

SURGICAL SPIDERS : Why softer robots will make better, safer doctors

AUSTRALIAN

POPULAR SCIENCE



A SMART TELESCOPE
(for citizen science)

SMALL IS IMPORTANT

Tiny things that keep the world working

THE RISE OF EMOJI

And the future of expressing yourself

LITTLE CARS

Why we still make them

THE LATE NIGHT BLUES

Your phone really is making you blind



FUTURE *of* **FLYING**

Lap of luxury...
...or Hell off Earth?

X-T100

Show Me Your World.



For some people, a day is just like any other day. For you, every day is unique. Only you can capture your story as you see it. Every moment is a memory waiting to be captured. The Fujifilm X-T100 is your companion in everyday life, letting you document your day through photography.



For more information please visit:
www.fujifilm-x.com



Available from leading photographic stores and selected retailers

POPULAR SCIENCE

ISSUE #118, SEPTEMBER 2018



EDITORIAL

Editor Anthony Fordham afordham@nextmedia.com.au

DESIGN

Group Art Director Malcolm Campbell
Art Director Danny McGonigle

ADVERTISING

Advertising Sales
Lewis Preece lpreece@nextmedia.com.au

Advertising Traffic

Diane Preece dpreece@nextmedia.com.au

Division General Manager

Jim Preece jpreece@nextmedia.com.au

Production Manager

Peter Ryman

Circulation Director Carole Jones

US EDITION

Editor in Chief Joe Brown

Articles Editor Kevin Gray

Managing Editor Jill C. Shomer

Senior Editor Sophie Bushwick

Technology Editor Xavier Harding

ART AND PHOTOGRAPHY

Acting Design Director Chris Mueller

Photo Director Thomas Payne

Digital Associate Art Director Michael Moreno

Associate Art Director Russ Smith

Acting Production Manager Paul Catalano

POPSCI.COM

Online Director Carl Franzen

BONNIER'S TECHNOLOGY GROUP

Group Editorial Director Anthony Licata

Group Publisher Gregory D Gatto

BONNIER

Chairman Tomas Franzen

Chief Executive Officer Eric Zinczenko

Chief Content Officer David Ritchie

Chief Operating Officer Lisa Earlywine

Senior Vice President, Digital Bruno Sousa

Vice President, Consumer Marketing John Reese

nextmedia

Executive Chairman David Gardiner

Managing Director Hamish Bayliss

Circulation Director Carole Jones

Popular Science is published 12 times a year by nextmedia Pty Ltd ACN: 128 805 970 Building A, 207 Pacific Highway St Leonards, NSW 2065

Under license from Bonnier International Magazines. © 2014 Bonnier Corporation and nextmedia Pty Ltd. All Rights Reserved. Reproduction in whole or part without written permission is prohibited. Popular Science is a trademark of Bonnier Corporation and is used under limited license. The Australian edition contains material originally published in the US edition reprinted with permission of Bonnier Corporation. Articles express the opinions of the authors and are not necessarily those of the Publisher, Editor or nextmedia Pty Ltd. ISSN 1835-9876.

Privacy Notice

We value the integrity of your personal information. If you provide personal information through your participation in any competitions, surveys or offers featured in this issue of Popular Science, this will be used to provide the products or services that you have requested and to improve the content of our magazines. Your details may be provided to third parties who assist us in this purpose. In the event of organisations providing prizes or offers to our readers, we may pass your details on to them. From time to time, we may use the information you provide us to inform you of other products, services and events our company has to offer. We may also give your information to other organisations which may use it to inform you about their products, services and events, unless you tell us not to do so. You are welcome to access the information that we hold about you by getting in touch with our privacy officer, who can be contacted at nextmedia, Locked Bag 5555, St Leonards, NSW 1590

www.popsci.com.au

To subscribe, call 1300 361 146
or visit www.mymagazines.com.au



The Technology is the Personal

The most unrealistic thing about TV's *The Expanse* - a science fiction show with magical fusion drives that operate for weeks and never run out of fuel, and magical people who stay in space for years and never run out of bone minerals - is the mobile phones.

Not because of the way they project holograms around the room or have icons that float in mid-air next to them. No, the unrealistic part is how all the personal communications tech in *The Expanse* looks the same.

According to *The Expanse*'s exhaustively detailed wiki, the handsets people use in that universe (about 250 years in our future) are just dumb terminals. They hook into some kind of ubiquitous computing service that's everywhere - embedded in the walls even - and your mobile phone bill reflects how much computing power you used over the month, or whatever.

And that's a prediction I can get behind. We've already offloaded all our non-personal data storage to the internet, and we're in the process of giving "the cloud" our personal stuff too.

But what *The Expanse* doesn't do, or at least not explicitly enough for me to notice, is let its characters personalise the user experience of their mobiles.

It might seem like a tiny thing, but the way you can have your background and your icons, and a hideous protective cover in your preferred shade of electric pink, is a huge part of why the smartphone has so effectively penetrated our culture.

In 2018, a person's smartphone is their little oasis, their own little world, in a way. For an increasing (and maybe disturbing) number of people, the smartphone has become very much part of them.

I'm just picking on *The Expanse* because the handsets appear every other episode, but the way the show has characters use their "mobiles" for nothing more than making video calls and occasionally remote-controlling some piece of space-equipment, makes the amazingly well-done holographic displays pointless.

Plot-wise, they could do those scenes exactly the same way with Star Trek communicators. From the original series.

I have some sympathy for the show's designers, though. People in the real world take what has been a carefully designed interface and customise it to look hideous. They put their icons in really awkward places. They clog up the display with widgets that hardly do anything. They set their background to a badly composed, blurry picture of their cat. Drooling. Because "it's how I like it".

The people who make up future computer interfaces for TV shows spend thousands of hours designing graphical elements and making it all work together... so asking them to then go and do a really ugly badly set up version for each character is maybe too much.

But if these shows want realism, to make these worlds feel "lived in", that really is what should be done. Every sign shouldn't be in the same font, some UX elements should clash and get in each other's way. That's how the world works.

Well, mostly. I've been driving Audi's RS5 coupe this month. Great car, and it has a high-tech "virtual cockpit" where all the gauges are computerised and turn into different things when you push buttons on the steering wheel.

It's also a real-world example of what life *would* be like if we had to live with science fiction TV show user interface designs. Oh it's all very *consistent*, stylistically. But to open the settings menu, you need to press a button marked with a square-bracket. To change drive modes? Asterisk button.

And I can't even put a picture of a drooling cat in the background.

ANTHONY FORDHAM
afordham@nextmedia.com.au

▶ SEPTEMBER 2018

Contents

For daily updates: www.popsci.com.au

40

But What About On The Inside?

Future airliners look super cool. Future airliner cabins for economy-class passengers? Not so much. From seats that don't recline, to having to squat on a sort of saddle for two hours, is there nothing too awful for the industry to contemplate? No.



08



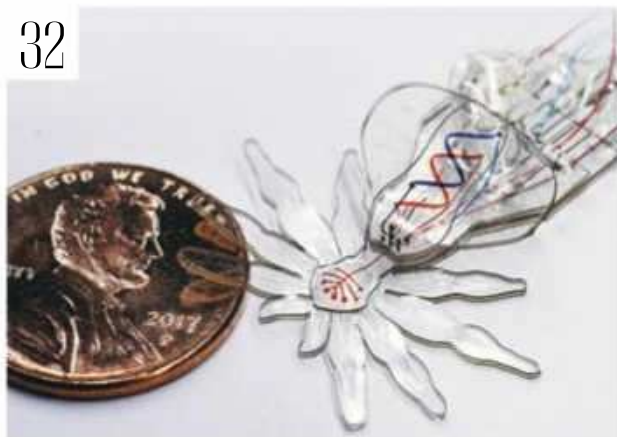
14

State of the Art
Your guide to everything

24



32



- 08 Macro for your smartphone
- 10 Things to measure other things
- 12 Obsessed endures
- 14 Ant farms. No, really.
- 16 Camping gear that packs down.
- 18 The Note9 does tricks.
- 20 Smaller engine... bigger power?
- 22 PCs in your pocket
- 24 Oversight: The history of small.

Insight
Important stuff for futurists

- 27 Blue light at night can actually send you blind. Maybe.
- 28 Squishy spiderbot surgeons could save you from stroke, one day.
- 34 A smarter telescope, built for citizen science.

Features
Read, think, read some more

- 40 Flying economy sucks... forever?
- 50 Two bugs, way way WAY up close.

Rethink
Take a second look

- 58 Why care about the ginger emoji?
- 68 Your microbiome, mapped.
- 70 Weird bone caves!
- 71 The dust mites hide!
Spores to power future motors!
- 72 From the Archives: We praise Columbia's test flight.
- 78 Retro Invention: Tiny cars!

The Other Stuff
Bonus Extra Material!

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

78





Big Picture

FASTEST AIRBAG EVER

As the world's car manufacturers continue to deal with airbag recalls, other airbag developers have the luxury of not needing to protect human lives. All they need to protect is a massive investment in time and money on the part of NASA.

The Low-Density Supersonic Decelerator is a concept re-entry vehicle designed to help probes and rovers survive the punishing process of setting down on Mars. The disc-shaped vehicle deploys an airbag to create atmospheric drag (even in Mars' extremely wispy excuse for an atmosphere), and to induce a stabilising spin. This test vehicle, sitting on a recovery barge in the Pacific in 2014, worked perfectly - at least in terms of the airbag. Ironically, its old-school parachute, which only opened at the last minute, was torn apart and the LDSD "touched down" at about 40 km/h.

Still, all instruments were recovered, and a 40 km/h impact is a lot better than its initial speed at re-entry: about Mach 4.32 (5334 km/h)!





ARTHUR C CLARKE DOES IT AGAIN

The idea of using airbags on the *outside* to decelerate a spacecraft isn't new, and has popped up once or twice in SF movies that try to be "about the science". A very early appearance was in the 1984 film *2010: The Year We Make Contact*, where bags protected the *Leonov* as it used Jupiter's atmosphere to brake into an orbit around Io. Why such a high-risk manoeuvre? Because it looks cool!





Not Meth, Salt
Shot using the Moment
Macro Lens over the iPhone
8 Plus portrait cam.

**State
of the
Art**

Mobile Macro

by STAN HORACZEK

ON THEIR OWN, SMARTPHONE CAMERAS CAN grab impressive images of the full-size world. But while their wide-angle lenses can effortlessly capture landscapes, they can't expose the miniature scenery all around us. That requires some extra glass. The Moment Macro Lens magnifies what your phone sees by 10 times, revealing, for



example, ordinary salt—seen in the inset at upper left—as a vista of jagged crystals.

The setup contains a lens and a removable hood. To capture a sharp, well-lit image of a tiny scene, place the translucent lens hood on or around the subject; it's clear enough for ambient light to illuminate the object but opaque enough

to block excess rays that can create distracting flares or other artefacts.

Inside, three curved glass elements focus the remaining light into the camera. The assembly connects to a mount on a variety of Moment smartphone cases, so the system should still work just fine after you upgrade to the latest device.

17.7

MM

The height of the lens hood, which positions the camera at the perfect focusing distance.

**State
of the
Art**

Measured Success

by JESSE WILL

TO LOVE PRECISION IS TO LOVE DECIMAL POINTS. MINUSCULE measurements can make all the difference with pernicky processes like hanging a perfectly level picture, baking a Pinterest-worthy batch of cupcakes, or even crafting a masterful cuppa. These digital tools can precisely perceive the tiny increments that can turn a merely good result into a truly great one.

1

Weight

A sprinkle of excess baking powder can ruin your confections, but the **American Weigh AMW-SC-2KG** digital scale uses strain gauges to meter ingredients—or anything else you can fit on its 100-mm steel tray—down to 0.2 grams.

2

Colour

Film, photos, and video games deserve accurate color. The **Datacolor Spyder5PRO** employs a light sensor called a colorimeter with seven built-in filters to detect changes in hue and brightness scarcely perceptible to your eye.

3

Temperature

Poke its 114 mm stainless-steel probe into a vat of homebrew for two seconds, and the **Javelin PRO Duo** will indicate temperature to a tenth of a degree, with a margin of error just under 0.5 degree Celsius (pic shows Fahrenheit mode).

4

Size

Turn the thumbwheels on the **Starrett EC799A-12/300** electronic caliper to get a read, down to 0.03 mm, of anything between its jaws. Minute changes in electrical charge between two sliding plates map to lengths up to 300 mm.

5

Distance

The **Extech DT40M** laser distance meter replaces your floppy tape measure with a concentrated beam of light. Analysing the laser's reflection allows it to quantify distances between 50 mm and 40 metres, within 2 mm.



FINE MECHANICAL WATCHMAKING, FROM JAPAN.

PRESAGE



TRIMATIC

Trimatic symbolises three Seiko inventions that ensure the highest levels of reliability and durability in its mechanical watches.

SEIKO

SINCE 1881

State
of the
Art

Obsessed

The world is full of amazing and possibly not very useful gadgets, and this is the page that celebrates them (or at least mocks them with gentle fondness). This month we've found everything from a 3D printed camera to a 3D printer (but not the kind you can use to print this particular camera). Plus a new thing for making coffee that will amuse your friends if you can't get it to work.

selected consciously by ANTHONY FORDHAM

NOTE ON PRICING: Prices, where appropriate, are given in currency of origin because the USD is on a bit of a tear right now. Also, we can't figure out the import rules anymore, like do you always have to pay GST on top of everything now, or what? Still, at least it means we don't have to go to a *shop*. Ugh!



The Standard 4x5

www.nikonowicz.com
FROM US\$260

Digital cameras are so passé. Everyone's into going back to super-primitive pinhole lens cameras, you know with the magnesium flare flash and the cloth over the head, all that. To get the kinds of results only 5-10 minutes of fiddling with Instagram filters can replicate, you need to 3D print your own 4x5 format camera. Film? Nah mate, photographic plates is what this is all about. On the other hand, the Standard 4x5 is reasonably cheap and might give you a new appreciation of how convenient digital really is.



Modal Electronics SKULPT

www.modalelectronics.com
\$449

We love analogue synthesizers here at PopSci and we're open-minded enough to give some of the digital ones a go too. Modal's says this is a "virtual analogue" synth. Okay. It's a four-voice synth with all the esoteric synth features you've forgotten about since the rats got to your Telstar EP. Still Modal's has rep and the SKULPT has many, many knobs to twiddle. Funk on.



XYZPrinting Nobel Superfine

www.xyzprinting.com
US\$2699

Most 3D printers sacrifice smooth resolution for simplicity and cheapness of materials. Digital light processing (DLP) printers like the Superfine give a much better result, and now they're not too insanely expensive. The resin is messy and toxic, sure, but if fine detail matters to you then all the sponging up after each print will be worth it.



Roidme F8 Vacuum

www.roidmi.com
\$US289

No we didn't leave off the word "Dyson", this is a cordless bagless vacuum cleaner that isn't a Dyson, they do exist. The Roidme F8 did get a big campaign on Indiegogo which was a bit cheeky since Roidme is owned by Chinese megacorp Xiaomi. Who cares right? It's not a Dyson, it's way cheaper than a Dyson, and it generates 18.5 kilopascals of centrifugal air pressure! No, that's a real thing, it is!

Nomad Espresso Machine

www.coffeeparts.com.au
\$479

Do you demand café-quality espresso at all times, no matter where you are, no exceptions? Like, for instance, when you're car-camping? The Nomad will provide that espresso. A clever rocking lever lets you pressurise the system without undue exertion, and the True Crema Valve produces a crema that is, if nothing else, an extremely convincing facsimile. All it needs is ground coffee and boiling water.



