also includes lost economic potential due to death, as well as healthcare and substance-abuse treatment for people with addiction.



96.2

Americans killed by guns on an average day—in 2016, 37% were homicides and 59% were suicides.

115

The number of opioid-related deaths in an average day, according to the CDC. There were 42,249 of these mortalities in 2016.

\$350 MILLION

Additional funding allocated to the CDC in the 2018 budget for opioid prevention measures, such as monitoring prescriptions and helping addicts avoid relapse.

\$0

CDC budget devoted to firearm-related-injury prevention, the result of a 1996 amendment mandating that the agency can't use funds to "advocate or promote gun control."

SHUTTERSTOCK



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Asteroid Smackdown

by MARY BETH GRIGGS

EARTH IS IN A CONSTANT GAME OF CELESTIAL BUMPER CARS, COLLIDING WITH—and obliterating—the relatively puny space rocks that dare cross its path. The planet is still standing after 4.6 billion years, but a modern collision could devastate cities, continents, and even life itself. (Just ask the dinosaurs.) NASA's Centre for Near-Earth Object Studies keeps watch on more than 18,000 potential troublemakers, ranging from just one metre to more than a kilometre across. Meteors smaller than 30 metres usually explode in midair, like one did over Chelyabinsk, Russia, in 2013. There wasn't enough shrapnel to leave a crater, but the sonic boom did blast out windows. So how much havoc could larger rocks wreak?

SIZE REALLY DOES MATTER

DIAMETER	IMPACT ENERGY (MT)	AVG. YEARS BETWEEN IMPACTS
5 m.	0.01	1
10 m.	0.1	10
25 m.	1	100
50 m.	10	1,000
150 m.	300	20,000
300 m.	2,000	70,000
600 m.	20,000	200,000
1 km.	100,000	700,000
5 km.	10,000,000	30 million
10 km.	100,000,000	100 million

LIGHTS OUT

This debris could throw enough dust to block out the sun—globally.

CHELYABINSK

Russia's air-borne explosion was 20-30 times more powerful than Hiroshima.

KABOOM

Equals about 11,000 tons of TNT. The Eiffel Tower weighs around 10,000.

THE DINO KILLER

These can obliterate nearly all life—but our odds look good.

NEED FOR SPEED

One reason these flying objects are so dangerous is their velocity. A zipper asteroid can do more damage. And these things are fast—upwards of 70,000 km/h. All other factors (size, angle of entry, target) being equal, a faster asteroid can dig a bigger crater, and melt the rock it's slamming into.

TOUGH STUFF

Composition is key. Metal asteroids are durable enough to reach the surface even at small sizes, while carbon-rich rocks almost always break up in the atmosphere. The stony sort—which make up 94 per cent of all meteors—fall somewhere in between. But even a broken-up hunk of space junk can cause a dangerous shockwave in transit.

LOCATION IS EVERYTHING

More than 70 per cent of Earth is ocean. If an asteroid happened to make a water landing, it might be less harmful than if it struck populated land. Experts do have some (minor) concerns about a tsunami, which occurs when large amounts of water get displaced, but the real worry is a high-speed projectile launching dust from the seafloor high into the atmosphere.

Rethink



What Lies Beneath

by AMELIA URRY

PERMAFROST ISN'T JUST CHILLED DIRT: IT'S COLD STORAGE for everything from mammoths to the microbes inside them. Any soil that stays frozen for at least two years is permafrost, but the frigid layers can be tens of thousands of years old and as thick as 1,500 metres. But climate change is warming the Arctic twice as quickly as any other place on Earth, causing some strange threats to emerge. While many of these artefacts might not do any damage in the modern, melting world, some could be bad news.



1 Exhumed fumes

The scariest entity to emerge from the melt so far is methane, a greenhouse gas 30 times more potent than CO₂. Released when formerly frozen matter decomposes in thawed tundra, the gas boosts atmospheric temperatures, defrosting more acreage—a feedback loop that could get severe.

2 Tiny but tenacious

Bacteria that form protected spores, such as tetanus and botulism, are the most likely to pose a threat once defrosted. No one knows how long microbes can survive a hard freeze, but in 2007, scientists reported signs of cellular life in 8-million-year-old Antarctic ice.

3 Ye olde maladies

In 1918, a virulent flu killed tens of millions. Scientists have found fragments of the virus in thawed graves of its Arctic victims. And in 2004, traces of smallpox—officially eradicated in 1980—showed up on 18th-century Siberian corpses.

4 Oh, deer

In the early 1900s, *Bacillus anthracis* infections - better known as anthrax - killed 1.5 million reindeer in northern Russia. In 2016, rising temperatures released the bacterium's spores to cause anthrax poisoning in thousands of deer (and a few dozen humans).

5 Unknown diseases

In 2017, a teacher contracted a bacterial infection while excavating seal remains from an 800-year-old Alaskan dwelling. Old diseases, including those that plagued our hominid ancestors, could lurk anywhere—and our modern immune defences might not work against them.

6 Big-shot microbes

In 2014, virologists discovered a pathogen 10 times bigger than the flu in 30,000-year-old permafrost. Once warmed, it started preying upon amoebas. It doesn't seem to infect humans, but reports of antibiotic-resistant bacteria from the same era could be a cause for worry.



TALES

FROM X THE

FIELD

MY INSPIRATION

From Bank Clerk to Arctic Explorer

ANN DANIELS,
WORLD-RECORD-BREAKING
POLAR EXPLORER



Twenty-five years ago, I never dreamed of exploring the Arctic—I worked as a bank clerk in England. Then I saw the chance of a lifetime: a classified ad seeking “ordinary” women to join the first all-female team to the North Pole. The trip required half a million dollars in total, and the two organizers thought amateurs would get more funding. Of course, no one was ordinary except for me—they were all outdoorswomen and mountaineers. I’d never even skied.

After more than a year of training, the expedition began, and I stepped onto moving ice for the first time. One day, as we were traveling along the edge of some thin ice, it cracked. Nobody saw me plunge into the water or heard me shout.

When you get wet in temperatures of minus 30°C, you develop frostbite in minutes. I grabbed the nearest chunk of ice and almost hauled myself out, but it broke—twice. I knew I had only one more chance. Fortunately, I managed to pull myself onto a ledge on my third try.

Then I had to roll in the snow. This seems very odd, but the powder absorbs moisture, which can cause hypothermia. By then my teammates had returned. To protect me from frostbite, they took off my boots, thawed my bare feet against their skin, and wrapped them in a pair of dry socks. I had to put my frozen boots back on, but I stuck each foot in a plastic bag first, to keep my toes dry.

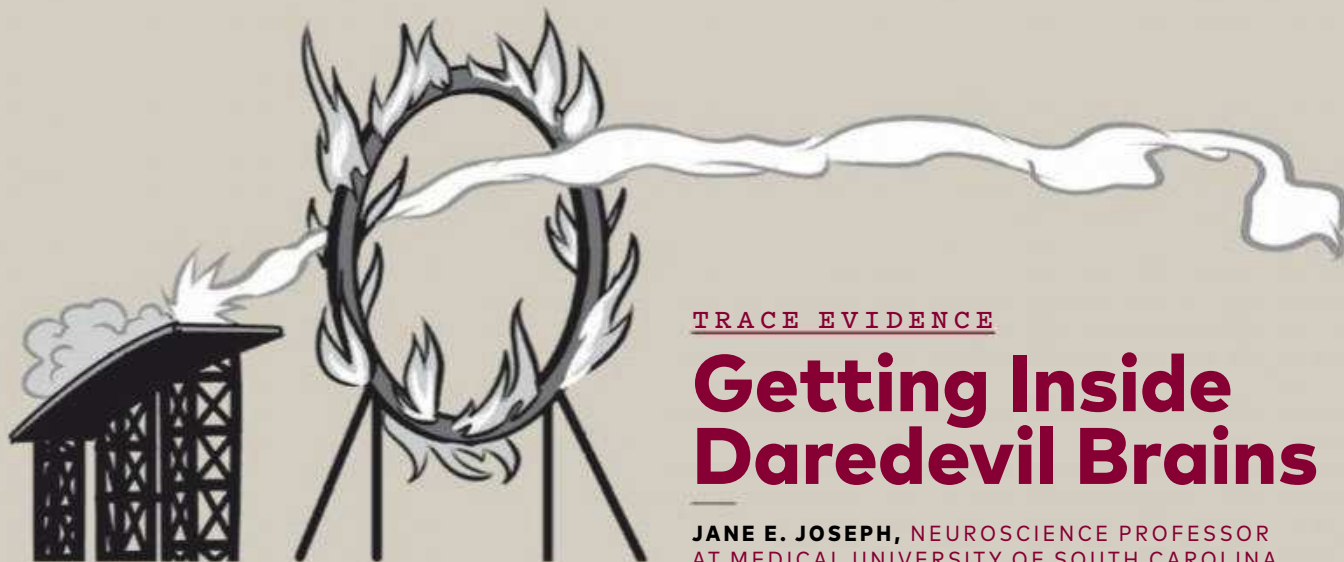
Although it was brutal, I fell in love with the Arctic on that first trip. Now I ski out to take measurements and collect samples for scientists who don’t have the skills to trek to the North Pole themselves. Last year, I put trackers in the ice to see where it’s going and how quickly it’s moving. This is important to me because over the years, I’ve seen the Arctic disappear with my own eyes. I feel like I’m helping this amazing place that affects the whole planet.

Nothing as scary as that fall through the ice has happened to me since, unless you count the solo expedition during which a polar bear stalked me for three days.



ILLUSTRATIONS BY RAFAEL ALVAREZ

AS TOLD TO ANNA BROOKS



TRACE EVIDENCE

Getting Inside Daredevil Brains

JANE E. JOSEPH, NEUROSCIENCE PROFESSOR
AT MEDICAL UNIVERSITY OF SOUTH CAROLINA



As a cognitive neuroscientist, I study how the brain processes thoughts and emotions. I used to focus on sensation-seeking behaviour, which involves people pursuing risky activities to get a thrilling reward.

In 2015, a journalist heard about my work with daredevils and suggested I test the brain of free-solo climber Alex Honnold, who scales cliffs—such as Yosemite National Park's 1,000-metre-high El Capitan—without ropes. I would describe him as a super-sensation seeker, but he's also

conscientious; he climbs with intention and thought, as opposed to an impulsive adrenaline junkie. Like our other subjects, he had to take personality questionnaires and then undergo an fMRI scan while viewing emotional pictures. Negative ones showed unflushed toilets or natural disasters, while positive images included mild erotica and people hang gliding.

Anatomically, Honnold's brain is normal (if there is such a thing). But his amygdala, historically considered the brain's fear detector, didn't respond to our images like an

average sensation seeker's did—the pictures weren't intense enough to stimulate that part of his brain. That could be because he regularly faces real fear and has conditioned himself to distinguish it from anxiety.

Feeling scared is an appropriate response to an immediate threat, such as hanging off a cliff with no protection whatsoever. Anxiety happens when a non-threatening stimulus, such as imagining roaches or rotting food, triggers an association with danger. As an extreme risk-taker, Honnold knows the difference.

AS TOLD TO ROB VERGER

HOW IT WORKS

Scooping Lava From Active Volcanoes

JESSICA JOHNSON, GEOPHYSICS RESEARCHER
AT THE UNIVERSITY OF EAST ANGLIA



Most of a volcano's activity happens below the surface—but we can still learn so much by collecting samples from the lava that emerges. It comes out at around 980°C; you might stand a few metres away and feel fine, but move any closer, and the heat overwhelms you. Once, as I stood at the edge of a crater at Hawaii's Kilauea volcano, my camera started melting. As soon as I took a few steps back, everything cooled off—and the camera still worked!

When I took samples, I'd always wear Kevlar gloves, and often a protective suit. First, I'd scoop up a glob of lava—it's surprisingly sticky, like thick toffee—with a steel tool called a rock hammer. Then I'd drop the sample into a bucket of water, cooling it to prevent gas from escaping and changing its chemical makeup. Because different gases seep from the ground at different depths, lava's composition tells us where it came from and how long it lurked below the surface.

AS TOLD TO CLAIRE MALDARELLI



NOV 1934

From The Archives

That Time We Suggested Using Radiation to Breed Supermen

TYPICALLY IN WRITING POPULAR Science in 2018, we try to avoid combining certain phrases, like “bathed with X-rays”, “rearrange the genes of mankind”, “virgin females from one race, and males from the other”, “build a new race of supermen” and “in Berlin, Germany, scientists...” Because the imagery that all this stuff evokes has a certain... historical context.

Back in 1934 that context didn't yet exist, of course. X-ray machines were three storeys tall, DNA had not yet been fully described (though geneticists were starting to get a handle on it), and this magazine had

no problem talking about “the search for the M-ray that is asserted to control growth and death.” Pseudoscience? Not us!

Actually, this article is a pretty well-researched description of the state of the science of genetics in 1934, and we should thank Sterling Gleason for it. We can only assume editor Raymond J Brown - after his eyes glazed over somewhere in the eighth paragraph about mutant flies - decided to spice it up with a jazzy headline.

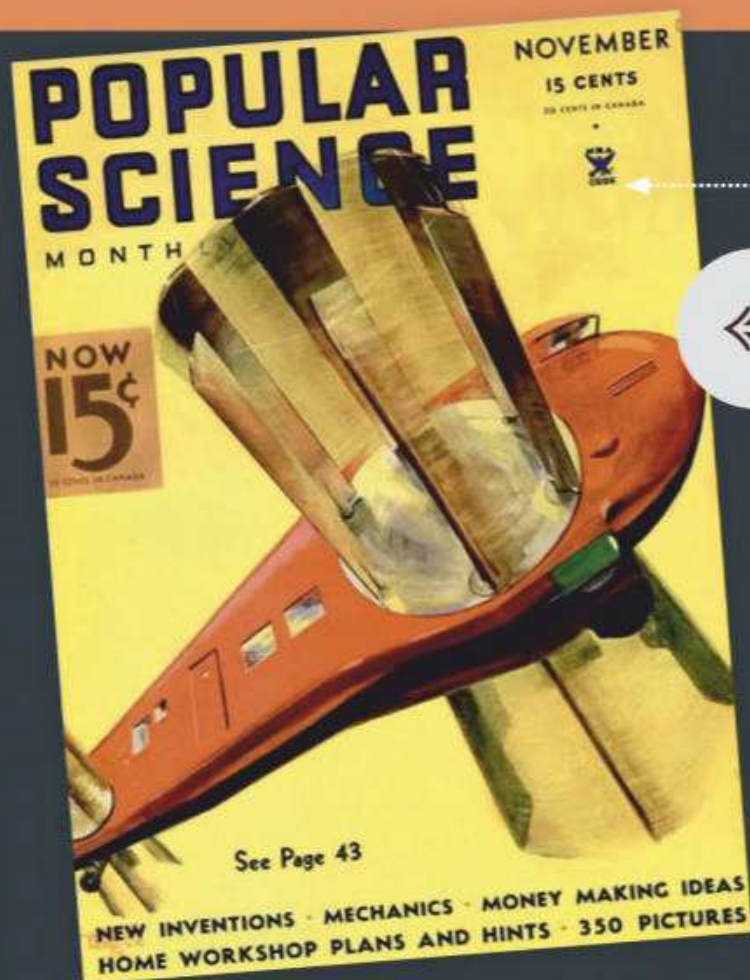
Mr Gleason does eventually get around to speculating how bombarding corn with X-rays could be applied to creating a new

race of supermen, but really, this piece is mostly about scientists wondering how these things called “chromosomes” actually work.

If nothing else, however, the article serves as a reminder of how much data and detail scientists were able to observe and record, even in a world that had no computers or even calculators, whatsoever.

That said, we're still sorry in hindsight about promoting the Nazi scientists and their “fourteen kinds of X-ray machines, as well as other curious apparatus... for producing heat rays, ultra-violet rays, light rays, as well as the super-penetrating emanation of radium.”

by ANTHONY FORDHAM



Wait, We Used to Support the NRA Too?

NOVEMBER 1934

Ignore the big picture of the cyclogyro, those planes were never built. The weird thing on this cover is that little blue eagle with NRA CODE written on him. What's all that about? Were we supporting gun ownership?

Well, it turns out that after the Great Depression, the US initiated a program called the National Recovery Administration. Established by FDR in 1933, it was supposed to create a set of fair practices for all industries, and set reasonable prices. In the USA, I know, right?! Businesses that were compliant got to sport the “Blue Eagle” - a quick Google search will show you certificates for “Retail Trade”, “Motor Vehicle Maintenance Trade”, “Picture Moulding and Picture Frame

Code Authority”, “Construction Industry” and of course “Optical Manufacturing”. Obviously.

If this all sounds suspiciously like workers rights and union interference with ‘Murican freedoms, well, so did the US Supreme Court. It declared the NRA “unconstitutional” in 1935, and so it was shut down... only to be replaced by the National Labor Relations Act, which boosted support for the unions, and created the New Deal Coalition, which dominated US politics for the next 30 years.

Yeah so anyway, the staff of Popular Science were a bunch of commie sympathisers in 1934, on account of how they paid their writers fairly.