Blackview BV9000 Pro

www.blackview.hk
US\$310

Are you always smashing your smartphone pretty much straight out of the box? Not in anger, but just because you're that kind of person? You need a tougher machine, obviously. The BV9000 can take what you dish out, with its kevlar casing, Gorilla Glass 5 display, IPX68 waterproof rating, and massive 4180mAh battery. So not only can you kick it down the stairs, you can leave lying at the bottom all day without it going flat.



GENKI for Switch

[Kickstarter/Indiegogo](https://www.kickstarter.com/projects/genki/genki-for-switch)
\$US39

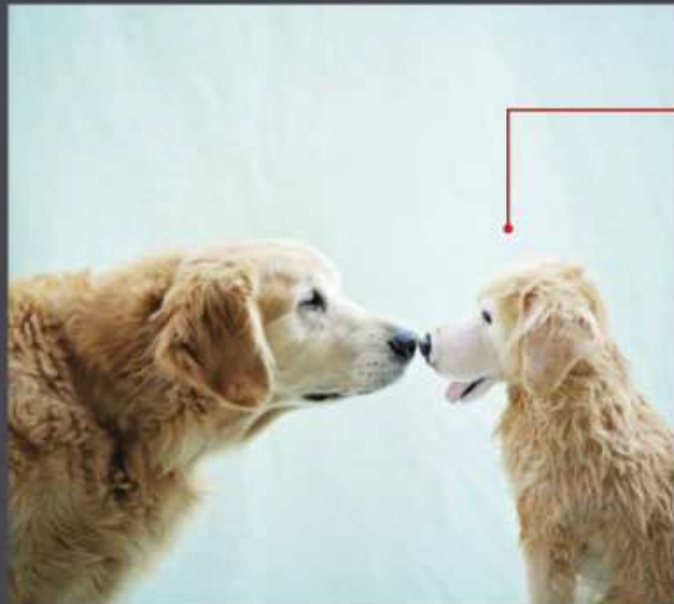
Incredibly, the Nintendo Switch gaming console doesn't have Bluetooth on board. What is this, the 1950s? Okay so it saves battery or whatever. The Genki won't use much battery either thanks to its support for Bluetooth's newest ultra-low-power format. It plugs into the Switch's USB-C port and can send crisp tunes (and boing-beep noises) to two headsets at once. It's even styled like a Switch, see? Cool earbuds not included, but a stand is.



Coolala Outdoor Aircon

www.coolalairconditioning.com
US\$799

One of the worst things about nature is the lack of air conditioning. Thank goodness Coolala has now invented a small air conditioning unit for you to trundle around the park, relaxed and comfortable as it puffs cool dry air onto your ankles. Requires a bulky battery pack to run unplugged (not shown) but also runs off folding solar panels. Essential bit of kit this, absolutely essential.



Cuddle Clone

www.cuddleclones.com
FROM US\$249

Can't bear the thought of being without your precious pet, but also quite sensibly think actual taxidermy is super creepy? Don't stuff your poor moggy! Get a convincing plush replica made to order instead. Just supply Cuddle Clones with an ample collection of photos and they'll do their best to recreate Chairman Meow's weird face. They also do horses, which sounds like a heck of a thing, if you think about it.



Beeline Moto GPS

beeline.co
US\$120

After the sixth time you get crash-tackled to the ground by zealous highway cops for looking like you are about to start looking at your phone on your motorbike, you'll be in the market for a GPS like this. The Beeline Moto provides minimalist info: a distance, and an arrow that points in the direction you need to go. Requires an app to function, but has a 30 hour battery life and won't get you arrested. Probably.



**State
of the
Art**

How to Be a God

by ELEANOR CUMMINS

KEEPING ANTS ALIVE ISN'T EASY. A TYPICAL COLONY REQUIRES REGULAR fruit infusions, lots of water, and protein sources such as mealworms, crickets, and fruit flies. Because these pets can't freely roam your home (that's called an infestation), you'll need to set up a formicarium—the technical name for an ant farm. Forget that chunk of plastic nasty you got for your ninth birthday. These formicaria are serious scientific instruments. Plus they look cool.



EASY
Casita from Tar Heel Ants

Australia's own Big-headed Ant is a perfect first subspecies—and this is their ideal starter home. The aerated concrete material holds in moisture, which provides your insects the humid conditions they need to thrive. And a port drilled into the back of the unit allows for a quick water injection via syringe.



MEDIUM
**Gypsum Farm from
Ants Kingdom**

Established your ant-tending skills? It's time to start a colony. Capture a local queen (but just be aware that generally, the bigger the ant, the bigger the sting), and install her and a few workers in this formicarium. String the plaster modules together with tubing as the population grows.



HARD
**Omni Nest from
Ants Canada**

Australia's common bulldog ant (*Myrmecia pyriformis*) has actually killed people. So these critters need to be locked down. This spacious insect domicile is a series of 17 individual acrylic chambers held together with steel screws for maximum security—and high visibility.

MICHIO KAKU

THE FUTURE OF HUMANITY



SYDNEY NOV 8
SYDNEY OPERA HOUSE

BRISBANE NOV 10
SOUTH BANK PIAZZA

PERTH NOV 12
PERTH CONCERT HALL

MELBOURNE NOV 14
MCEC PLENARY 2

BECOME A MEMBER AT
THISIS42.COM

#THISISKAKU
#THISIS42



THIS IS 42™

PROUDLY
SUPPORTED
BY

SCIENCE
ILLUSTRATED

AUSTRALIAN
POPULAR
SCIENCE



**State
of the
Art**

Compressed Camp

by ROB VERGER

WHEN YOU'RE CLIMBING A STEEP, ROCKY TRAIL ON the side of a mountain, a bulky pack catching on branches or scraping against boulders will slow your ascent. Lightweight, space-saving camping essentials can provide warmth, shelter, and comfort out on the trail without making you feel like a pack mule. In addition to staples like food, water, a first-aid kit, and a multitool, these super-squishable items—which total just 3.9 kilos—will get you through your next night in the woods.

1/Backpack

The **Osprey Levity 45's** main compartment holds 45 litres of gear, which easily accommodates everything on these pages—with room for trail mix. The steel frame at the rear of the pack suspends nylon netting, a design that evenly distributes weight across your back. It also provides breathing room so your sweat can evaporate.

2/Tent

Shelter typically adds the most bulk to a hiking load. The **REI Co-op Quarter Dome 1** tent has about the same sleeping space as a twin mattress, but it packs down to 15-by-45 cm—about the size of a house cat. Its aluminum poles support a nylon structure with a mesh top that lets you glimpse the stars. A removable waterproof cover repels rain.

3/Sleeping bag

Fall nights are crisp, but the **Marmot Phase 30** cocoon will keep you toasty in temperatures as low as -2 degrees Celsius. The bag's fill is mostly soft down, which creates millions of microscopic air pockets that trap warmth. Squeezing the air back out compresses the sack down to about the size of a football.



4/Stove

Nights and mornings in the outdoors call for hot meals and coffee to fuel your trek. The **MSR WindBurner** packs neatly in its 1-litre aluminium pot for storage. When it's time to cook, the pot screws directly onto the burner, which attaches securely onto a fuel canister below it. The sealed setup boils water in less than five minutes.

5/Jacket

The **Mountain Hardwear Ghost Whisperer** down jacket weighs less than a grey squirrel and can smooch into one of its pockets, creating a shape about 12-by-25 cm small. Both the down insulation and the tightly woven nylon exterior have a durable water-resistant coating, so you'll stay dry on misty mountain mornings.

6/Pad

The inflatable **Therm-a-Rest NeoAir Xlite** mattress lifts you 65 mm above the rocks and sticks on the cold ground. Your lungs and the fresh air blow it up in about two minutes. A screw-down valve will keep it fully puffed overnight. Deflated, it's just 22-by-10 cm—roughly the footprint of a 1-litre water bottle.

7/Poles

Supportive sticks take stress off your joints, especially on downhills. Clamps at the top of the **Black Diamond Distance Carbon FLZ** trekking poles allow you to adjust their height between 90 and 110 cm. To collapse into a 35-cm-long package, the carbon-fibre supports each break into three sections, strung together by a Kevlar cord.

8/Light

A bulky lantern is unnecessary. The diminutive **Petzl Tekkina** headlamp can throw a 10-metre beam wide enough to illuminate your entire campsite and burn for more than 200 hours on its lowest power setting. Crank up the power to maximum brightness and it will light up the trail as far as 40 metres in front of you.

**State
of the
Art**

What It Does, Not What It Can Do

by ANTHONY FORDHAM

THAT SAMSUNG WENT AND ANNOUNCED the Galaxy Note9 (sic) superphone this month is no surprise: it's been about a year since the Note8 was launched, and this is how the smartphone market is paced. What's interesting about this launch is how little emphasis Samsung puts on the phone's hardware spec - as opposed to its many software-driven features.

Oh sure, the Korean giant is keen to push the Note9's 8GB of RAM (on the top model) and the optical image stabilisation in the camera. And to point out new hardware-level features like how the S-pen works as a Bluetooth remote, and how there's hybrid-SIM support - which is so hot right now. But what didn't get pushed heavily at the Sydney launch was the CPU (Exynos 9810 Octa for our market). Or the megapixel rating of the camera (12MP). The screen size yes (bumped up to 6.4-inches from 6.3 on the Note8) but the resolution, no (1440 x 2960).

Instead Samsung emphasised the things that actually mean something to the average user - including the bigger battery (it cracks 4000mAh at last), and 512GB internal memory plus 512GB SD card, which make the phone "1TB ready!"

Then there's the baked-in software features, especially the camera's "artificially intelligent" assistant. This mode can identify 19 different types of typical scene (indoor party, sports, bowl of fruit, dead body etc) and automatically tweak camera settings to optimal. Or at least, what the AI thinks is optimal.

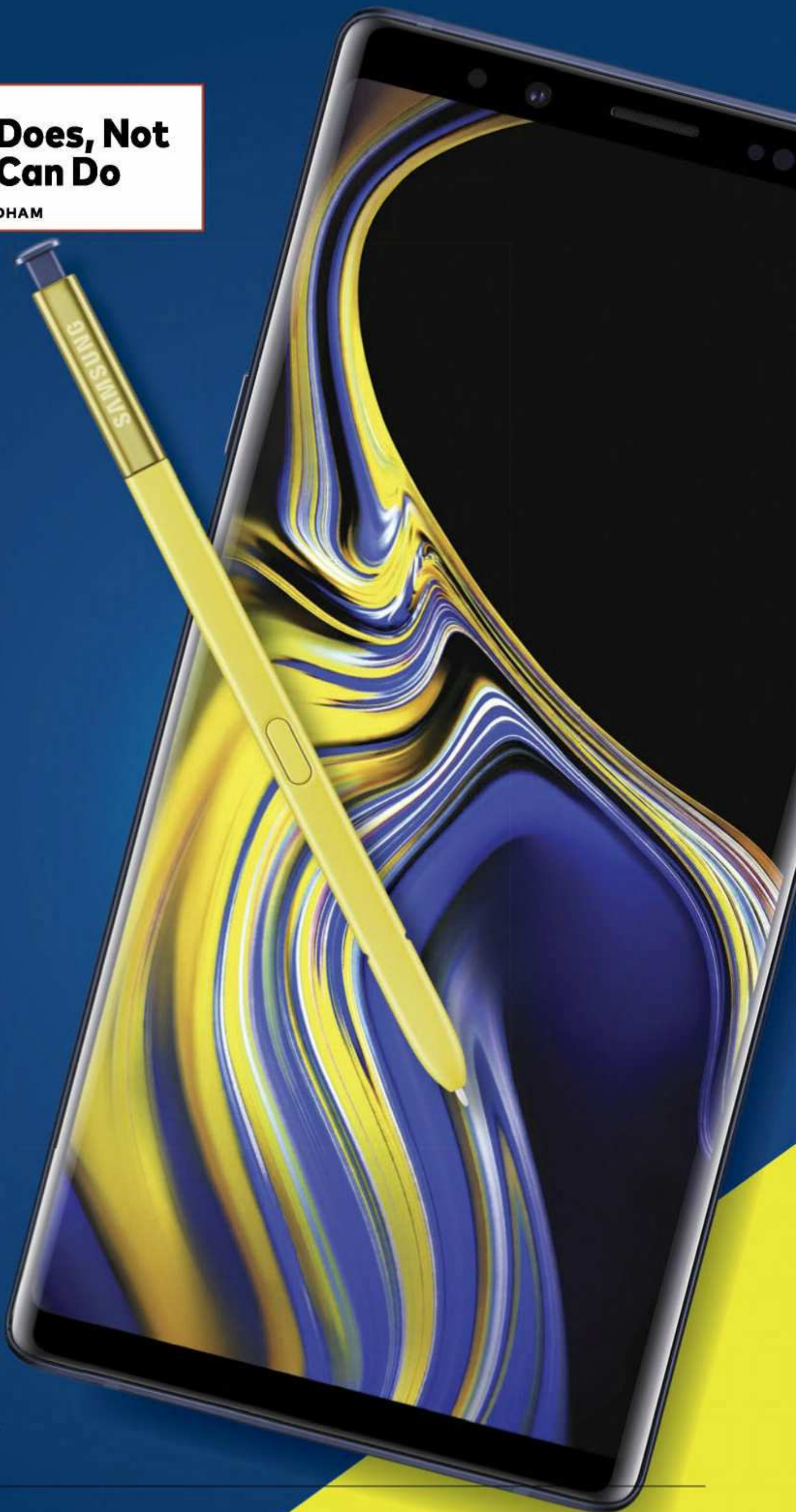
So is the Note9 just the smartphone equivalent of the old automobile industry trick of sticking fins on last year's car and calling it a new model? Maybe not. Maybe it's an early example of what's likely to be the future of personal electronics: For each new model, the black slab stays more or less the same. It's just the software inside that evolves, that offers new experiences. The challenge for Samsung, Apple and others in the decade ahead?

Convincing people they have to pay for it.

Samsung Galaxy Note9

www.samsung.com.au

Price: \$1499/\$1799



ANY TUNE. ANY ROOM. WIRELESSLY.



SURROUND YOURSELF WITH SOUND, NOT WIRES.

The **HEOS** Bar delivers exceptional performance to enhance the sound from a TV or Blu-ray player, while retaining the elegance of a slimline soundbar – and the ability to act as an audio streaming solution.

You can also extend your home theatre to wireless 5.1 surround sound or add **HEOS** speakers for music anywhere in your home.'

www.heos.com.au

HEOS PLAYS



4x Better Than CD



Play & Share



USB Music Anywhere



**State
of the
Art**

Less Engine, More Shove

by ANTHONY FORDHAM



◀ Unlike Porsche, Audi does allow its owners to actually see the engine of their car (the plastic cover comes off). But like Porsche, attempting to wrench this wired-with-explosives supercomputer yourself is not recommended.

YOU HAVE TO FEEL SORRY FOR FANS OF the big V8. When government legislators - especially in Europe - came for their beloved donks, in the name of reducing emissions mostly, it was a sad day indeed. But at least the V8 fan could put on a sad face and mourn the loss of all that *grunt* and *shove*. The world might be saved, but cars would never go that hard again. There would be no more *monsters*.

Engineers, meanwhile, gave the V8 fans a puzzled look and got on with the job of creating even more insanely powerful engines with fewer cylinders and less displacement.

Here's one of the latest examples: the 2018 Audi RS5. This top-shelf grand tourer used to have a 4.2L V8, which produced 331kW of

power and 420Nm of torque. Those are big numbers, even in a \$160,000+ car. But two other numbers ran afoul of the quest to cut emissions: 10.5 and 24.6. That's litres of petrol consumed and kilograms of CO₂ emitted, per 100km, respectively.