RAYMOND J. BROWN, *Editor*

Sensational Study of HEREDITY *May Produce* New Race of Men

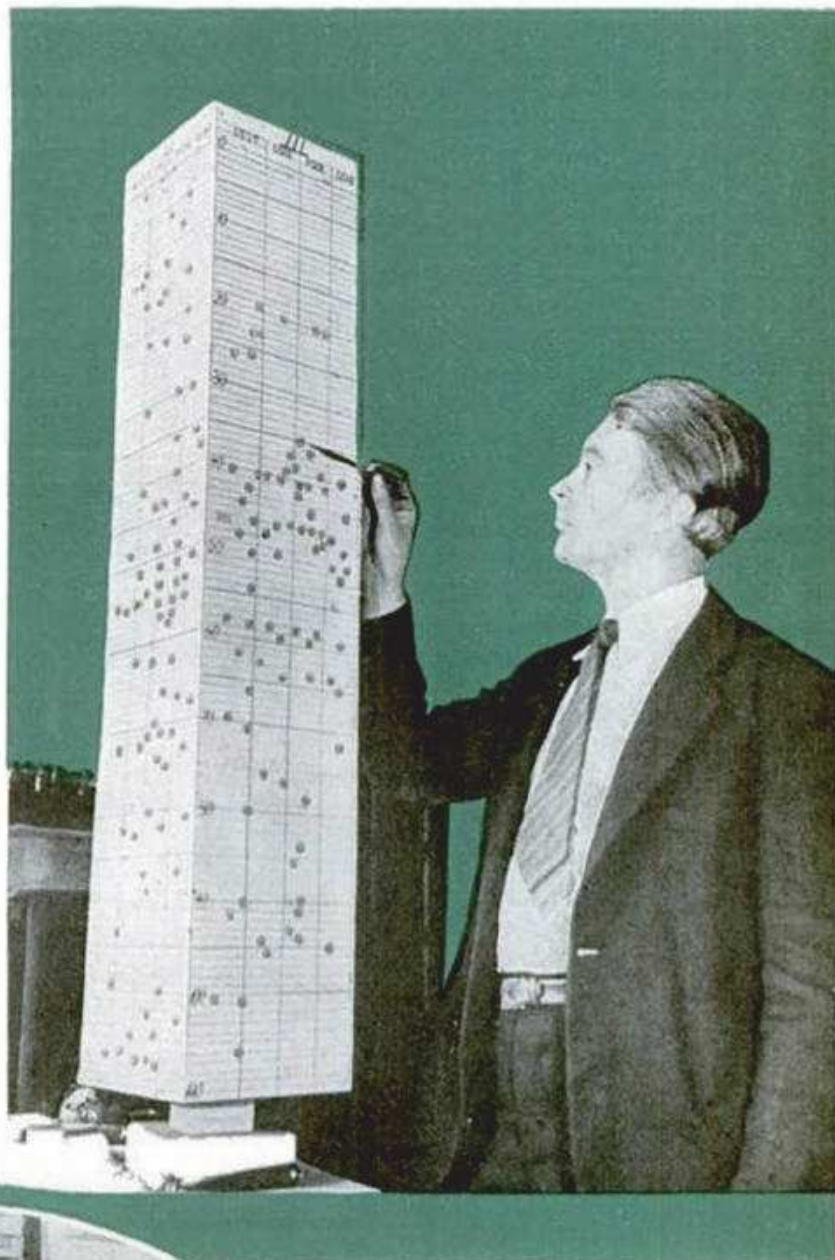
By
**STERLING
GLEASON**

BLACK light, heat, and X-rays are being used by experimenters in sensational efforts to solve the mysteries of heredity. Workers in a score of laboratories in many different countries are delving for secrets locked in the living animal cell.

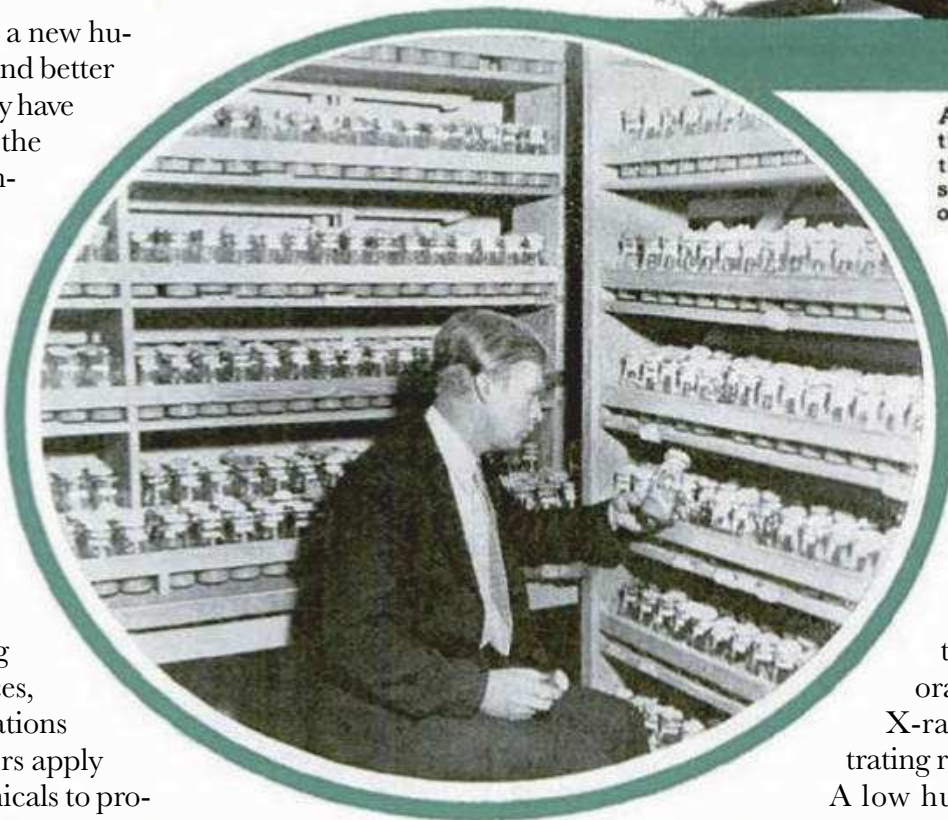
From their discoveries may emerge a new human race, stronger, more intelligent, and better able to resist disease. As the first step, they have produced an amazing chart by which the character of generations of flies yet unborn can be accurately foretold.

Radiations, the newest and most powerful tool of the physical sciences, are chief instruments in this biological study. Lightlike ether waves penetrate animal cells in the search for an M-ray that is asserted to control growth and death. Mysterious emanations of the human body, with the strange power to kill yeast, are being analyzed and compared with the flashes of energy given off when living cells are active or divide. Artificial races, laboratory-produced, grow for generations in the refrigerator while experimenters apply radiation from vacuum tubes or chemicals to produce types of life hitherto unknown.

In a pair of narrow-mouthed glass flasks, Dr. Calvin Bridges, an associate of Dr. Morgan famous cytologist, at California Institute of Technology, recently held in bottles two swarms of tiny gnat-like flies. From each flask he emptied hundreds of flies into small glass chambers filled with ether vapors. Succumbing instantly, the insects became mo-



Above, life chart of heredity-controlling genes. The black dots show the position of genes in a chromosome. At left, stock room filled to overflowing with experimental flies



tionless and were then poured out upon a gleaming white plate under the binocular microscope. Virgin females from one race and males from the other were selected for the start of a spectacular experiment.

Into a tiny quartz tube Dr. Bridges put the males, then took them to the Kellogg Radiation Laboratory which houses the three-story X-ray tube producing the most penetrating rays ever controlled by man.

A low hum arose as giant oil-immersed transformers went into operation in the laboratory.

A sharp hissing sound came faintly through concrete and lead walls as a million-volt flame of electricity crashed across spark gaps. A stream of invisible X-rays was being reflected from a target hidden in the cylinder of the tube which passed through the exposure room from floor to ceiling.

Three seconds later, Dr. Bridges removed the X-rayed insects from their searing bath and placed them together in a flask containing a little agar, molasses, and yeast.

Within ten days, a new generation of the flies had been born. What mysterious rearrangement of the life-controlling elements, or genes, had been wrought by the influence of the X-rays? Placing the anesthetized insects under the microscope, Dr. Bridges sought the answer.

Striking abnormalities were at once apparent. The eyes of one male were bright vermilion instead of the normal dull brick red. The wings of another stood out stiffly at an angle from the body instead of folding back neatly along its sides. Still another had an extra pair of wings which no normal fly should have.

Into glass homes went the freak flies, to breed new generations of their kind. The results of these experiments were recorded by sticking push-pins with lettered heads into a tall, four-sided post, marked off by horizontal divisions. More knowledge had been added to the famous life-chart which graphically depicts how this species produces new kinds in bewildering variety.