So to the horror of V8 fans, Audi replaced the 4.2L with a 2.9L twin-turbo V6.

Except the V6 still makes 331kW, while a combination of turbos and computerised fuel management boost torque to a face-melting 600Nm. That means 0-100 falls from 4.5 seconds to 3.9 seconds, and all the shouting is available much lower in the rev-range too: peak power at 5700rpm vs 8250, and peak torque from 1900 vs 4000.

As for emissions, fuel consumption drops to 8.8L/100km and CO₂ to 199g (per kilometre).

So it's pretty clear that the new V6 is a more sophisticated piece of technology, a better engine in every way. Except it doesn't sound as cool as a V8. As if that matters.

Indeed, the V8 has been a useful tool: lots of power from a relatively mechanically-simple package. But like the straight-eight before it, for sheer grunt, we just don't need it anymore. Let's allow it to retire, with dignity, to where all high-capacity high-cylinder-count engines eventually go: behind the bald spot of a supercar driver.

Where it can listen to him whinge about how it's not a V12.

audiocconnection

sound and vision

SERVING AUSTRALIANS FOR MORE THAN 30 YEARS

We have developed a reputation for our expertise in high-end 2 channel audio since 1987. Today, not only do we continue our tradition of high-end audio, we also specialise in smart home solutions. Speak to our experienced team who can consult, design and install the perfect smart home solution for you.

Services we provide:

- Audio Video Setups
- Acoustic treatments
- Two channel and multi channel audio solutions
- On-site consultations & advice on technologies to suit your home
- Wi-Fi and internet solutions
- Installation services
- Smart home solutions
- Home audio visual cabling advice
- Home security and access control solutions
- Full wiring schematic drawing documentation and plans
- Project Management – working with all trades involved



OUR BRANDS Arcam · Autonomic · Ayre · Burmester · Clearaudio · Control4 · D'Agostino · Dali · DCS · Definitive Technology · Denon · GoldenEar Technology · Flexson · Gryphon · Hegel · KEF · Lilin Security · Linn · Lyngdorf · Mark Levinson · MBL · Nordost · Padimount · Revel · Sonos · Sony · Steinway Lyngdorf · Pass Labs · Pathos · T+A · TruAudio · VideoStorm · VTL · Wilson Audio

**State
of the
Art**

Keep a PC in Your Pocket

by ANTHONY FORDHAM

THE IDEA OF A FULL-FEATURED WINDOWS 10 (OR YOUR preferred Linux) PC crammed into a pocket-sized box isn't new. But early explorations of this form-factor resulted in machines that weren't really good for anything, because they had to make do with extremely low-powered CPUs and limited storage. Now, high-performance chips that sip daintily on electricity and don't create too much heat are available, and crucially so is high-performance storage. Teeny tiny PCs are proliferating like weird mushrooms in a forest after heavy rain. **Here are three that caught our eye.**



3/ Kangaroo+ Mobile Desktop

www.kangaroo.cc

From \$200

There are approximately nineteen billion tiny PCs like this available online right now, but only the Kangaroo+ comes with a battery and a fingerprint reader. The former gives a claimed four hours of "casual" unplugged use, while the latter supports Windows Hello for faster sign-ins. This extra stuff comes at the expense of Windows itself - you have to bring your own operating system. An Intel Atom x5-Z8500 2.24GHz CPU, 4GB of RAM and 64GB of onboard storage aren't exactly cutting-edge, but will get the job done. Especially when you consider the Kangaroo+ is about the size of a smartphone, and weighs just 200g.

1/ GPD Win 2

www.gpd.hk

\$800+

Yes, it costs as much as a proper laptop, but this gaming-focused nano PC has it all... assume that to you, "all" means a six-inch 720p touchscreen and built-in gaming controller. With an Intel m3-7Y30 2.6GHz CPU, 8GB of RAM and 128GB of storage, it's nearly the same on the inside as last year's MacBook. Gamer types will be alternately delighted and frustrated with the Win 2's ability to play many - but not all - games, and can spend hours tweaking all kinds of esoteric settings to eke out another few frames per second. It also has enough ports and plugs on the back to hook it up to a big display, keyboard and mouse, and use it as a normal desktop. Which would be weird.

2/ LattePanda

www.lattepanda.com

From \$100

Don't worry makers, the world of tiny PCs hasn't forgotten you either. Previous "dev board" style computers like the Raspberry Pi weren't capable of running Windows 10, but the LattePanda can. Like the Kangaroo+, this teeny PC uses an Intel Atom X5 CPU, and you can get it with either 2GB or 4GB of RAM. A key feature for tinkerers is the on-board Arduino co-processor. This gives it a total of 32 general-purpose input/output (or GPIO) headers, into which you can plug your killer robot's various sensors.





Extreme Sharpness

Introducing the fully refreshed line up of PENTAX binoculars.

Experience bright and crystal-clear views thanks to the innovative coating technology. All models increase the transmission of light and have adopted full multi-coatings to avoid flare and ghosting. Additionally all the roof prism models adopt a new coating to significantly improve the transmission of visual light. From observation to spectating, the bright and clear optics will give you a spectacular view. The full range from high end models to handy compact models will offer you the best binoculars to enrich your viewing experience.

PENTAX
SPORT OPTICS
Since 1938

Z Series
Ultimate performance

S Series
Superior quality

A Series
Advanced compact

U Series
Versatile & compact

Shop online at pentax.com.au

Ask about the new range of PENTAX Binoculars at your nearest Sport Optics Dealer

DigiDIRECT (1300 889 148) digidirect.com.au | Ted's Cameras (1300 768 833) teds.com.au | Camera House (133 686) camerahouse.com.au
Bintel NSW & VIC (02 9518 7255) bintel.com.au | Paxtons NSW (02 8076 1903) paxtons.com.au | Michaels Camera Video Digital VIC (03 9672 2222) michaels.com.au
Leederville Cameras WA (08 9242 1855) leedervillecameras.com.au | Gerry Gibbs Camera House WA (08 9451 8833) gerrygibbscamerawarehouse.com.au
Photo Continental QLD (07 3849 4422) photocontinental.com.au | Suncoast Optical QLD (07 4031 6610) suncoastoptical.com.au
Walch Optics TAS (03 6223 8855) walchoptics.com.au | Diamonds Camera Video & Digital SA (08 8224 0665) diamondscamera.com.au

Oversight

Zooming In On the History of Magnification

by ERIN BLAKEMORE

WHILE THE NAKED EYE CAN PICK OUT OBJECTS as thin as a hair, humans have never been quite satisfied with that limited perspective. The smaller we can see, the smaller we want to see. So, over the past three millennia, we've worked to improve on our powers of sight, with a little help from a lens. A magnifying lens, that is. And we've made some not-so-tiny discoveries along the way. Here are the biggest moments in our quest to see minutia.

1

YEAR: 750–710 BC

IMAGE: Cuneiform (2x)

In 1850, archaeologists unearthed the oldest-known magnifier in what is now Iraq. The 40-mm-wide Nimrud lens may have helped ancient Assyrians view minuscule inscriptions. This polished rock crystal refracts light through its curved surface. Prismatic power was the best we had for thousands of years.

2

YEAR: 1625

IMAGE: Bee's eye (30x)

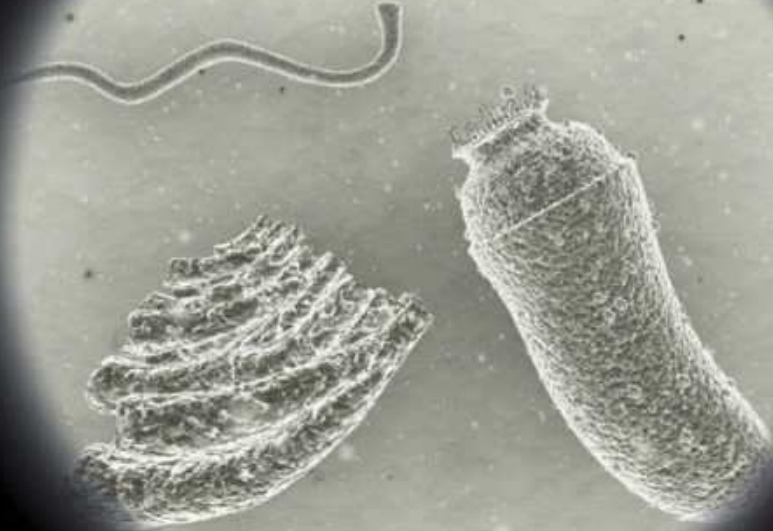
Seventeenth-century spectacle-seekers made the first microscopes: The compound model uses a second glass lens to boost magnification. Galileo was likely the first to add a third. With the improved view, scientists peered into bugs' eyes and discovered the delicate hexagonal lenses of the "compound eye".



1



2



3



4

3

YEAR: 1665

IMAGE: Cross section of cork (50x)

Physicist Robert Hooke figured out how to block stray light rays, but he also focused illumination: He passed the glow from an oil lamp through a flask of water to diffuse the beam. This made blurry but bright images, revealing something wild in a slice of the bark of a cork oak tree: empty spaces. Hooke dubbed them "cells."

4

YEAR: 1677

IMAGE: Microbial creatures (300x)

When Antony van Leeuwenhoek's expertly ground glass lenses revealed single-celled organisms 10 times smaller than plant cells, his colleagues could hardly believe it. They spent three years looking for their own "animalcules." After Hooke and others repeated the experiments, scientific study got a lot smaller.

5

YEAR: 1903

IMAGE: Gold nanoparticles (10,000x)

Richard Zsigmondy and Henry Siedentopf used their ultramicroscope on colloids, mixtures containing super-teeny particles. They sent a beam through the slurry at right angles, then used a compound scope to see how the light scattered. Their first blingy find: the 4-nanometre-wide bits that colour glass.

6

YEAR: 1939

IMAGE: Tobacco mosaic virus (500,000x)

Max Knoll and Ernst Ruska created the tool that, eight years later, would first spot viruses: the transmission electron microscope. Scientists took samples of cells and shot electrons through instead of light. As they hit, they formed an image, which viewers could project onto a fluorescent screen and magnify.

7

YEAR: 1955

IMAGE: Tungsten atoms (1,000,000x)

Erwin Müller found a way to visualise the atoms on the end of a needle with his field ion scope: Put the poker in a vacuum chamber and shock it. The needle emits electrons that ionise surrounding gas. As the ions fly away, they collide with a special screen, creating a magnified image of the kaleidoscope-like atom lattice.

8

YEAR: 2015

IMAGE: A single atom (20,000,000x)

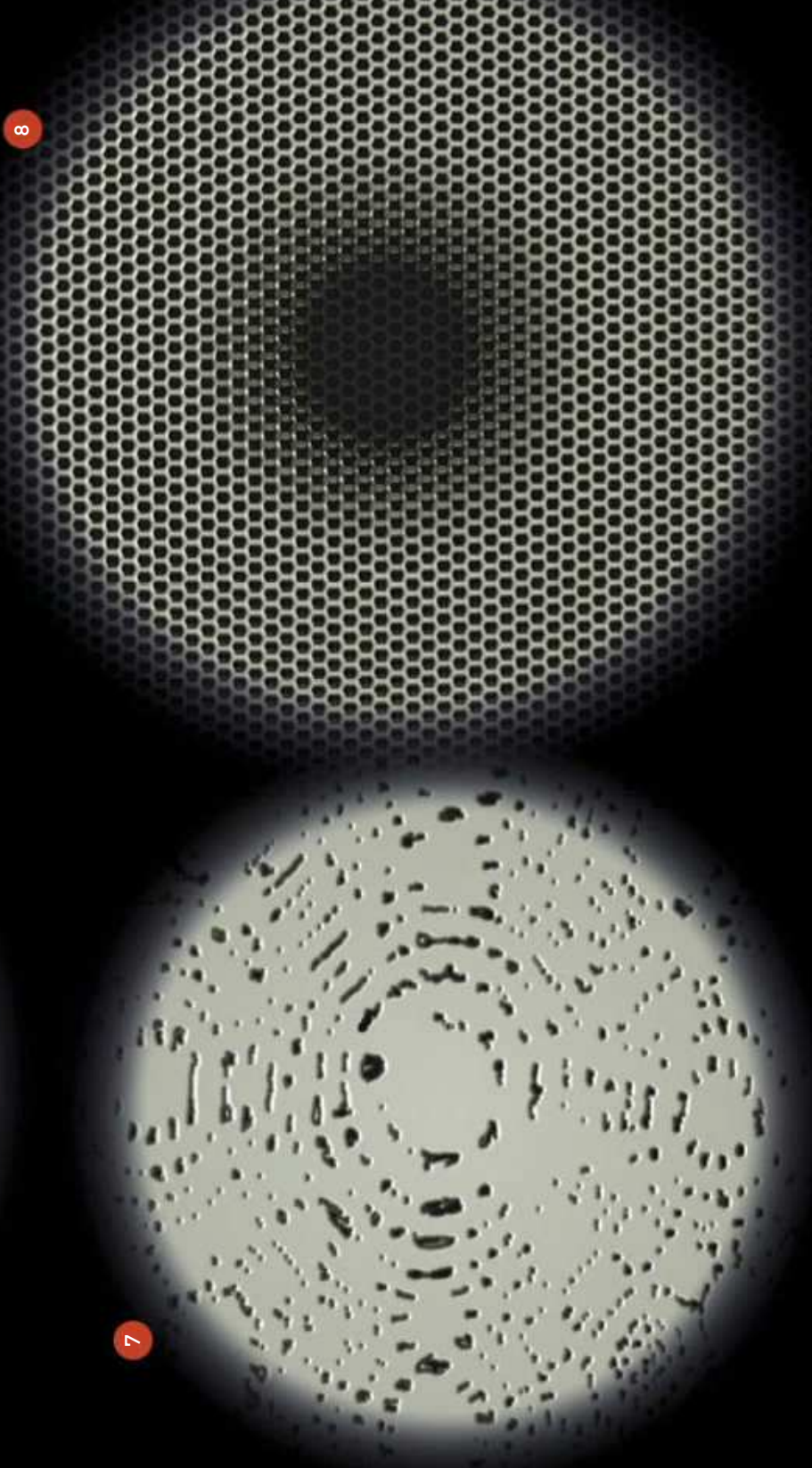
The UK's SuperSTEM lab sees objects a million times thinner than a hair. Electrons zip through magnets that focus them toward the sample, then pass through a set of lenses. The scope sees which ones lose energy on the way, translating that data into an image—and revealing the intricate structures of individual atoms.



6



5



8



7



ILLUSTRATIONS BY SINELAB

Small Wonders

We're biased toward big. Big ideas, big data, big science—the more mega an achievement, the more attention we shine on it. But what about the smaller innovations that make our lives easier, safer, and longer? Scattered throughout the remainder of this issue, you'll find a celebration of the very small, and very important.