In thick-walled vaults at California Institute of Technology, more than 700 distinct races of the tiny fly, known as *Drosophila*, live in refrigerator-like vaults and reproduce their kind for the benefit of science. The insects go through their life cycle at the rate of three generations (sic) a month, thirty-six a year. Many of them have a recorded family tree which, if they were men instead of flies, would date back 15,000 years before Adam.

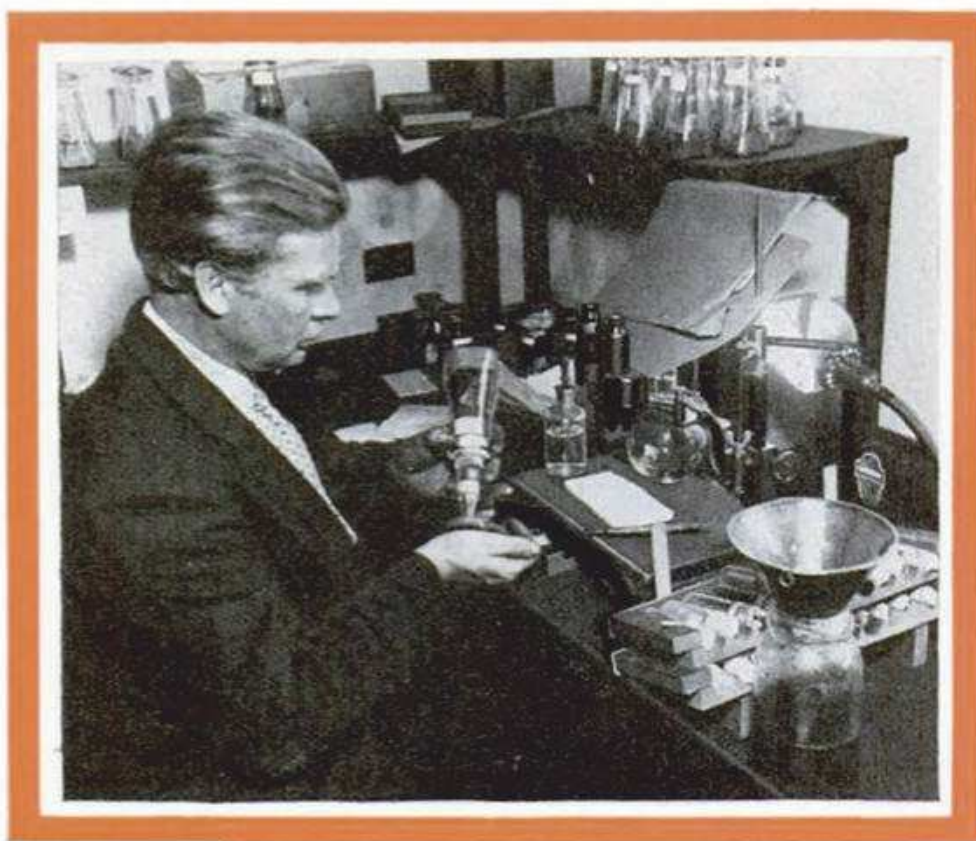
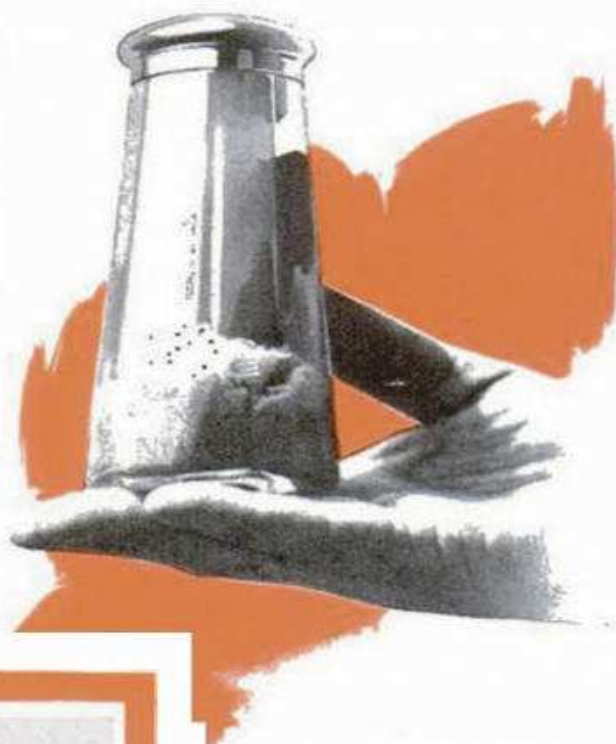
For forty years, scientists have known that characteristics are inherited according to a definite plan. But no one understood

kinds of cells—body cells, and reproductive cells, the latter being the only link between one generation and the next. All cells multiply by division. In a growing child, each cell is believed to split at least once a day, producing millions in a month, billions in a year. But what mysterious change goes on in the reproductive cell to produce freaks, or “mutations”?

Dr. Morgan undertook to find out, using the tiny yeast fly as guinea pig. One day he made the exciting discovery that one of his flies had snow-white eyes instead of the normal brick-red. He bred the fly to produce a race of white-eyed flies and found the trait to be “sex-linked”; that is, it followed sex. Only the males of a particular generation had white eyes. Females were normal. Soon other sex-linked traits, as yellow body-color and miniature wings, appeared.

Why did these characteristics follow sex? Dr. Morgan said that whatever element in the germ cell determined sex also must contain something which caused the “mutations.”

Below is one of the specially designed culture bottles used in raising pedigreed strains of experimental flies. These flies are so small that 500,000 of them will weigh only a pound



In this laboratory, flies are etherized and then placed on a white plate and examined under a high-powered lens

piece. Thus he proved that the genes which produced the characteristics are actually parts of the chromosomes.

So tiny are the chromosomes that even under the most powerful of microscopes, they can be seen only indistinctly. Then came the startling discovery that in the salivary glands of the *Drosophila* larva, chromosomes grew to be sixty to seventy times bigger than ordinary. In these giant cells, experimenters could see the four pairs of rods with great detail. Their banded structures were clearly visible and the point at which the chromosomes had

broken and recombined could now be accurately plotted on the life-map.

Years of research showed that each part of each chromosome contained specific character determiners. Each controls the development of one characteristic of the fly. Thus the genes which Morgan had suspected, actually exist as minute groupings of the chromosome material itself.

Further research has now given the world a strange life-chart. Each side of the square post on which it is built represents one of the four chromosomes. Each button with which it is studded represents a gene, controlling some physical characteristic of the fly. The experimenter can read directly upon the map what proportion of grand-children will show any given combination of traits.

This actual mapping of the microscopic chromosomes created a sensation among scientists. In thirty or more laboratories all over the world,



Four kinds of chromosomes found in fly *Drosophila* are shown in these wooden models. The genes are invisible lying along the edges of chromosomes

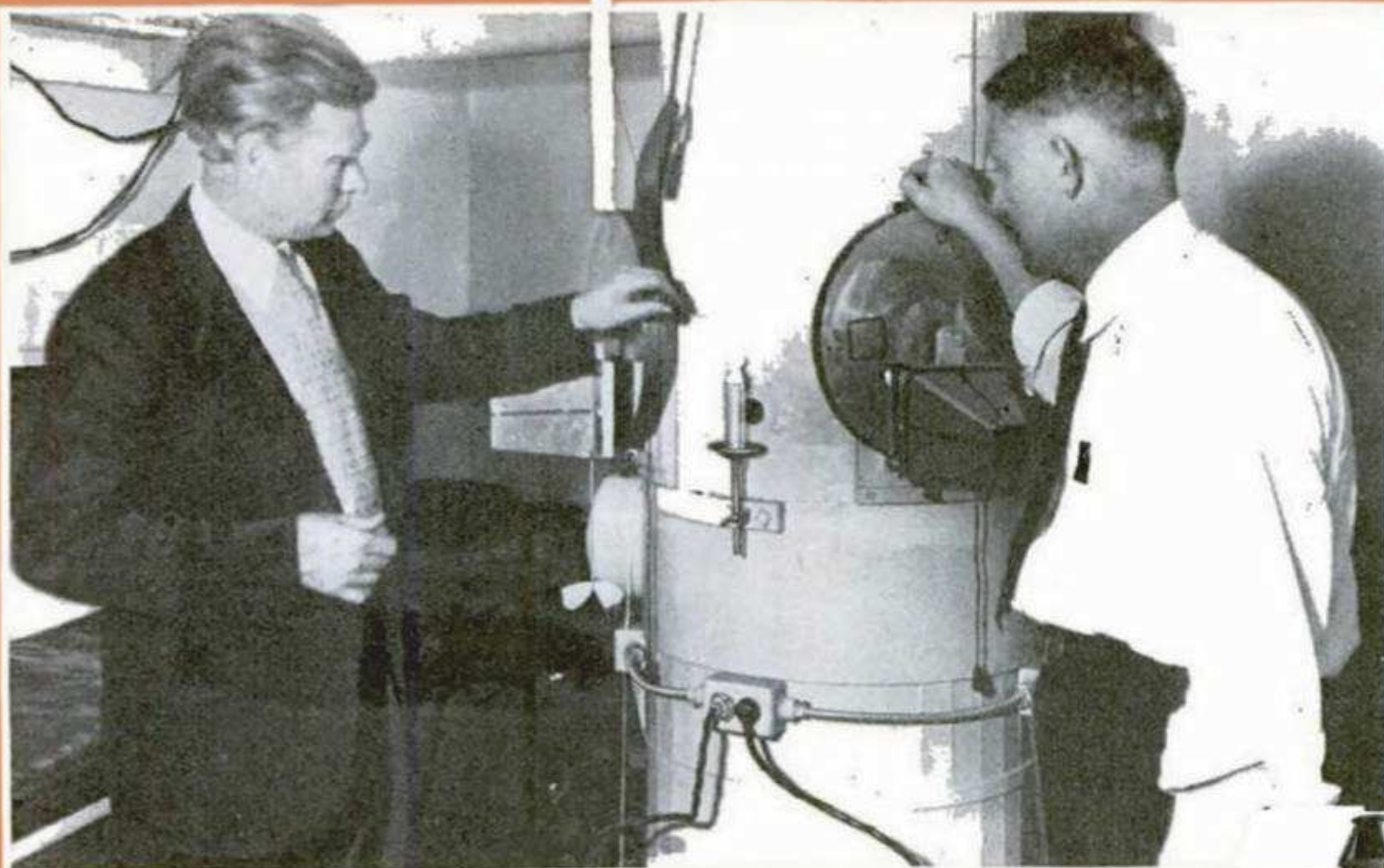
why freaks, unlike any known ancestor, sometimes occur. For example, there was a short-legged lamb which in the eighteenth century suddenly appeared in the flock of Seth Wright, a New England farmer, and was reared by him to produce the Ancon breed of sheep, favored because they are so short-legged they can not jump over an ordinary stone wall.

It was also known that the body contained two

Under the microscope the scientist could see the four pairs of rodlike chromosomes, like tiny punctuation marks. Chromosomes had already been studied intently for several decades without definite knowledge of their function. Experimenters knew them only “stainable bodies” in the central portion or nucleus of each cell. But now — Morgan was saying that one particular chromosome, which was different in males and females, must contain the genes which cause white eyes and other sex-linked characteristics, as well as sex itself.

His colleague, Dr. Bridges, soon discovered that certain freak flies with strange sex characteristics—flies half male, half female—were seen to have new configuration in their chromosomes. Certain freaks were remarkable, in that no part of the fly was left unchanged. Bridges found that such flies had suffered accidents resulting in broken chromosomes, the loss of a whole section of chromosomes, or sometimes the gain of an extra

X-Rays and Invisible Light Reveal Life Secrets in Germ Cell



In the new study of heredity, flies are exposed to the powerful X-rays from a million-volt tube. This picture shows the first step in radiation treatment in the Kellogg Radiation Laboratory

more than a hundred workers are spending their time in filling in blank spaces of the life-chart. Twice a year a special bulletin is issued by Drs. Bridges and Demerec as an international clearing house for information.

Even with the rapidly growing *Drosophila*, experimenters might have worked for years without finding more than a few of the freak types which permit them to find the genes had it not been for X-rays. Nature produces few freaks, perhaps one in several thousand generations. But under bombardment with X-rays, mysterious changes occur in the germ cells. Chromosomes are shattered and recombined in new patterns producing freak flies at 150 times the normal rate.

WHY do body cells suddenly begin to run riot and multiply at an extraordinary rate, producing the mysterious disease known as cancer? In the chromosome of the mouse, Dr. Maud Slye, of the University of Chicago, has sought the answer, carrying her researches into the living germ cell of the little rodent in much the same way that Drs. Morgan and Bridges have probed the germ-cell of *Drosophila*. She has found that mice can inherit a susceptibility to cancer. For twenty-four years she has bred the animals for study, beginning with a pair mated in 1910. On the laboratory operating table, she has performed more than 116,000 mouse autopsies. Breeding tests have enabled her to narrow the source of the strange liability to cancer, to a single gene located in a chromosome of the mouse. Another gene, she discovered, has the power, if inherited, to protect its possessor against the disease.

Other experiments, revealing the effect of rays on plant life have produced results almost as

spectacular as those conducted upon insects and animals. Magicians of the laboratory have altered the characters of plants, changed their time of blooming and produced new varieties by exposing them to the bombardment of invisible rays.

A few years ago, Dr. L. J. Stadler, of the Missouri College of Agriculture, employed a curious portable X-ray machine to study the effect of the rays upon growing corn. Pushed up and down the rows like a hand cultivator, the apparatus bathed each stalk with X-rays before it passed on. As a result, Dr. Stadler found curious alterations took place in the growing plants. Through his researches, he hopes to develop new and better varieties of corn and other grains.

In Berlin, Germany, scientists in a unique ray laboratory have been employing fourteen kinds of X-ray machines, as well as other curious apparatus, to study the relation of rays and plant life. Besides the X-ray aids, they have installed apparatus for producing heat rays, ultra-violet rays, light rays, as well as the super-penetrating emanations of radium. Seaweed and other forms of marine plants as well as the more familiar plants of the fields have been subjected to exhaustive tests. On the roof of the building which houses the laboratory, automatic apparatus keeps tab on the exact amount of ultra-violet reaching the earth. These researches, it is expected, will prove beneficial by giving a clearer insight into the relation of growth and rays.

Far more mysterious than man-made rays are those of nature. The light of the sun seems to



With this unusual little plow, etherized flies are separated into groups of males and females, of white eyes or red eyes

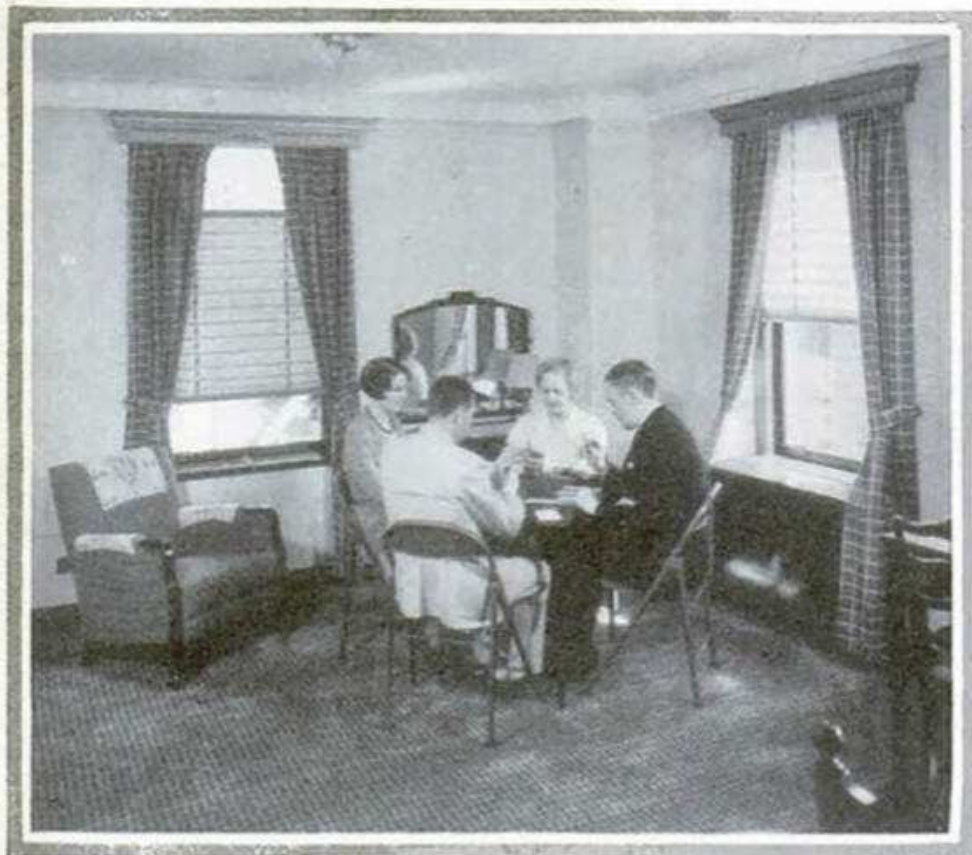
engender in certain plants the power to kill the Japanese beetle. Plants are known to give off potent radiations. Prof. Lieske of Mulheim, Germany, found that certain deposits of peatlike brown coal had the power to speed growth of flowers and to bring rats and mice to swift maturity. Mysterious mitogenetic rays given off by certain growing plants seem necessary for cell division and growth.