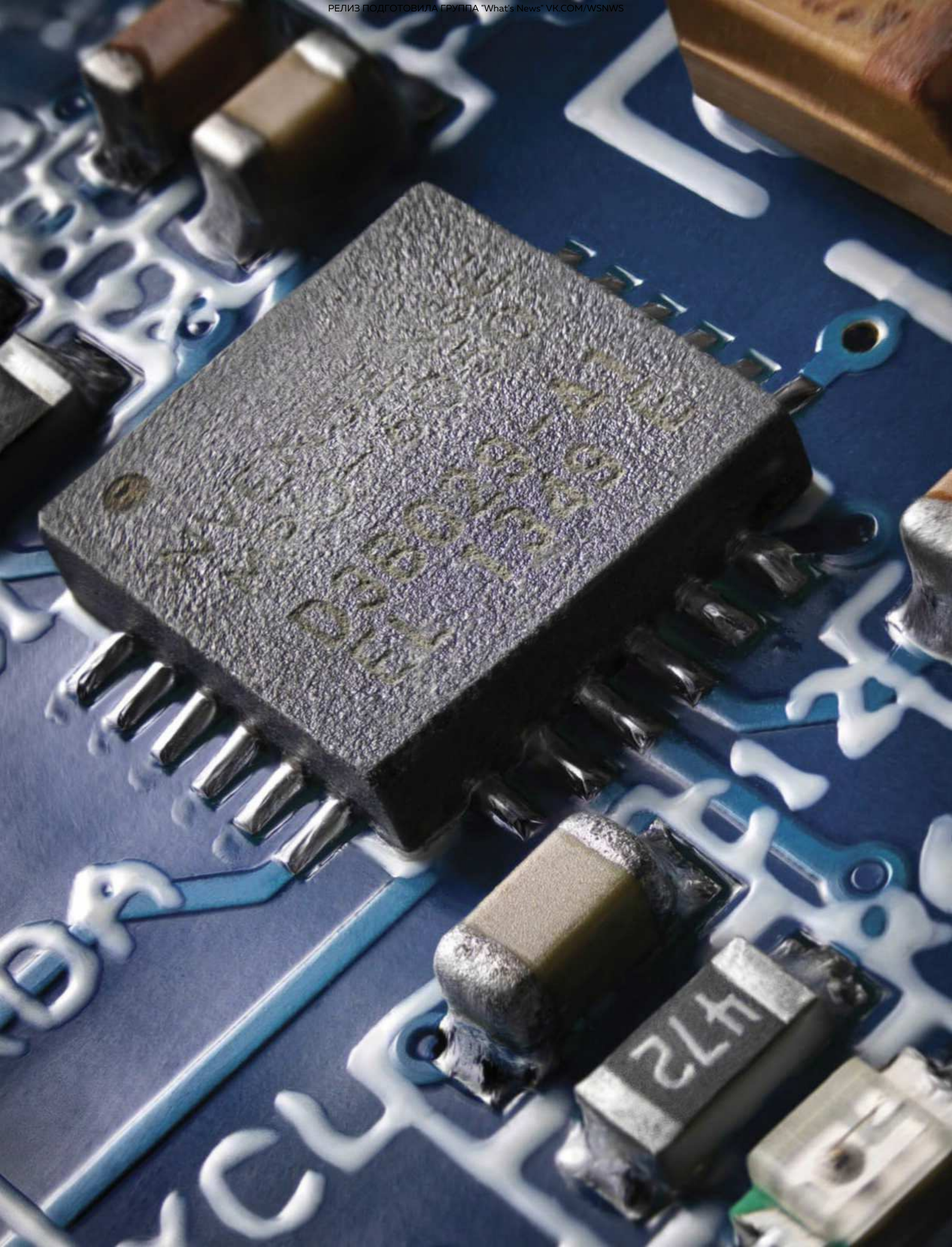
ITEM:
Accelerometer

INVENTED:
18th century

USE:
Sensing movement



Developed in the 18th century by English physicist George Atwood, the first accelerometer—a device to measure acceleration—was taller than a full-grown man. Today's micro-electromechanical sensors are as small as 3 mm square by 0.9 mm thick. When movement flips an electrode forward, it completes a circuit, indicating a change in acceleration force or direction. These diminutive invigilators of movement help ensure images on our phones and tablets stay upright, keep planes on course and missiles on target, and, in a lifesaving incarnation, signal airbags to inflate when cars crash. According to ANCAP and Monash, car airbags have saved 2700 lives and prevented or reduced the severity of over 36,000 injuries since the early 1990s.



AUSTRALIAN HI-FI ▶ AV SHOW 2018

OCTOBER 19TH – 21ST 2018, THE COMO MELBOURNE

THE BEST HI-FI & AV SHOW IN TOWN!

The Australian Hi Fi & AV Show 2018 is the only show in Australia where you will get an exclusive audition of all the latest models from German TV manufacturer Loewe – including the Australian release of some spectacular new models.

Other exclusives include the LINN range of fine audio, Q Acoustics award-winning Concept 500 loudspeaker, and the world-wide release of the new Cyrus range of electronics.

Other brands/models only at the show include the EISA Award winning Micromega M-ONE M-150, Focal Clear Headphones, Bricasti Design and of course dozens of other quality brands from around the world are on demo: Yamaha, Dynaudio, PS Audio, Arcam, McIntosh, Definitive Technology and Sonus faber to name just a few.

CELEBRATING
7 YEARS! ALWAYS 3RD
WEEKEND OF OCTOBER!



Astell&Kern

ARCAM

audio research

cocktail Audio

Bricasti Design

BRISTON

D. DEFINITIVE TECHNOLOGY

DYNAUDIO

FOCAL SYSTEM ACTIVE

HALCRO

LINN

LOEWE.

MICROMEGA

M&K SOUND

MOON
DIMAUDIO

PARASOUND

PS AUDIO

ACOUSTICS

Quality
Speakers

rega

YAMAHA

LIVE MUSIC PERFORMANCES BY AUSTRALIA'S OWN MARY WEBB

Exclusive live concerts featuring songs from her latest album 'Love Like Planets', followed by a unique insight into how the album was made by the album's producer Mike Kirkham.

[/australianhifiavshow](#)

[/HIFIAVSHOW](#)

[chestergroup.org](#)

POPULAR
SCIENCE

ISSUE
118

SEPTEMBER
2018

INSIGHT



30

BLUE LIGHT IS DOING
YOU PLENTY OF
DAMAGE

32

COULD FLOPPY
SPIDERBOTS MAKE
SURGERY SAFER?

34

THE MIND BEHIND THE
SMARTEST LITTLE
TELESCOPE EVER

Don't Put On That Blue Light

by ELEANOR CUMMINS

Blue light's rap sheet is growing ever longer. Researchers have connected the high-energy visible light, which emanates from both the sun and your smartphone (and just about every other digital device in our hands and on our bedside tables), to disruptions in the body's circadian rhythms. But wait, there's more!

Following a series of new studies, eye specialists have drawn attention to the relationship between our favourite devices and eye problems, ranging from everyday eye strain to glaucoma to macular degeneration.

Humans perceive colour in three in a relatively thin bands inside the spectrum of visible light, with peak sensitivities in areas that correspond to “kinda red”, “yellowish green” and “green but sort of a blue green if you know what I mean”. For convenience, these are labelled red, green and blue.

As you'll recall from primary school science, direct sunlight includes all the wavelengths we can perceive, without any particular bias toward one wavelength.

But we no longer spend all day in direct sunlight, of course. Our longest periods of bright light exposure are often not from daylight at all.

In a recent paper published in the journal *Scientific Reports*, researchers at the University of Toledo have begun to parse the process by which close or prolonged exposure to the 445 nanometre wavelength we call “blue light” can trigger irreversible damage in eye cells. The results could have profound consequences for consumer technology.

BLUE LIGHT BLUES

“Photoreceptors are like the vehicle. Retinal is the gas,” says study author and chemistry professor Ajith Karunaratne (and by ‘gas’ he means petrol, of course).

When cells from the eye were exposed to blue light directly — in theory, mimicking what happens when we stare at our phone or computer screens—the high-intensity waves trigger a chemical reaction in the retinal molecules in the eye. The blue light causes the retinal to oxidise, creating “toxic chemical species,” according to Karunaratne.

The retinal, energised by this particular band of light, actually *kills* the photoreceptor

cells, which do not grow back once they are damaged. If retinal is petrol, Karunaratne says, then blue light is a dangerous spark.

Relax: catastrophic damage to your vision from looking at blue things isn't guaranteed. But the experiment shows that blue light can kill photoreceptor cells. Murdering enough of them can lead to macular degeneration, an incurable disease that blurs or even eliminates vision.

Blue light does occur naturally in sunlight, much more intensely than even your phablet with the brightness turned up. The Sun also radiates other forms of visible light and ultraviolet and infrared rays. But, Karunaratne points out, few of us spend very much time staring directly at the sun.

That's because as kids, most of us were taught it would fry our eyes. Digital devices, however, pose a bigger threat. The average Westerner spends almost 11 hours a day in front of some type of screen, according to a 2016 Nielsen poll.

When we stare straight at our screens—especially in the dark—we channel the light into a very small area inside our eyeball. “That can actually intensify the light emitted from the device many many fold,” Karunaratne says. “When you take a magnifying glass and hold it to the sun, you can see how intense the light at the focal point gets. You can burn something.”

So to change metaphors: if our phone is the sun, and the lens of our eye is a magnifying glass... then that little spot in our retina is the ants. You psycho.


RED LIGHT DISTRICT

Some user experience designers have been criticising our reliance on blue light, including Amber Case, author of the book *Calm Technology*. On her Medium blog she documented the way blue light has become “the colour of the future,” thanks in part to films

like 1982's *Blade Runner*.

The environmentally-motivated switch from incandescent light bulbs to high-efficiency (and high-wattage) LED bulbs further pushed us into blue light's path. But, Case writes, “if pop culture has helped lead us into a blue-lit reality that's hurting us so much, it can help lead us toward a new design aesthetic bathed in orange.”

The military, she notes, still uses red or orange light for many of its interfaces, including those in control rooms and cock-



Fears of kids damaging their eyes by reading books by torchlight were mostly unfounded. But the effects of staring at a tiny screen in an otherwise dark room late into the night, are less benign.

pits. “They’re low-impact colours that are great for nighttime shifts,” she writes. They also eliminate blue light-induced “visual artefacts”—the sensation of being blinded by a bright screen in the dark—that often accompany blue light and can be hazardous in some scenarios.

Apple offers a “night shift” setting on its phones, which allow users to blot out the blue and filter their screens through a sunset hue. Aftermarket products designed to control the influx of blue light into our irises

are also available, including desktop screen protectors. There are even blue light-filtering sunglasses marketed to specifically to gamers. But as the damage done by blue light becomes clearer—just as our vision is getting blurrier—consumers may demand bigger changes.

COLOUR US CONCERNED

Going forward, Karunarathne plans to stay in data-collection mode. “This is a new trend of looking at our devices,” he says.

“It will take some time to see if and how much damage these devices can cause over time. When this new generation gets older, the question is, by that time, is the damage done?” But now that he appears to have identified a biochemical pathway for blue light damage, he’s also looking for new interventions. “Who knows. One day we might be able to develop eye drops, that if you know you are going to be exposed to intense light, you could use some of those... to reduce damage.”



NO HARD FEELINGS

Spiderbots, Work It!

by KAT ESCHNER

Less than five millimetres long and stylish to the point of gaudiness, male peacock spiders are some of the jewels of the arachnid world. But could their amazing powers of dance put to real use?

The answer is “maybe”, because the jazzy little spider has provided inspiration for soft robotics researchers from Harvard University. Their new peacock spider robot is less than 25mm long, and it has some amazing properties.

“The idea of designing and fabricating a soft robot inspired by the peacock spider comes from the fact that this small insect (sic) embodies a large number of unsolved challenges in soft robotics,” says lead author Tommaso Ranzani.

The (real) spider is tiny and can move with sub-millimetre precision. To prepare for its mating dance, it also has “a large number of independently controllable degrees of freedom,” Ranzani says. The gaudy colours in nature help attract a mate.

The gaudy colours in the robot, however, are from dyed water. The water courses

through tiny pathways in its body, specifically designed to cause the spiderbot to move in specific ways, in response to operator inputs. With incredible precision.

ILIVE TO DANCE

Although it can't shake its booty quite as lithely as its arachnid inspiration, the researchers say that this robot, or one like it, would be able to perform delicate surgical tasks at scales much smaller than what's currently possible for soft robots.

A patient's veins, for instance, are at the micro- or even meso-scale, requiring precision that current surgical bots can quite manage. But this spiderbot might be able to.

Additionally, “if you want to go into the human body, you want to use something soft,” says Kam Leang, a robotics engineer at the University of Utah who also works on soft robotics for medical applications.

But the tiny peacock spider isn't ready to strap on a surgical mask quite yet. This design is proof of concept for a new robot construction method known as Microfluidic Origami for Reconfigurable Pneumatic/Hydraulic devices, or MORPH.

SPIDERBOTS, ASSEMBLE!

The team constructed the spider in a single process over several days. First, they produced 12 layers of silicon, each with embossed patterns on it sort of like a computer chip.

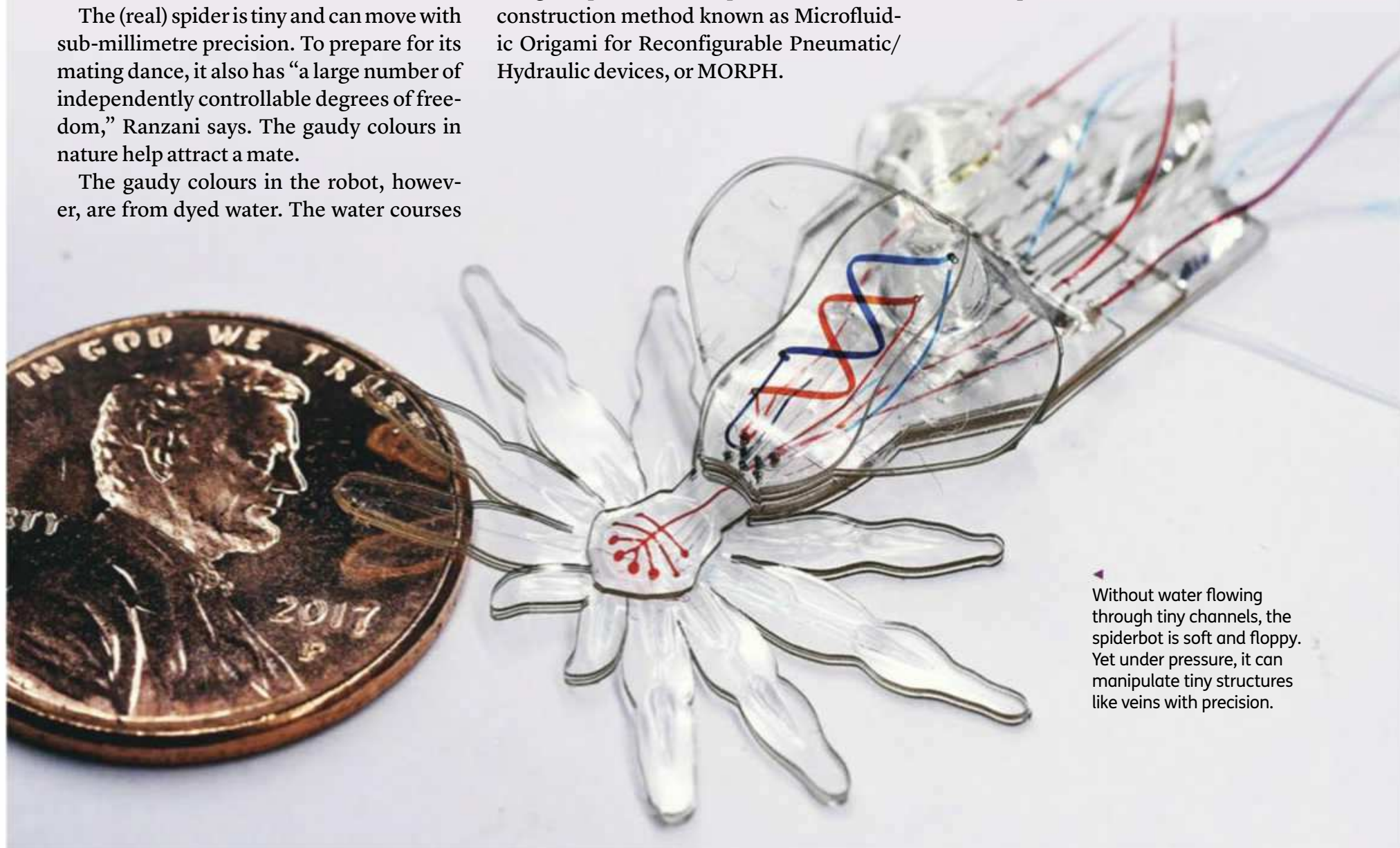
Then, they used tiny lasers to make those patterns even more structured, so when all the layers were stuck together, they formed what's known as “embedded microfluidic circuitry.”