Fantastic though such experiments may seem, they open up marvelous opportunities. X-rays are harnessed to halt the ravages of cancer. Radio waves generate artificial fevers which break the grip of malaria. Electrical currents stimulate cell activity and speed circulation to ward off pneumonia. Will other unknown rays, in combination with a life-chart like Morgan's, enable man to analyze and rearrange the genes of mankind and build a new race of supermen?

Novel Appliances for

Obsessed (1934 EDITION)

Proof we've been pushing gadgets on readers for at least the last 84 years! Note that many of these innovations are electrical, but the magazine has to make a point of mentioning that.

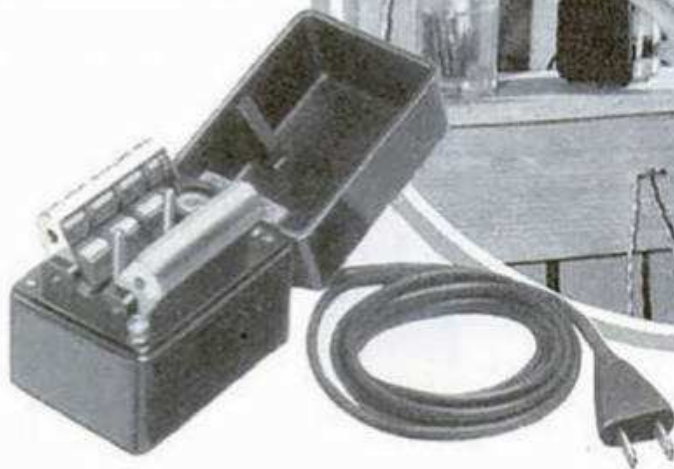


WATERPROOF WINDOW SHADE. Made of pleated fabric, that is waterproof, a new type of window shade can be lowered, or folded accordion fashion, to cover any desired portion of the window. The blind is raised in the ordinary way but is folded by use of a cord

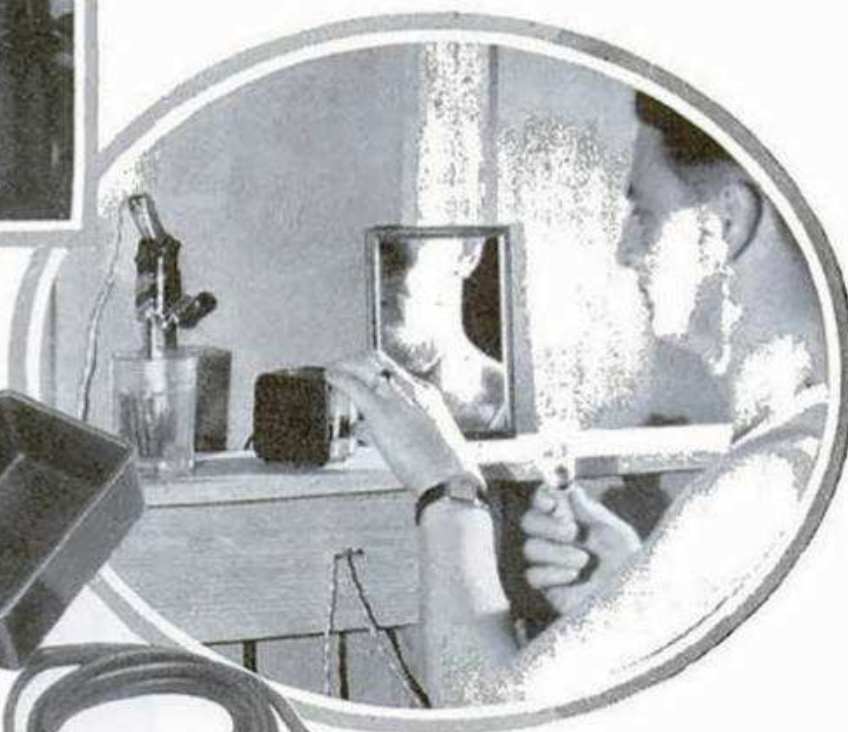


**NO TIME LAG IN
NEW THERMOSTAT**

Operating on a new principle, this thermostat actually anticipates temperature changes, according to the manufacturer, and so governs the heating plant without a time lag. Placed near the baseboard, as above, it governs the temperature in the lower portion of the room. View at upper right shows thermostat open revealing electric element that works the controls in response to difference in temperature between it and the room, thus bringing quick action

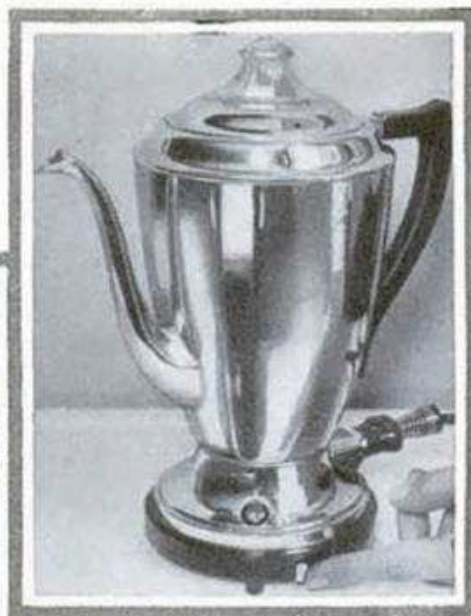
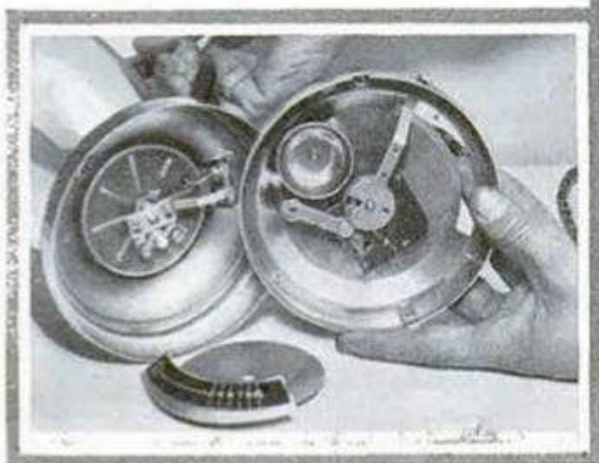


ROBOT KEEPS BLADES SHARP. This is the outfit shown in use in the photo in circle. It is plugged into any convenient socket and is ready for use



RAZOR SHARPENER. Electrically powered, this razor sharpener automatically hones and stropps razor blades. The power is turned off when blade is sharp

PERCOLATOR RINGS BELL. When coffee is properly prepared, the electric percolator, shown in these two views, rings a bell. By moving a lever, it can be set to deliver from two to eight cups. The inside of the percolator is graduated as a guide in filling it. The interior parts of the pot are shown in photo below



the Household



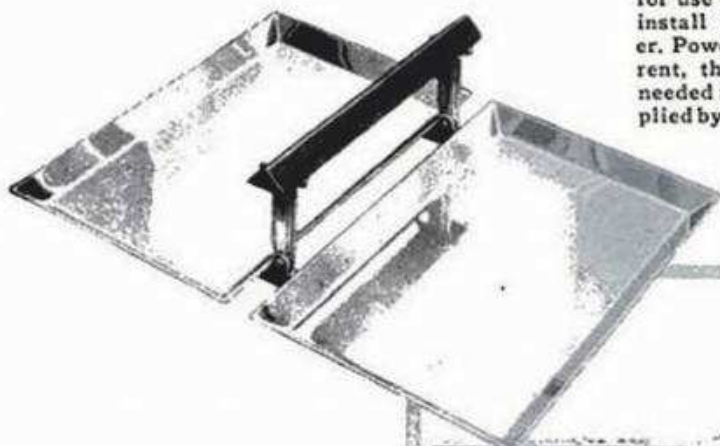
ELECTRIC MIXER. Fruits and vegetables to be used in jellies or soups are dropped into the hopper of this colander and a switch turned. House current operates the mixer