This circuitry, when pressurised with fluids, is what causes the folding or origami.

If something like water or air is used, the spider can move into a new position and then move back to its original shape, but a fluid that goes solid when exposed to a stimulus like heat or UV light can leave the spider permanently “folded” into a new shape.

This sounds simple, but Ranzani says that precisely placing the layers during the bonding process and laser-cutting the pathways were both extremely delicate processes. The layers and channels of the spider are both narrower than a human hair.

Although it's already pretty snazzy, Ranzani says the peacock spider robot is just the beginning. “This device is proof of concept of the manufacturing process,” he says. “We believe it will pave the way to a new generation of soft micro robots that can exploit their small scale, and deformable and resilient bodies, to explore highly unstructured and complex environments.”



Without water flowing through tiny channels, the spiderbot is soft and floppy. Yet under pressure, it can manipulate tiny structures like veins with precision.

Focal Length: 210mm Exposure: F/5.6 1/250sec ISO: 1600



70-210_{mm} F/4 Di VC USD

Reach out and capture the beauty.

Partner up with this compact, lightweight, user-friendly telephoto zoom.

Expand your world with each shot.



70-210mm F/4 Di VC USD (Model A034)

For Canon and Nikon mounts

Di: For full-frame and APS-C format DSLR cameras



TAMRON

www.tamron.com.au

Insight

Looking Sharp

by SARAH SCOLES



WHEN SETI RESEARCHER FRANCK Marchis was a kid in France, he looked at Saturn for the first time through a telescope and saw the planet magnified from a speck in the night sky to a beautifully ringed orb. *There's a whole universe out there*, he thought. Which, of course, he already knew, but it's different to feel it.

Young Marchis' studies soon sent him to Chile, where telescopes sit high in the world's most arid desert, the better to capture every last photon. In 1996, he trained one of those telescope on Io, a moon of Jupiter, and caught something no one had ever witnessed from the ground: an active volcano, in the process of erupting.

Obsessed with sharpening his view, Marchis concentrated on developing adaptive optics—telescope sensors and mirrors that contort to make up for atmospheric turbulence that otherwise blurs images. With these systems, Marchis captured ever clearer pictures of comets, Uranus, and Neptune. In 2005, he was the first to discover an asteroid with two tiny moons. He also helped develop the Gemini Planet Imager, an instrument that debuted in 2014. It blocks diffracted starlight from obscuring the target object and then uses spectroscopy to measure its telling features.

Recently, Marchis joined Project Blue, a collaborative effort to snap images of planets in the habitable zones of Alpha Centauri, the star system closest to the sun. "We are kind of like the cartographers of the 18th century," he says. But for space. The undertaking relies on private funding, so Marchis went to the 2017 Consumer Electronics Show to learn how other people pitch. There he came across a telescope created by two physicists and an engineer. It was an early design of an instrument called the eVscope. They hoped, once perfected, it would reveal the skies to amateurs in the kind of colour and detail typically reserved for professionals.

Marchis ended up joining the venture as chief scientific

officer. The team had already engineered the eVscope's sight, but the system needed refining, and its auto-pointing abilities needed work. "We are a small startup, meaning that our work is not compartmentalised and sometimes is outside the scope of our main skills," Marchis says. Today, with Marchis' help, the telescope uses GPS and a map of celestial objects to figure out where it is currently pointed, then can aim somewhere else autonomously.

Just tell it you want to look at, say, the Orion Nebula. Viewing it through a typical backyard scope, you'd see the nebula as a black-and-white patch of dots and smudges. That's because when we gaze up at a dim figure in the dark sky, our eyes don't receive enough photons to activate our colour vision. The eVscope, though, can collect light over time. If you look at the nebula for 10 seconds, you'll see a smaller-scale colour version of what those mountaintop Chilean telescopes show.

While the eVscope will compete with similar instruments when it ships in early 2019, Marchis leveraged his astro bona fides to help connect his product to the scientific community. SETI researchers can alert eVscope owners to here-now-gone-later cosmic events such as comets or supernovae, and users can choose to let the telescope's software transmit their view of the phenomenon straight to SETI.

Marchis has been testing eVscope prototypes with nonprofessionals on Bay Area streets and at star parties. "Seeing colour in a nebula from a garden in San Francisco?" he says. "That's pretty cool."



MARCHIS HAS SPENT HIS CAREER GETTING CLEAR PICTURES OF COMETS, URANUS, AND NEPTUNE. STILL, HE SAYS, "SEEING COLOR IN A NEBULA FROM A GARDEN IN SAN FRANCISCO? THAT'S PRETTY COOL."



**ITEM:**Spectacle
screw**INVENTED:**

20th century

USE:

Joining hinges



London optician Edward Scarlett was among the first to advertise “temple arms” for spectacles around 1730. Later appendages featured a doorlike hinge that let users fold their specs for travel. The first models used metal posts to affix frames to arms. But, as the refinement of industrial threading machines like lathes continued into the 20th century, tiny stainless-steel screws took that job. Over time, the fit has become standardised: Most frames now require fasteners with a shaft diameter of 1.4 mm, while some thin wire frames use ones as small as 1.2 mm. The number of people globally wearing some kind of corrective lenses is in the hundreds of millions. That’s a lot of screws that can and do get loose.



The Foundation for the Advancement of Astronomy supporting excellence

The Foundation for the Advancement of Astronomy, established by the Astronomical Society of Australia, recognises excellence through the Society's activities.

- **The Bok Prize** for outstanding research by an Honours/Masters student
- **The Charlene Heisler Prize** for most outstanding astronomy PhD thesis
- **The Louise Webster Prize** for excellence by an early career researcher
- **The Ellery Lectureship** for outstanding contributions in astronomy
- **The David Allen Prize** for exceptional astronomy communication
- **The Berenice & Arthur Page Medal** for excellence in amateur astronomy
- **The Richard Cole Fund** to support training for postgraduate students

Donate to the Foundation for the Advancement of Astronomy

ABN: 37 660 297 848 asa.astronomy.org.au/FAA

Amount A\$: \$25 \$50 \$100 \$200 Other: _____

Preferred prize/activity to support (not compulsory): _____

Cheques payable to "Foundation for the Advancement of Astronomy"

Credit Card Payments: Mastercard Visa

Card Number _____ / _____ / _____ / _____ Expiry Date ____ / ____

Cardholder Name _____ Date _____

Cardholder signature _____



Donations of \$2 or more are tax-deductible for Australian residents. Donors can choose to select which Foundation activities they would like to support. The Foundation exists through the support of Australian astronomers and the general public. Please submit your payment to the ASA Treasurer, Dr Katrina Sealey c/- Australian Astronomical Observatory, PO Box 915, North Ryde, 1670, NSW.

Astronomical Society of Australia Inc

The organisation of professional astronomers in Australia asa.astronomy.org.au

POPULAR
SCIENCE

ISSUE
118

FEATURES

SEPTEMBER
2018

40

WILL THE FUTURE OF FLYING
BE GLORIOUS OR THE
WORST THING EVER?

50

TWO BEAUTIFUL BUGS
PHOTOGRAPHED IN
INCREDIBLE DETAIL





THE [SQUISHED UP] FUTURE



OF FLYING

AIRLINERS ARE BIGGER THAN EVER, BUT YOUR SEAT CONTINUES TO SHRINK. STILL, HOW BAD CAN IT GET? OH, IT CAN GET BAD...
BY RYAN BRADLEY • ILLUSTRATION BY MORON EEL

A

T

The flight was typical: It was full, getting to my seat took forever, and, once I did, the overhead-bin space had run out. So I shoved my backpack under the seat in front of me, where my feet should have gone. I was in the middle—row 31, seat E, American Airlines flight 2070, Phoenix to San Francisco. My neighbours had claimed the armrests, so I had to wedge myself in place, elbows pinched against my ribs or folded toward my lap. I'd be uncomfortable for the duration of the one-hour-and-50-minute flight. As I said: typical.

While I concertinaed my fairly average 5-foot-11, 78-kg frame into position, I realised I needed something from my bag. I leaned forward and hit my head on the seat in front of me. OK, going straight in wasn't an option; I'd have to veer out of my allotted space.

To my left sat a girthy man, his aisle-side arm resting upon his prodigious belly, the other spilling over the armrest and nearly into my lap. To my right, by the window, was a short but still quite stocky fellow; he wore large headphones, the bill of his ball cap tilted low.

I began moving, very slightly, this way and that, in a manner not unlike someone parallel parking a semi. I tilted my torso down into the space near the shorter man's legs and turned to face the aisle-side girthy man, my nose suddenly millimetres from his arm. He recoiled. I apologised, and gestured toward my backpack.

As I carefully dug around by my feet, a toddler wailed, and I thought, *That is the sound we are all making on the inside*. Our bodies want to move, and aeroplanes try to keep us still. We spill into each other's spaces, banging elbows and heads as we do what we're built to do.

The toddler was still screaming when I felt the heavy metal square I was looking for: a tape measure. I sat up and began my assessments. Between the seat in front of me and my knees: less than 130 mm. Across my lap, from one armrest to the other: 430 mm. My aisle-side

companion raised his eyebrows but said nothing. I tried to gauge how wide a berth my elbows needed, and bumped the window-side guy. He grunted and sighed. Somewhere between 480 and 500 millimetres.

The ironic thing about the compressed state of air travel today is that planes are getting larger. The jet I was on, an Airbus A321, stretches nearly seven metres longer than its predecessor, the A320. More space, more passengers, more profit. These bigger planes are increasingly the most common variants—both on American Airlines and across all carriers. The current Boeing 737s, the world's most flown craft, are all longer than the original by up to 13 metres. And yet, on the inside, we're getting squeezed.

That's because more space doesn't equal more space in Airline World. It equals more seats—and typically less room per person. In 2017, for example, word leaked that American was planning to add six economy spots to its A320s, nine to its A321s, and 12 (that's two rows) to its Boeing 737-800s. JetBlue is reportedly ramming 12 extras into its A320s, and Delta's will gain 10. And, come 2020, you'll likely find more seats on every United plane.

In Airline World, they call this densification, which is a silly word. Passengers call it *arrrrgh!*

Consumer Reports recently polled 55,000 of its members about air travel. There were

A WICKED WEB: Honeycomb Rows



The HD31 concept by French company Zodiac flips the middle seat. Passengers don't sit shoulder-to-shoulder, so they get cushions as wide as 600 mm (that's business-class-level space). The stagger boosts legroom by 100 mm, but you have to face your neighbours.



THE SHELL GAME: Risers



To jam in more chairs, some airlines are removing recline. By annexing a few centimetres of vertical space to elevate every other row, the StepSeat concept by Jacob Innovations creates room for passengers to lean back. A rigid shell prevents snoozers from slamming into the travellers behind them.

complaints about all aspects, from ticketing to agents checking carry-ons at the gate. But 30 per cent of economy-class fliers rated their seats as outright uncomfortable, and every airline received extremely low scores on legroom and cushiness in economy. Clearly, things are dismal and seem to be getting even worse.

They're so bad, in fact, that last year, nonprofit consumer-advocacy group *FlyersRights.org* filed a suit against the Federal Aviation Administration, after lobbying the agency to stop the squeeze and standardise seat sizes. Lawyers argued that the cramped quarters are dangerous, and, as they continue to shrink, are only getting more so. For Americans—who on average weigh seven kilos more than they did 20 years ago—the chairs can be harder to escape in an emergency. And wedging in and staying stationary for long flights can cause circulation problems.

Last July, the US Court of Appeals in Washington, D.C., ruled in favour of *FlyersRights.org*, ordering the FAA to review passenger quarters. Judge Patricia Ann Millett dubbed it "The Case of the Incredible Shrinking Airline Seat." The FAA has yet to propose a path forward.

Even without a public court case, the fact that we're cramped is a secret to no one, particularly statistician and fit expert Kathleen Robinette. She's been measuring aeroplane seats—among other things—for more than 40

years, which includes a three-decade tenure at the Air Force's research lab.

"The Air Force invests a lot of money in it because if their products don't fit, people die," she says. She also oversaw the Civilian American and European Surface Anthropometry Resource (CAESAR), an international survey that measured more than 4,000 people to model the range of human shapes and sizes in 3D. Agencies like NASA and companies like American can use the resource as reference for fit.

She's the one who suggested I bring a tape measure aboard my flight. I thought of her as I tried to capture the sliver from my heels to the bar below my seat, the line of demarcation between my space and another passenger's luggage. Too minuscule to measure.

A TIGHT HISTORY

The first airline passenger seats, in the late 1920s, were tacked on. Designers made quick additions, such as leather headrests and cushions, to cheap and light wicker furniture, which they bolted to the craft's floors. Boeing eventually improved on wicker with bent wood, but it wasn't until after World War II, once commercial flying became common, that anyone paid much attention to cabin design. Manufacturers—primarily Alcoa, which built aluminium seats—began churning out chairs

and, by the mid-1950s, an accidental standard began to emerge. Build seats to accommodate the hips of the largest men, the thinking went, and they'd fit almost everyone. At the time, most men had hips 45 centimetres or smaller; that's why most sky-pews are around 450 mm wide, though some shrink as narrow as 400.

Two hefty issues here: First, men's shoulders are, on average, more than 75 mm broader than their hips. Also, men aren't the only ones who fly. The average woman's hips are more than 75 mm wider than a man's. The seats, right from the beginning, fit no one.

But to really understand our current sorry state in the sky, you have to learn how the business of air travel has changed over the past half-century. The 1978 Airline Deregulation Act removed federal control over fares and routes and made it easier for new carriers to launch. Whereas before, the airlines operated almost like utility companies—regionalised, with a few players subject to massive oversight—the industry was suddenly part of the free market. Competition meant a quick drop in fares, so more people could afford to fly.

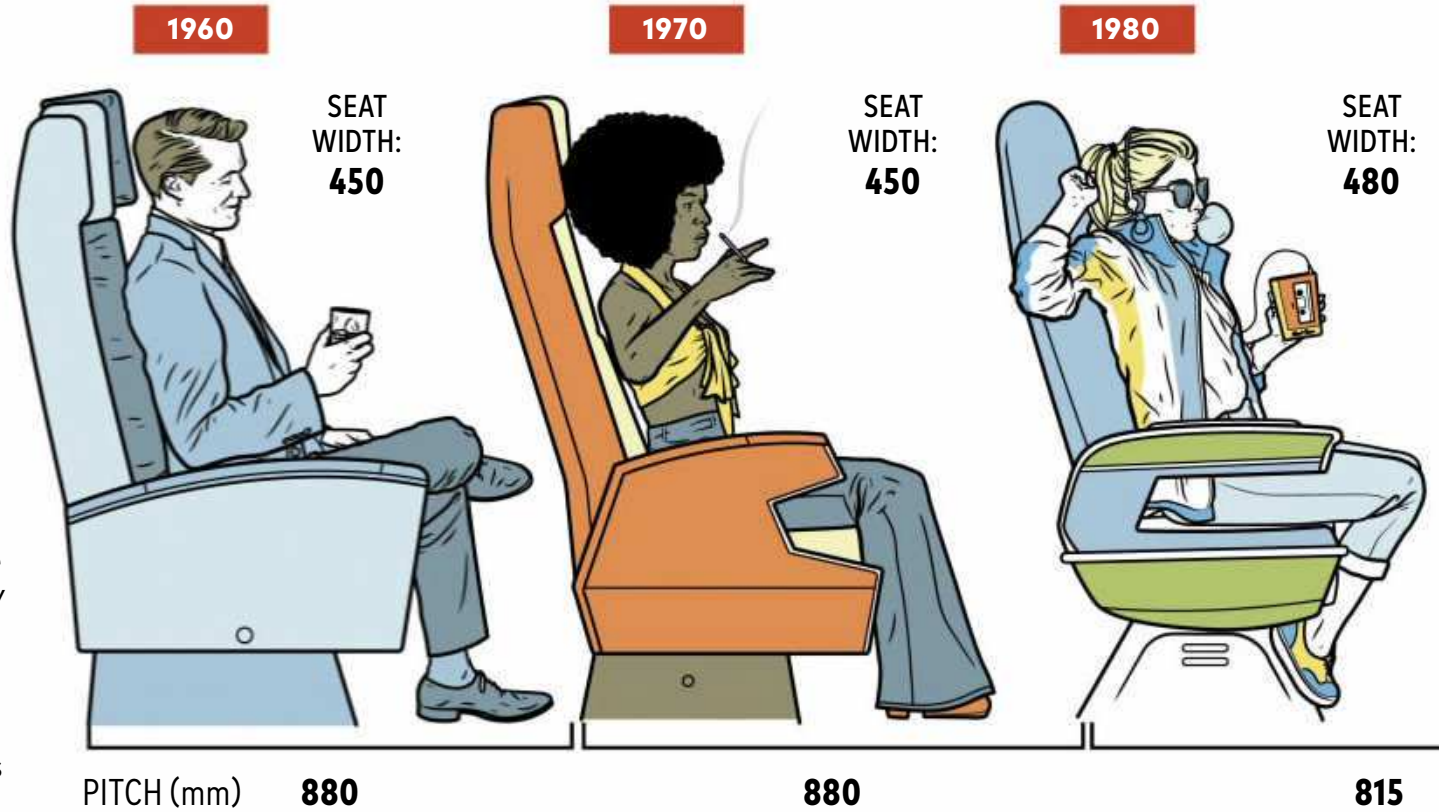
Then, in the mid '90s, Priceline and Expedia entered the scene, revealing to the masses the fluctuating nature of an airfare, allowing them to see how prices shift by the day and time. "This was really the revolution, the turning point," explains Seth Miller, an

SHRINKING PLANES, OH MY!

THANK YOU FOR FLYING

LOCATE YOUR REDUCED LEGROOM

Over the past 50 years, the space between rows (the pitch) has compressed by an average of 100 mm. Some budget carriers offer only 700 mm between seats, the tiniest space yet allotted on a commercial flight. Chairs have also transformed, from pillowy cushions to fire-resistant-but-minimal pads, each less than 10 kg. Trimmer profiles, though, slide butts back in the seats, restoring a few precious centimetres of lost legroom.



BYGONE AMENITIES



ENTERTAINMENT
Before seatback TV, airlines distributed postcards to fill out.



COAT RACKS
A closet for garment bags and outerwear preceded each section.



SEAT FLOTATION
Cushy recliners made butts comfy; but the chairs didn't float.

HOW TO USE A TINY BATHROOM

STEP 1



GET IN LINE With only one lavatory for every 80 passengers on some flights, expect a wait. Queue up in the aisle.

STEP 2



ENTER SIDWAYS Lavs are as much as 250 mm narrower now, with little room to turn around. Shimmy to enter.

STEP 3



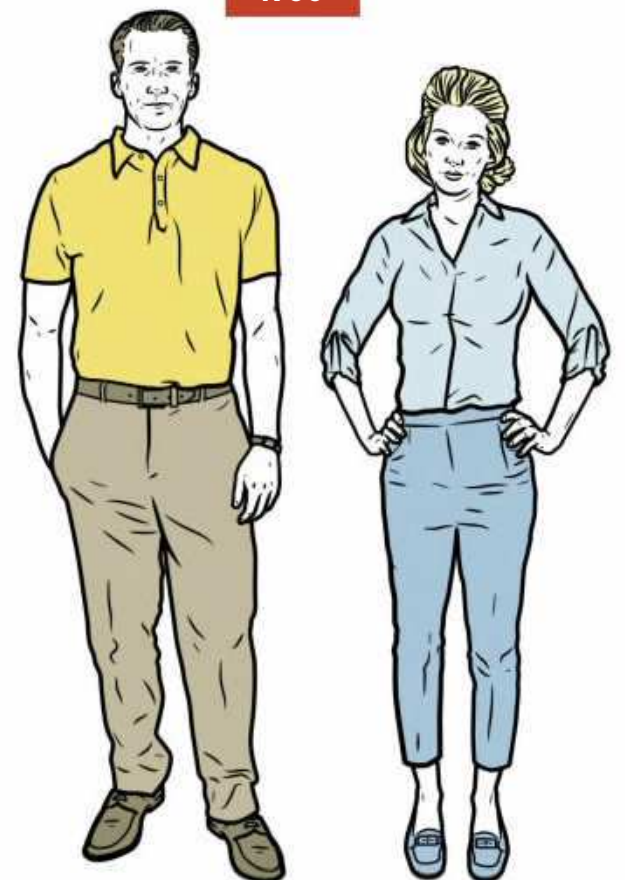
WASH CAREFULLY New kidney-shaped sinks are only 100 mm deep, so clean one hand at a time.

STEP 4

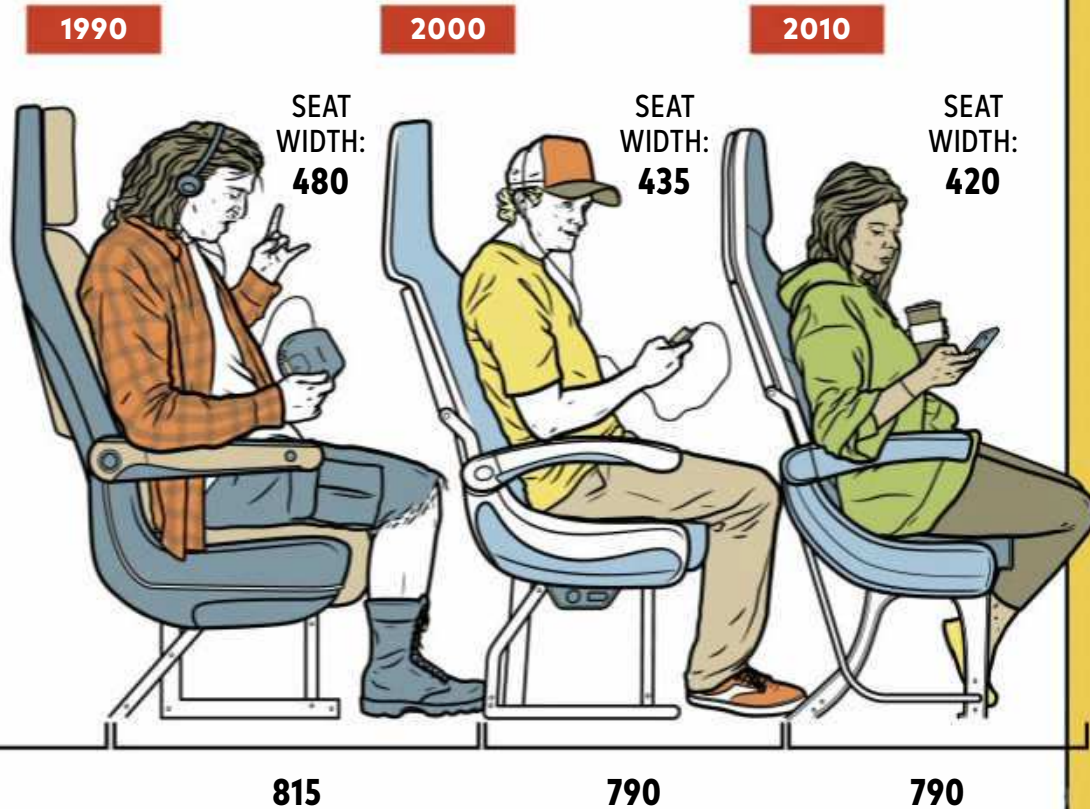


MIND THE DOOR Outward-swinging doors block flight attendants' access to the galleys. Exit with caution.

1960



Welcome to air travel in 2018. Here's what to expect in your cramped cabin. BY LEXI KRUPP



OVERHEAD SPACE
Hat racks, rather than bins, gave passengers more headroom.



TABLE SETTINGS
Travellers ate dinner with real cutlery, and sipped free bubbly.

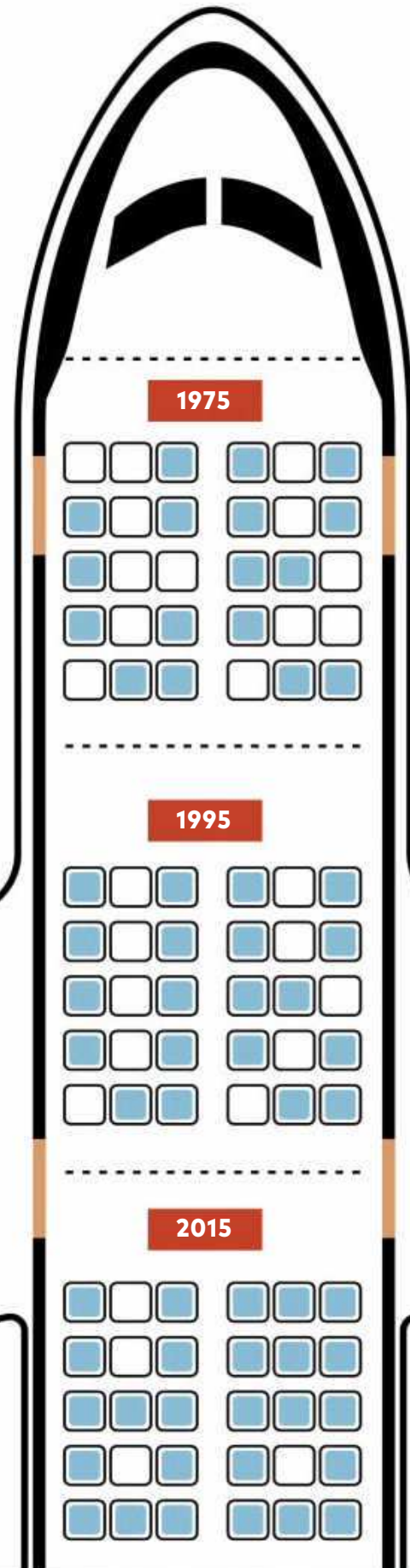


2016

AND YET, YOU GROW

As legroom contracts and seats narrow, passengers' bodies are going in the opposite direction. Most Americans are more than 11 kilos heavier than their 1960s counterparts. That extra weight generally hangs around people's waists, making the squeeze between armrests tighter. We've also grown 25 mm taller, bringing seatbacks and luggage bins even closer.

DON'T EXPECT ELBOW ROOM



Until the '90s, it was rare to find someone in the middle seat; most flights were less than two-thirds full, and people (naturally) grab windows and aisles first. That empty space meant passengers had more room to stretch out, boarding moved more quickly, and bin shortages were blessedly uncommon. Today, cheaper fares mean nearly nine out of 10 spots are taken on an average flight.

NOPE, NOPE, NOPE: Saddle Seats



Those aren't roller-coaster seats. They're the SkyRider 2.0 concept from Italian firm Aviointeriors. For super-short European hops, travelers perch atop the saddles in a near-vertical position, a scheme that would allow airlines to squeeze rows closer together and up capacity by 20 per cent.

aviation-industry analyst. Suddenly, the average consumer could find bargain flights. In 1965, during what many term the “golden era” of the jet age, only 1 in 5 people had ever been on an aeroplane. Today, that portion is flipped: 1 in 5 have *never* flown, while about half of us will jet at least once a year.

As ever more of us scramble for cheap airfare, carriers cram in rows by messing with pitch, which is the distance between any point on your seat and the same point on the one in front of you. Before deregulation, the average pitch was about 880 mm, roughly equivalent to today's domestic business class or “economy plus” upgrades. This past May, reports circulated that American would shrink pitch to 760 mm in most rows; that's about the norm, but many budget carriers such as Spirit ratchet it down as low as 710. When pitch is less than 760 mm, anyone taller than 5-foot-8 (172 cm - more than half of men and about five per cent of women) is in danger of getting kneecapped by a reclining seat.

This is not a simple matter of tabulation. “Clothes that fit don't exactly match your measurements,” Robinette, the fit expert, explains. Good design reflects the reality of existence, which is that we move. On a pair of Levi's, the hips are wider than waistlines, not only because hips by and large are wider than waists, but because they flex and turn and

sometimes jiggle and dance. Similarly, moving when seated allows us to shift when our joints get stiff or our butts go numb.

The lack of gap between chairs pins us in place, but that's only part of the aeroplane pinch. Aside from pitch, designers trim the galleys—where we enter and exit the plane, where the drink carts stow, and where attendants nuke tiny sandwiches and hang out. Once they're out of annexable space there, they can eat into the bathrooms (the “lavs,” in Airline World).

After apologising profusely to my girthy, aisle-seated companion, I made my way to one of those lavs. Once inside, I attempted the classic “I'm in a small room” move, reaching out to see if I could touch both walls at once. No luck, but not because the room was so wide: I couldn't raise my arms beyond my waist. I stretched my tape measure across the widest point: 860 mm. My elbows could tap both walls.

I manoeuvred my measurer over to the toilet and found that the “room” was just 580 mm wide across the bowl. Yikes. Many building codes require residential loos to sit in the middle of a 800 mm or wider span. Commercial codes demand 900. But the FAA has no such requirements: Single-aisle planes like the A321 don't have to have lavs at all, let alone ones to accommodate the disabled. It's also a bad situation if you're a bodybuilder or pregnant. (When Andre the Giant flew, attendants handed him

a bucket.) Still, a small room is better than no “smallest room” at all.

ANTI-SQUEEZE

The fight for comfort is a struggle among manufacturers (“framers,” in aero lingo), airlines, and passengers. “It's profit first, then comfort. That's the battle,” says analyst Miller.

The framers push airlines to think creatively about densification schemes, and display their zeal at conventions. Parts manufacturers like Rockwell-Collins and companies like Boeing and Airbus show concepts with stacked chairs, saddles, pitches as narrow as 600 mm, and even bunks in the cargo hold. “Airbus would love nothing more than to add 11 seats in a row. They mocked it up once, and a bunch of us sat in it. It wasn't good,” Miller recalls.

Vocal and often unionised flight attendants prevent the carriers from buying into any truly aggressive interiors. Attendants oversee evacuations, and some worry that shrunk seats make it difficult for passengers to exit. Pinched travellers can also be harder to manage. “Flight attendants are left to deal with a myriad of challenges,” an American attendants' union rep wrote me in an email statement, “including increased incidents of air rage that can only get worse as more aeroplanes are flying at full capacity.”