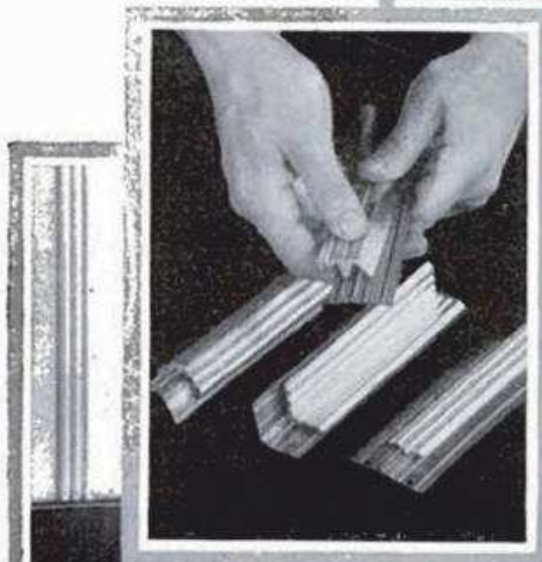
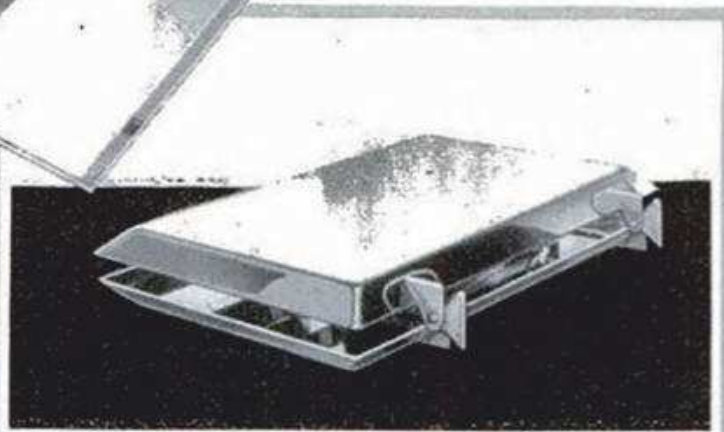
FRESH COFFEE. You can have fresh-ground coffee for use in your home if you install this electric grinder. Powered by electric current, the amount of coffee needed for each meal is supplied by turning control ring



AIR PURIFIER. This air circulator is installed in the attic of a house and electrically operated. It has a three-blade fan that causes a steady circulation of air so odors and smoke are drawn from the lower rooms



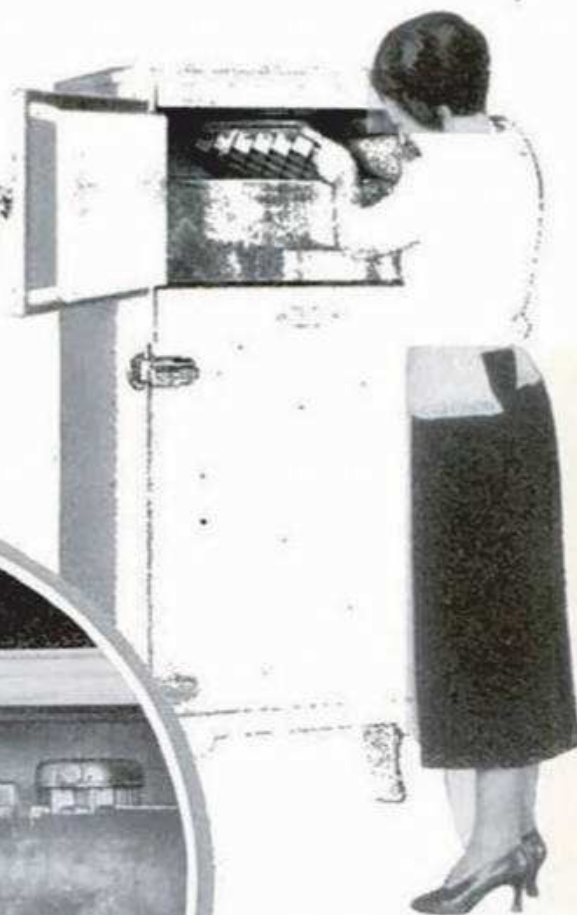
FOLDING TRAY. Ample room for a spread is provided by this tray when open as shown above. When closed, as at the right, it is conveniently put away in any small restricted space



METAL TRIM. An attractive finish can be given baseboards and wall panels with a new metal trim that snaps into place and is held by a copper spring-clip base. This base is easily tacked into place



MAKING ICE CUBES
Housewives who do not have automatic refrigerators can still have ice cubes with the aid of the device shown above. Filled with hot water and set on top of a block of ice, its cutting edges quickly sink into the ice. Then when it is lifted off, the cubes thus formed can be easily removed



The Worst Chair in the World

Invented on a whim. Co-opted into a marketing battle.
Responsible for human suffering. How did this even happen?

by ANTHONY FORDHAM

THERE'S SOMETHING GROTESQUE ABOUT the idea of trying to come up with a “humane” mechanical method of capital punishment. It really shows human innovation at its absolute worst.

The electric chair, after all, is indeed an innovative machine, designed to kill people as quickly and silently as possible. Painlessly? Oh sure, that's important too, but the key thing is that the condemned prisoner not thrash about or scream or make horrible noises. The witnesses don't like that.

But the reason the electric chair was invented at all had very little to do with sparing the condemned unnecessary suffering, and everything to do with the way Thomas Edison's company owned the patent on direct current electricity.

In the late 19th century, the War of the Currents saw Westinghouse's alternating-current based systems in fierce competition with the Edison Electric Light Company's DC. AC's big advantage was its lower cost of transmission across long distances. DC's advantage, to Edison at least, was that his company

owned the patent on it.

Edison's company claimed that AC was simply too dangerous to be used for anything that involved the idiotic, fork-wielding public. This claim was not without cause: Supporting Edison's case was the unfortunate frequency of deaths around the first generation of electric street lamps.

This was a time of very little regulation of how overhead wires were strung. Telephone, telegraph, burglar and fire alarms, these were all new technologies that needed overhead wires, and so up they went.

Then along came electric street lighting, arc-lamps mostly, which ran on incredibly high voltages. So into the rats' nest of existing overhead wires were added 6000 volt cables. All it took was for a storm to down one, or for a lineman to grab the wrong handhold, or for an idiot to take the wrong dare, and zap: AC would claim another victim.

These deaths initially mystified the world of the 1880s. In Buffalo, New York, in 1881, a drunken dock worker managed to electrocute himself in an arc lighting power house. The coroner brought the death to the local scientific society.

Now, while most people - including Thomas Edison - might

▼ **Witnesses say the** execution itself appears instant. But prisoners clearly show fear and distress during what critics say is a cruelly long strapping-in process - up to 15 minutes before the switch is thrown.



respond to a death by electrocution with horror, or with wild rantings about the inherent dangers of the AC system, a society member (and dentist, just by the way) named Alfred P Southwick took a more considered approach.

A powerful force that can kill a man dead instantly, without leaving a mark? There must be a useful application for such a thing! At least, this is what we presume Southwick thought, because he spent the next year or so in partnership with local doctor George E Fell, doing experiments on dogs. But which we mean: they electrocuted hundreds of stray dogs.

Southwick eventually published the results of his experiments and proposed that they be adapted into a system for executing prisoners. His timing was good: in the late 19th century, a series of horrifically botched hangings had left the public uneasy about capital punishment. Southwick had a solution!

It all sounds pretty sick from this end of history, and who knows, Southwick's creepy invention may not have gone anywhere, were it not for New York State's decision to set up a death penalty commission, and consult the Edison Electric Light Company on the finer details of electrocution.

Thomas Edison, of course, was more than keen to support the idea that an AC system could kill a man stone dead in an instant, and he even went as far as to recommend a Westinghouse generator be used to create the lethal current. Westinghouse, of course, being his main competitor.

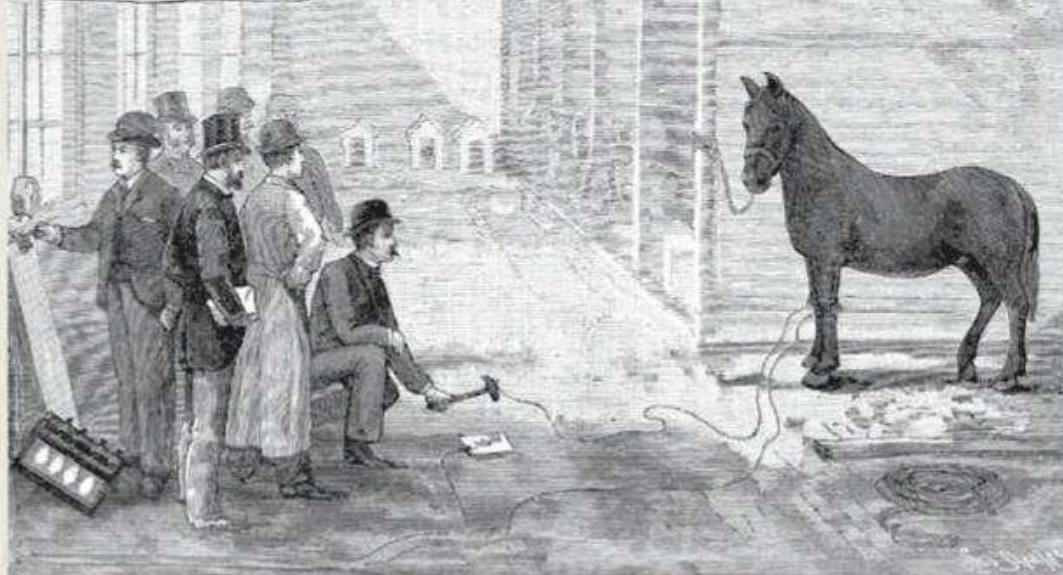
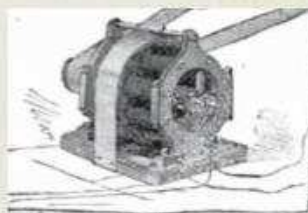
Many dead dogs and horses later, New York State had passed the necessary legislation, and the first condemned man - murderer William Kemmler - was scheduled to be electrocuted on 6th August 1890.