Market forces may have triggered densification, but passengers share the blame. We want cheap airfares—as every analyst and designer and engineer and attendant I spoke with explained. And we will endure the pinch for the savings. “Do I wish we all had 900 mm of pitch? Of course, but I'm not willing to pay for it,” Miller says, adding, “Most flyers agree: ‘I'll put my knees to my chin, suffer for three hours, and buy dinner when I get there’ is the logic.”

The few in-flight comforts that remain seek to distract us from our bleak surroundings. Free snacks and TV are calculated moves, and so is the cabin design, explains Roser Roca-Toha of Airbus' aircraft marketing department. Her team will present a carrier with up to 150 different seating configurations and a slew of aesthetic tweaks, such as cabin colours and mood lighting, to divert discomfort. These user-experience window dressings—first popularised by Virgin America—can be relatively inexpensive for the airlines. Even the pricey things, such as entertainment, are getting cheaper, as carriers replace \$10,000-a-pop seatback screens with in-flight Wi-Fi and access to streaming

catalogues through flyers' own tablets and phones. A more densely packed plane can offset the price of these add-ons in a few months.

Diversion is one of the framers' last cards to play. They've pushed the geometry of seating almost as far as our girth will allow it to go. There's just one thing left to give: the recline. Those few centimetres, Roca-Toha explains, might slightly improve one person's situation but will likely downgrade that of whoever's behind them. If one flyer reclines, the rest of the plane also has to, if only to reclaim the space ceded to the instigator. "A good compromise is a pre-recline—a natural recline that is fixed in place. It's kinder, and more natural," Roca-Toha says. Frontier Airlines and Spirit now have stationary, pre-reclined seats, and overseas carriers British Airways, Norwegian, and Ryanair have also opted to do away with tilting chairs.

My fellow passengers and I navigated these tiny spaces while we hurtled above the southwestern Sonoran desert. In this moment, in transit to work or our loved ones, the cabin design forced us in each other's way. Getting

into and out of my row, I'd apologised to my seatmates. A few rows up, another man did the same; "I have terrible news," he said, announcing himself to his neighbours.

We blame each other, and ourselves, for our discomfort. But we are wrong. "It's not you," Robinette says. "Most people are near average size. That's literally why it's an average. But people assume it's them, not the product." It's the product. It can be fixed.

Right now, nearly everyone is, to varying degrees, uncomfortable on an aeroplane. And yet sometimes, we band together and cry out: Enough! The designers do listen. Roca-Toha explains that passenger feedback—from survey cards and online forms—is the most powerful

tool framers have in perfecting craft.

I was sceptical, but she's right. Remember American's plan to add more seats across its fleet? The scheme would have chopped pitch to 730 mm on the carrier's new 737s, but attendants and passengers protested, taking to Twitter and Facebook to complain. The company instead cut its extra-legroom option on one row, and spread the space across the economy cabin, holding pitch at 760 mm. Don't laugh: 30 mm of wiggle room is a small victory for us, but consider the airline's sacrifice: the padded profits from thousands of upgraded trips. If we can do that, maybe we can do one better. Wider seats? Roomier rows? Or we can start small: No saddle seats, ever.

B

Framers have pushed the geometry of seating almost as far as our girth will allow it to go.



SKY CAMP: Bunks



Making room to lie down on long-haul flights typically means airlines can't fit as many travellers on board. Jacob Innovations' proposed FlexSeat setup stacks the beds. The company claims the tiered cots better accommodate large travellers and provide room for bigger carry-ons. Just be careful standing up.

**ITEM:**

Mesh

INVENTED:

25,000 BC

USE:

Stopping bugs



Weaving dates back to the Paleolithic era, some 27,000 years ago, and precedes the domestication of plants and animals and farming. Hungry humans may have used nets to snare prey. Since then, mesh has played an essential part in our comfort and survival. One of its most prominent current incarnations is the mosquito net, a life-or-death level essential protective covering in some countries. Thanks to machines that churn out cotton, polyester, polypropylene, and nylon weaves as fine as 0.6 mm, the air-permeable shields can work as a key tool in preventing the spread of malaria and other bug-borne illnesses. Insecticide-treated mesh helped prevent more than 600 million cases of malaria and saved 6.8 million lives between 2000 and 2015.



FOCUS

ON THE DETAILS

A hyperclose look at two of our favourite (and most magnificent) insect supermodels. Lean in!

BY STAN HORACZEK

PHOTOGRAPHS BY LEVON BISS





Entomologists estimate Earth's bug population at around 10 quintillion. That's

19 zeroes, people. But while insects, with an estimated 6 million species, account for one of the largest biomasses on our planet, most pass us by with a buzz on their part and a "Yagh!" on ours.

Photographer **Levon Biss'** has always wanted a closer look. He became obsessed with bugs when he and his son trained a microscope on a ground beetle.

Under magnification, the bug revealed an iridescent-green body with geometric markings. Captivated, Biss decided to use his cameras—which he usually points at celebrities and athletes for high-end magazine covers—to capture the brilliant majesty of these hectic hexapods.

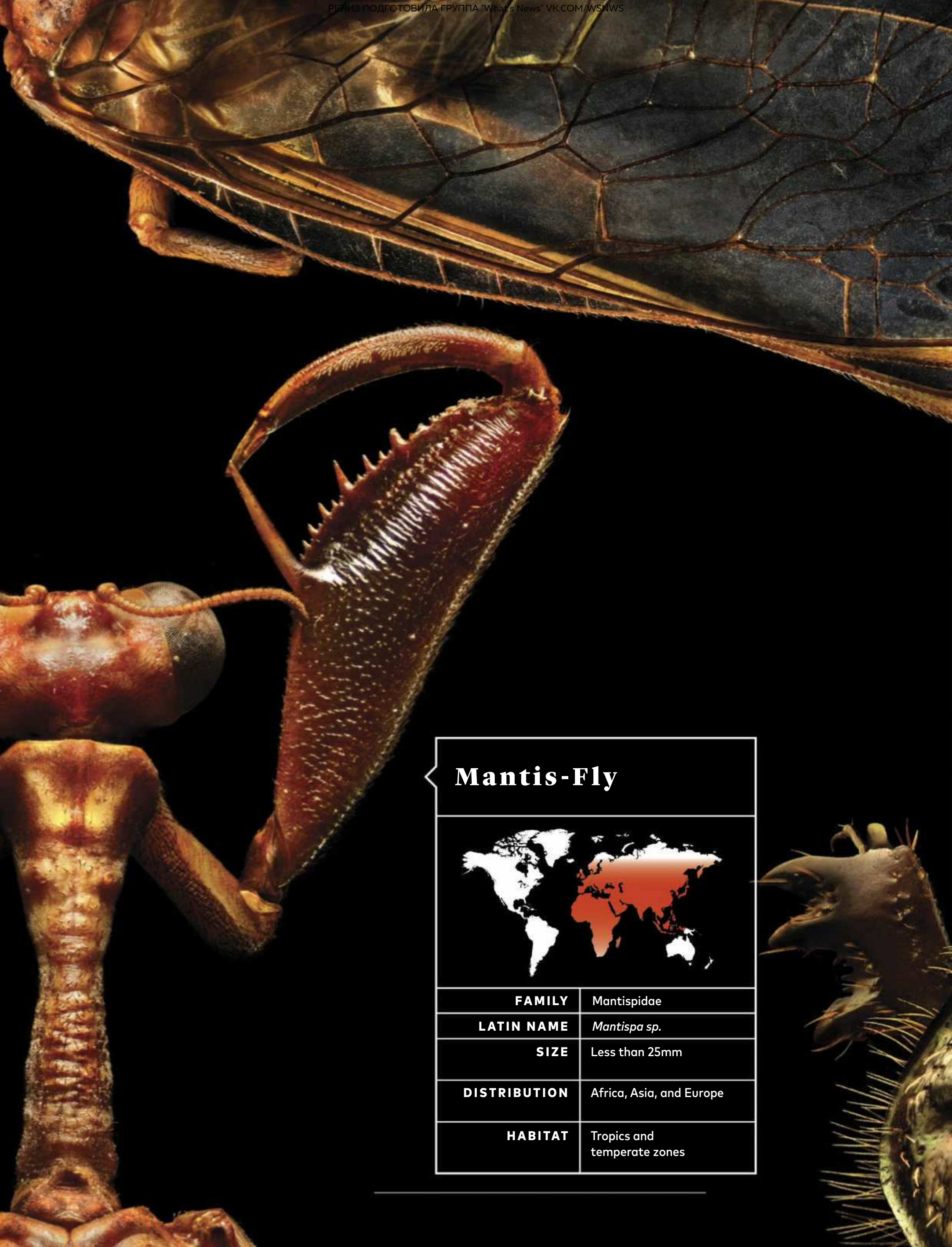
Focusing on tiny subjects is tricky. Depth of field is hard to achieve at these zoom levels. Biss built a camera rig with a microscope lens. Then he mounted it on a rail that moves it 10

microns (one-seventh the width of a human hair) at a time. In this way, he takes up to 10,000 images of each bug and later stitches them together with software.

Today, Biss' "microsculptures" hang in art galleries. Each of his digital files also lives online for anyone to access. This magazine isn't physically large enough for us to show off exactly how detailed and crisp these images really are. But unlike other bug pics you may have seen, these could be blown up to billboard size.



YOUR MAJESTIC MODELS



Mantis-Fly



FAMILY	Mantispidae
LATIN NAME	<i>Mantispa sp.</i>
SIZE	Less than 25mm
DISTRIBUTION	Africa, Asia, and Europe
HABITAT	Tropics and temperate zones



Splendid-Necked Dung Beetle



FAMILY	Scarabaeidae
LATIN NAME	<i>H. splendidicollis</i>
SIZE	Up to 15-mm long
DISTRIBUTION	Madagascar
HABITAT	Tropical dry forest



SUBSCRIBE

FOR YOUR CHANCE TO WIN THE

Ultimate AV Experience!



**GREAT
GIFT IDEA!**

PRIZE VALUED AT

\$9,944!

Klipsch®

DENON®

Enjoy state-of-the-art big screen 4K Ultra projection images and reference-quality surround sound, taking sports, movies and concert home entertainment to a new level

BenQ's latest TK800 projector delivers true 4K Ultra High Definition 8.3 megapixel resolution using XPR technology — whether it's sports or movies, you can enjoy a brilliant picture 100-inches or bigger, with vivid HDR colour even in rooms with some background lighting.


Denon AVR-X1400H 7.2-channel AV Surround Receiver is the engine room of the audio system, delivering state-of-the-art 3D surround sound and powerful music performances, including the latest in streaming and multiroom technology from HEOS inside.

The 5.1 surround sound speaker system is the Premiere system from Klipsch, the 'Great American Loudspeaker Company'. Klipsch's 'Premiere' home theatre system delivers dynamic movie and music performance via technology developed for some of the company's ultra-high-end loudspeakers.



- **HUGE SAVINGS** on the cover price
- **FREE delivery** to your door
- **NEVER miss an issue**

 **mymagazines.com.au**

 Australia-wide **1300 361 146**
OR CALL Sydney metro **(02) 9901 6111**

 **(02) 9901 6110**
OR FAX

 **Locked Bag 3355**
OR MAIL **St Leonards, NSW 1590**



Please send me a subscription to **POPULAR SCIENCE**

- 24 ISSUES** (2 years) **ONLY \$165** **SAVE OVER \$74!**
- 12 ISSUES** (1 year) **ONLY \$89** **SAVE OVER \$30!**
- New Subscription Renewal Gift Subscription

MY DETAILS:

Name: Mr/Mrs/Miss/Ms

Address:

Postcode:

Daytime phone:

E-mail address:

Please provide phone or email in case of delivery issues

PAYMENT:

I enclose cheque/money order for \$_____ payable to nextmedia Pty Ltd

OR please charge my MasterCard Visa American Express

No.

Expiry: / Name on card:

CVV: Cardholder's signature:

GIFT RECIPIENT'S DETAILS:

Name: Mr/Mrs/Miss/Ms

Address:

Postcode:

Daytime phone:

E-mail address:

Price offer available to Aust and NZ residents only ending 26/9/18, inc GST. Savings based on cover price. Overseas: 1yr/12 issues A\$150. Subscriptions commence with the next issue to be mailed, please allow 6-8 weeks for delivery of your first magazine. This form may be used as a Tax Invoice; nextmedia P/L (ABN 84 128 805 970). See www.mymagazines.com.au for full terms. Open to Aust and NZ residents over the age of 18. One entry per Eligible Product Purchase, defined in full terms. Competition opens 2/8/18 at 00:01 and closes 24/10/18 at 23:59. Winner drawn 30/10/18 at 11:00 at 207 Pacific Hwy, St Leonards, NSW 2065. The total prize pool valued at up to \$9,944 (incl.GST). Winner notified by email and published online at www.mymagazines.com.au from 5/11/18 for 28 days. The Promoter is Nextmedia Pty Ltd of 207 Pacific Hwy, St Leonards, NSW 2065. Authorised Under: NSW Permit No. LTPS/18/25430. ACT Permit No. TP 18/01165. SA Licence No. T18/1071. Please tick if you do not wish to receive special offers or information from nextmedia or its partners via [] mail [] email or [] phone. Our Privacy Notice can be found at nextmedia.com.au. If you prefer to receive communication electronically, please ensure we have your current email address.

USE NEW TECH!

To read about new science and tech!



That's right, you heard right, the Australian Popular Science app is out now!
Plus, you can check out our other great science title Australian Science Illustrated.

WHY GO APP?

Save time! Receive alerts when the next issue is out!

Save money! Subscribe for even greater savings!

Use your expensive tablet for **something more enriching** than tweets and recipes!

AVAILABLE NOW ON APPLE NEWSSTAND.

Load the Newsstand store and search for POPULAR SCIENCE and SCIENCE ILLUSTRATED

POPULAR
SCIENCE

ISSUE
118

RETHINK

SEPTEMBER
2018



58

WHY DOES IT MATTER IF
THERE'S A REDHEADED
EMOJI OR NOT?

68

A MARVELLOUS MAP OF
YOUR MAGNIFICENT
MICROBIOME

70

BONE CAVES, SHY DUST
MITES, AND POWERING THE
FUTURE WITH SPORES!

72

OUR NAIVE 1981 PRAISE OF
THE SPACE SHUTTLE
COLUMBIA!

78

THE SHORT AND LARGELY
TAX-BASED HISTORY OF
TINY CARS



The Winding, Heated, and Absurdly Technical Oral History of the Ginger Emoji

BY GREGORY MONE







In November 2014, a tech-industry consortium announced a new set of emoji that offered more variety in the physical appearance of the pictograms. **EMMA KELLY, editor and founder of the site *Ginger Parrot*:** checked and saw that redheads were just not on there. She wondered, has no one brought this up? Is there no one at Apple with red hair? Has everyone forgotten about Ed Sheeran?



Kelly fired off a post on her blog, launched a petition on *change.org*, and fed quotes to *The Guardian* and other media outlets. But she soon discovered it would take much more than an online protest to get her way. But it wasn't because the problem was considered trivial. Far from it.

Emoji are subject to a complex technical bureaucracy. The type and number of new pictograms released each year are strictly controlled by the Unicode Consortium, an international organisation—including, most notably, representatives from Apple, Google, Microsoft, and Adobe. Unicode's core mission is to convert the world's alphabets and symbols into code that all smartphones, desktops, laptops, and computers can read. The dollar sign, no matter the phone or font, is U+0024. The taco: U+1F32E. Websites, email clients, word processors, and other interfaces then transform that code into

words and icons—and vice versa.