Everything was just right. The chair had been built the way George E Fell, wanted (albeit against the recommendations of the Medico-Legal Society), and it was connected up to a Westinghouse-brand AC generator. Anti-AC campaigner and Edison ally Harold P Brown had gone to considerable lengths to get a Westinghouse generator - after all, it was important for the proponents of DC that the electric chair, and thus death, become indelibly associated with alternating current. What Brown didn't realise was that people just thought ALL electricity was deadly. Which it is.

Perhaps the most repugnant aspect of the electric chair is the way nobody seemed able to agree how to actually

Poor Topsy the elephant

is often cited as a victim of the War of the Currents (and of AC power). But she was executed in 1903, long after Thomas Edison had left the electric lighting industry.



Thomas Edison was definitely involved in the early experiments on electrocuting animals, however. After murdering hundreds of dogs, attention turned to "lame" horses.

electrocute a human being. They knew 6000 volts - the voltage of street lamps - could kill instantly, but their dog murdering experiments led them to believe this was overkill. So they dialled it way down.

William Kemmler was subjected to 17 seconds of 1000 volts AC, while strapped to the chair. He was knocked out, of course, but attending physicians discovered he was still breathing. They had to wait for the generator to charge up again before they could deliver another 2000 volts. This killed Kemmler alright, but not before exploding some of his blood vessels and singeing his skin where the contacts were fixed.

George Westinghouse himself later said: "They would have done better using an axe." Witnesses generally agreed it was far worse than a hanging.

And yet here we are today. The US still uses the electric chair, and AC current is in every home.

THIS... THIS IS NOT A GOOD CHAIR

Opposition to the death penalty in the US is based mostly around their Constitution's 8th Amendment, which limits penalties the state can hand out, including "cruel and unusual punishment". The electric chair is widely agreed to be "unusual" but opinions differ on whether it qualifies, legally, as "cruel". And yet, the history of execution by chair is full of ghastly anecdotes. Fred Van Wormer was executed in 1903, but was found to still be breathing, even after the electrocutioner had gone home. He

died before he could be strapped in again. Willie Francis, rather than dying in 1946, yelled "Take it off! Let me breathe!" Denied clemency for his ordeal, he was electrocuted the following year. And as late as 1997, during the electrocution of Pedro Medina, flames burst from his head. The cause of all these problems? The cause of all these problems? There's no common link. Electrocution is very much a "sledgehammer" approach to execution. But that makes it imprecise, and variable.





BEST OF: Mars: The Other One

For very small values of one.

[Whatever happened to the real Mars One anyway? That jape was like a real life version of something that I'd get roped into. Uh, that's not to imply that I'm not real or none of this actually happened...]

MY NEW AGENT, FORMER UNIONIST BUT now free-market evangelist/opportunist Kurt Blockade, stood at the door of the high school gymnasium and bade me enter.

"But I already said," I said, because I'd already said. "I don't *want* to go to Mars."

"Oh come on," he stage-whispered to me, floodlights gleaming on his shaved head. "You don't think this insane scheme is actually going to *send* anyone to actual Mars do you? It's all a publicity stunt, a great lactating teat of money upon which we should suckle."

I looked at him doubtfully.

"The milk in this case," he said, "is money." He nodded helpfully and shoved me through the door. This was his style. Not for Kurt Blockade the guaranteed \$125 payment. He was more about opportunity.

The opportunity in this case looked somewhat doubtful. The room was full of maybe 200-300 hardcore nerds, many of them in orange jumpsuits. On the stage up the front was a podium. Behind the podium was a man, and behind the man was a Project Tuesday banner. The banner had that picture of Mars in a Viking hat, that had been doing the social media rounds for the last week, since Project Tuesday's lead, the doubtfully-named Thor Hnafnirson, had announced the whole thing on Google+. Of all places.

"It's called Project Tuesday," said Hnafnirson, as a rather blunt opening to some kind of speech, "because the word 'Tuesday' is from the Old English word *Tiu*, meaning Mars." He nodded in a self-satisfied manner.

"Why does it have a Viking hat?" someone yelled from the back of the room. When 300 pairs of angry nerdy eyes swivelled to look at me, I realised I was the one who had yelled it.

"Because Vikings are awesome!" bellowed Hnafnirson. "We are all descended from Vikings, well not all, but the best of us are! And we are filled with the spirit of exploration, just like the Vikings, who were the first to discover the old New World, you know!"

"I thought those were Icelanders?" I found myself interjecting. Hnafnirson waved a hand dismissively.

"It's all the same, part of a rich tapestry," he said. "Anyway, we're getting off the topic, and the topic today is SPACE EXPLORATION. You've seen hundreds, maybe even *thousands* of half-baked, cuckoo-clock plans to colonise the Red Planet, but what have all these terrible and very bad plans had in common?"

"The base would have collapsed in less than two months!" I bellowed. What was *wrong* with me? Was I

confronting some kind of deep rooted prejudice I didn't even know it had? Do I, fundamentally, hate start-up space explorers and everything they stand for?

"No!" replied Hnafnirson. "Well, yes, but that's not what I'm going for here. The problem with all those kooky space-schemes is they had a bad case of tomorrow-itis! Do you know what tomorrow-itis is?"

The gathered throng made an inchoate noise that came across as meaning, given enough time, they could probably figure out what tomorrow-itis was, especially with a little more context, but to keep the whole thing rolling maybe Hnafnirson should just tell us.

"They always promised to go to Mars TOMORROW!" cried Hnafnirson in triumph. "Or next year, or next decade, or whenever someone got around to building their risk-shy gold-plated space tech. I say *hell no* to that mentality and I say let's go to Mars RIGHT NOW!"

Beaming, Hnafnirson pulled on a rope, and the Project Tuesday banner fell down, revealing a rocket on a launchpad behind him. Now - as a hobbyist rocket at maybe 1:30 scale, this thing was very impressive. It reached all the way to the roof and had sufficient diameter to carry, say, a guinea pig in reasonable comfort. But it was, in all important respects, a toy rocket.

I started to shuffle backwards toward the doors.

"Come on!" cried Hnafnirson. "She's fuelled and ready on the pad!" He made a sort of ushering motion. The nerds in the crowd looked at each other doubtfully.

"Oh right," said Hnafnirson. "I get it. None of you freaks *actually* has the balls to *really* go to Mars. You all sign up and compete for the limited places and waste my time, on the basis that deep down you think it's never really going to happen. You think you can get lots of social media cachet and heaps of Twitter followers because you're 'on the crew' but when I stand up in front of you and say here is this rocket, fuelled and ready to go, then you chicken out." He folded his arms, petulantly. "Well?" he demanded.

"That's not a real rocket!" said a thin and reedy voice. I grabbed at my throat, but this time, it hadn't been me.

Then a whole bunch of CSIRO unionists burst in and carried Hnafnirson and his rocket off the stage in a storm of expletives and argument about demarcation. The 300 space nerds also took this opportunity to leave or, as one of them put it in passing: "Escape with their lives." I took advantage of his distress and pick-pocketed him.

As the dust settled and the last of the unionist boots rattled up the school halls, I saw my new agent Kurt Blockade standing there. He looked sheepish.

"Sorry," he said. "Reflex action. Calling the union I mean. I just couldn't stand by and -"

"No worries," I said. "I grabbed someone's wallet when they stampeded. There's like \$28 in here."

"Score!" cried Kurt Blockade.



BY
SUBJECT
ZERO

"You've seen hundreds, maybe even thousands of half-baked, cuckoo-clock plans to colonise the Red Planet, but what have all these terrible and very bad plans had in common?"

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