For most of its 27-year history, Unicode was concerned with simple characters—musical and mathematical notations, currency signs, punctuation marks. Starting a decade ago, this group of accomplished linguists, font designers, and software developers began including the smileys that had become popular across several Japanese telecom companies. Thereafter, these technical overlords were tasked with debating such matters as the prevalence of unicorns and the cultural import of small piles of poop. A deeper look at Kelly's campaign for ginger representation reveals that they take this responsibility very, very seriously.

CHAPTER ONE

Adopting pixelated cuteness

Emoji began in 1999 in Japan, a country with a long history of pictographic language. In 2007, Unicode members started seriously debating how to include stylized picture characters to make it easier to exchange them across platforms. By 2010, the updated Unicode standard, version 6.0, included 722 emoji.

MICHAEL EVERSON, linguist; Irish national representative to the International Organisation for Standardisation, which helps develop Unicode: Emoji were little pixelated images that people could send along with their text messages in order to augment them with cuteness. A lot of people thought all of this stuff was, shall we say, unsuitable for encoding.

DOUG EWELL, emeritus member, Unicode Consortium: Are people going to be sending each other face-palm emoji in 10 or 20 years? It's like encoding a shag carpet.

EVERSON: We said, OK, if it has to be done, it has to be done.

EWELL: What Unicode ended up doing was to add these emoji to the standard in such a way that it would be possible to interchange them as if they're characters.

PAUL HUNT, font and typeface designer, Adobe Systems; member, Unicode Consortium emoji subcommittee: To your computer, it's just the same as a letter A or a Greek Alpha. Your computer sees a code that maps to a particular concept. For alphabets and other writing systems, the code matches to letters. For emoji, it maps to a particular little picture.

EVERSON: We added a whole bunch of emoji and moved on. Nobody knew what was going to happen.

EWELL: We assumed it was not going to grow out of control, and, over the years, it did.

FRED BENENSON, author of *Emoji Dick*, a version of the novel translated into emoji: Integrating emoji into Unicode turned them into a standard that was easy for hardware vendors to



implement. Before that, it was just this mess of glyphs—things like hearts, arrows, and cat faces.

JENNIFER 8. LEE, *co-founder, Emojination, a diversity advocacy group; vice chair, Unicode Consortium emoji subcommittee*: The fact that they are not infinitely variable, that there is a very controlled set, makes them a common vocabulary across people and cultures.

JENNIFER DANIEL, *creative director for Google emoji, Google*: At first people used them as nouns. Now they're being used more as punctuation to indicate intent, the way an exclamation point signals enthusiasm. Emoji allow people to text the way they talk, with tone and emotion.

CHAPTER TWO

Diversifying the emojiiverse

Each year, Unicode approves more emoji, but the organisation doesn't determine their final appearance. That's up to vendors such as Apple and Google. As these companies began to render their versions, user expectations changed.

MARCEL DANESI, *anthropological linguist, University of Toronto*: Early emoji removed issues of gender, race, and class completely. They were abstract symbols devoid of any of those connotations.

EVERSON: When Apple released a version of iOS with emoji in 2011, everyone thought it was cute and fun. Except Apple had screwed up skin colour, because they hadn't made all

Michael Everson

Apple had screwed up skin colour,

 because they hadn't made all the people blue Smurfs or yellow Simpsons. 

They made them white people.



the people blue Smurfs or yellow Simpsons. They made them white people.

DANESI: If you're using these a lot, one day you're going to say, I'm tired of using the basic yellow smiley face. It doesn't reflect my own skin.

DANIEL: People don't want to go to the emoji keyboard and not recognise themselves.

EVERSON: I proposed a fix that if we needed five grandfather emoji, let's just encode five grandfather emoji. What Unicode ended up doing was encoding five skin-tone patches that relate to the Fitzpatrick skin-burning scale.

THOMAS B. FITZPATRICK, *dermatologist (1919–2003), "The validity and practicality of sun-reactive skin types I through VI"*: A simple working classification was proposed, based not on hair or eye colour, but on what patients say their responses are to an *initial* sun exposure.

UNICODE TECHNICAL STANDARD #51: Five symbol modifier characters that provide for a range of skin tones for human emoji were released in Unicode Version 8.0. [Ed. note: Fitzpatrick's two fairest tones, I and II, share a modifier.] **ED-11 emoji modifier**: a character that can be used to modify the appearance of a preceding emoji in an emoji-modifier sequence.

HUNT: These things happen below the level of user interaction. The user just uses their emoji keyboard, and it will spit out the corresponding Unicode sequence for "princess with medium skin tone" or "woman runner with dark skin tone."

EVERSON: It was a way of dividing this thing up reasonably. There was a problem, and Unicode fixed it. It works, and people seem to be happy using it.

CHAPTER THREE

Great, but what about the hair?

With the release of version 8.0 in June 2015, Kelly and other red-heads were fuming. Modern Family actor Jesse Tyler Ferguson tweeted his disappointment, and comedian Scott "Carrot Top" Thompson wrote a think piece for Time. As far as Unicode was concerned, dye jobs weren't part of their job description.

UTS #51: It is beyond the scope of Unicode to provide an encoding-based mechanism to represent every aspect of human-appearance diversity that emoji users might want to indicate.... No particular hair colour is required; however, dark hair is generally regarded as more neutral because people of every skin tone can have black (or very dark brown) hair.

KELLY: I was quite angry at the time, so I fairly hurriedly created a *change.org* petition. Eventually we gathered more than 20,000 signatures. Unicode originally told me that what

these images look like wasn't actually up to them, that it was up to Apple and Google and the others.

DANIEL: There are differences in how we render them. Apple's emoji are highly rendered and realistic. Google's are more illustrative and playful. The circles, for example, aren't perfect circles. They're kind of squishy and soft. But that softness helps because it makes the illustrations friendlier.

KELLY: We wanted to physically go down there. We put out a call for redheads. A group of them went to Apple headquarters and delivered the signatures in a carrot-shaped USB drive.

APPLE INC.: *Did not respond to multiple requests for comment.*

KELLY: Of course, Apple being Apple, we have not heard anything from them. Someone has got it somewhere there.

DANIEL: Ultimately, vendors like Google are at the mercy of what Unicode passes and fails. The amount of emoji being added every year, and which are added, is really up to them.

LEE: We want to slowly ratchet it up as opposed to dumping them all at the same time. Fifty to 70 per year is a good target.

HUNT: The process starts with a proposal. If you want a new emoji to go into the Unicode standard so everyone in the world can use it, you need to create a report. Unicode provides a template, which is on its website.

BENENSON: I think it's kind of a bar for people who care about submitting emoji that shows they're putting thought into whether it should really be an emoji. Adding that little bit of process helps weed out unserious people.

LEE: It's really not that hard to create a good proposal. If you did reasonably well in high school, you could figure this out. It's the level of a high school lab report.

BENENSON: If it's a food-related emoji like the oyster, you have to take screenshots of Google search results on oyster versus hamburger to show that it's popular.

KELLY: I thought it was crazy that I had to do a proposal. It was so obvious that the ginger emoji should be there. So, as a form of protest, I refused to do the proposal.

LEE: It's not like the emoji subcommittee is rejecting proposals willy-nilly.

EVERSON: The committee did delete the frowning pile of poo as a candidate. I made a lot of noise about that. Proponents cited reasons such as, "We need this because what if you had digestive issues and wanted to text your proctologist." Can you not use words? Do you have to send your doctor a picture? What is wrong with you people?

Jennifer 8. Lee

You want a bagel emoji? ?

OK, let's make an emoji that looks like a bagel. 🥯 ✓

But the ginger—it's not straightforward. 🤔 What are we coding? 🖱️ 👩

CHAPTER FOUR

Let there be gingers!

On January 17, 2017, emoji subcommittee vice chair Jeremy Burge, citing social-media and online buzz, submitted a proposal summarising the group's options for adding redhead emoji. Gingers were still far from official. Unicode would spend more than a year debating how to implement the hair-colour change.

HUNT: We have quarterly Unicode technical committee meetings. That's where we'll decide which emoji will progress, how they will be implemented, and what the mechanisms will be.

LEE: The meetings are so long—it's like C-SPAN but with emoji. It's four weeklong meetings, and emoji are between one and two hours a day for the first four days. With the ginger, we had to go back to the drawing board three or four times.

HUNT: Part of why it was a difficult problem was that there were many ways this thing could be handled.

LEE: You want a bagel emoji? OK, let's make an emoji that looks like a bagel. But the ginger—it's not straightforward. What are we coding? Redheads could be old, babies, boys, girls. How do you approach that? Modifier characters are used in only one situation: skin tone.

MARK DAVIS, *lead internationalisation architect, Google; president and co-founder, Unicode Consortium:* Changing the architecture by adding more modifiers typically requires code changes that might be difficult to retrofit to older devices.

HUNT: It was going to be easier if the hair colours were treated as Zero Width Joiner (ZWJ) sequences—the sequence that involves several emoji glued together.

DAVIS: Existing and older systems know how to handle ZWJ sequences without code changes.

UNICODE TECHNICAL REPORT #51: The U+200D Zero Width Joiner can be used between the elements of a sequence of characters to indicate that a single glyph should be presented if available.

LEE: If you don't have the underlying emoji to glue together, then you still need to create the atomic-level ones—say, the happy woman on her own. One concern was, what does it look like when one piece of the puzzle is missing?

UTR #51: When an emoji ZWJ sequence is sent to a system that does not have a corresponding single glyph, the ZWJ characters are ignored, and a fallback sequence of separate emoji is displayed.

EVERSON: At one point, they suggested combining the person with a separate red-hair glyph. Basically, they were suggesting encoding scalps, which I thought was offensive. We got that changed to a dotted face with the hair on top—a way of showing that it's a control character if the sequence unravels, so you're not sending someone a disembodied scalp.



CHAPTER FIVE Bagels, lobsters, super- villains, and redheads

Unicode announced on February 7, 2018, it would add 157 new emoji, including superheroes, the infinity sign, and red, white, curly, and bald hairstyles. As Kelly awaits Apple's digital gingers, Unicode members and designers ready their keyboard updates and ponder the future of emoji.

HUNT: The process isn't completely finished at that point. Once the Unicode standard becomes official, then Apple and Google and the other vendors will take that information and do their own renditions.

DANIEL: We consider a range of questions when designing an emoji. Is it abstract enough for you to relate to? Or is it overly specific? If it's a person, did we get the expression right? Some emoji are really difficult and require lots of back and forth.

HUNT: Once the vendors update their operating systems with the new characters, people can start using them on their smartphones.

DANIEL: Some you just kind of nail. The redhead is fairly straightforward from a design standpoint: You just change the hair colour to red or orange.

KELLY: I felt relieved, mostly because it had been going on for so long, and I was very happy that all the work we'd done had finally paid off. It was long and confusing, but hey, we got there in the end.

BENENSON: I want people to sympathise a little with Unicode. This is a standards body of software developers, and due to a fluke in corporate history, it ended up in charge of this extremely salient cultural touchpoint and creative expression.

HUNT: It's a lot of work, but it's still fun. That's part of the reason why people love emoji. They're fun, and it will be interesting to see how this does evolve and how it changes the way we think and talk and communicate.

EVERSON: I don't think 70 years from now people will be sending each other pictures of eggplants to discuss certain matters. I don't think 70 years from now people will be sending each other colourful emoji at all.

DANIEL: Really, I'm interested in finding a way to mix and match these emoji to create something new. In the same way language and slang evolve, I hope there's a way for emoji to evolve.

**ITEM:**

Bearing ball

INVENTED:

1794

USE:

Rolling objects



The Romans, Greeks, Celts, and Chinese all independently devised uses for these friction-reducing mechanisms as far back as 900 BC. As did Leonardo da Vinci during the Renaissance (see: helicopter drawings). The first modern incarnation of ball bearings—a 1794 patent that showed how small orbs could spin in grooves between an axle and wheel—was meant to make it easier for horses to pull a carriage. Seventy-five years later, a Parisian bike mechanic placed them in the hub of a *vélocipede*, helping a rider win one of the world's first bicycle road races. Nearly every contemporary rotating machine relies on bearings to reduce rubbing and keep things rolling: They allow hard drives to spin disks, help the Mars rovers steer, and, yes, let your fidget spinner whirl.



Rethink

You Mean the World to Microbes

By JESSICA BODDY

THEY CAMP OUT ON SKIN, HIDE BETWEEN TEETH, DWELL in stomachs, and make us all stink. Meet your microbiome: the bacteria, fungi, and viruses that inhabit Planet You. Up to 50 trillion tiny beings occupy the average body—outnumbering (but nowhere near outweighing) the 30 trillion or so human cells in and on your person. And just like flora and fauna have divvied up Earth, different microbial groups inhabit various regions of our bodies. From topknot to toenail, they form entire ecosystems that keep their world (that's us) healthy, or make it terribly sick. Here are some of the groups we host, from noble knights to villainous scum.

[1] Snowy Scalp

Up north, a wild clan of fungi sometimes makes a living in the snowy tresses on your head. *Malassezia* eat the oils on your scalp, then spit out something called oleic acid. It can dry out your skin, creating a dandruff blizzard.

[2] The Heady Desert

Most researchers agree that healthy noggins are (basically) barren of bugs. The blood-brain barrier, a "smart" membrane, typically allows only beneficial molecules entrance. But conniving microbial spies—including

Streptococcus

pneumoniae, the culprit behind meningitis—can weaken this wall, sneak through, and interrupt brain function.

[3] Facial Grassland

Mischievous critters *Propionibacterium acnes* live on every face and love inciting chaos. When hair follicles get clogged with dirt, dead skin, and an oily substance called sebum, *P. acnes* chow down, inflaming the area. Voilà: You've got a zit.

[4] The Cliffs of Maw

Greedy little spelunkers



Streptococcus mutans climb into the crevices in and between teeth, secreting enamel-eroding acids. This microbial mining causes cavities—unless the digs are demolished daily by brush.

Bad breath? Blame the ***Solobacterium moorei*** lurking on your tongue and in your saliva. It turns proteins into the compounds that curse humans with halitosis.

[5] The Boggy Pits
Armpits are a microbial hot spot because they are hot and humid.

Staphylococcus hominis

are especially fond of this swampland, where they sip on sweat and leave behind new molecules with a special stink: BO.

[6] Gut City
The noble brotherhood of ***Bacteroides fragilis*** swears an oath to protect you. Molecules clinging to the microbes' armour can help orchestrate and control immune responses. Meanwhile, scavenging street urchins called ***Bacteroides thetaiotaomicron*** flit through the intestinal city snacking on plant bits our tummies can't

handle, enabling the gut to pick up more nutrients. ***Oxalobacter formigenes*** act like street sweepers, cleaning biological byways of compounds that can cause kidney stones.

Bifidobacterium longum are hardy townies that keep the colon in working order. They help break down carbs and keep you regular. They also help ward off other, more harmful strains—and use up enough resources to keep colonisers such as the diarrhea-inducing ***Clostridium difficile*** from getting a foothold.

Not every flavour of

Escherichia coli (street name *E. coli*) makes you sick. Many varieties occupy our gastro metro as productive citizens.

Aside from digesting food, they also synthesise vitamins B and K, which we then absorb.

[7] Sexy Oasis
Genitals are a haven for microbes, which often thrive in warm, moist conditions. Some ***Lactobacillus*** species—***crispatus***, ***gasseri iners***, ***jensenii***, and more—tend this garden by producing lactic acid, which regulates local pH

and keeps out pathogens. These locals also serve as a newborn's first microbiome.

Alas, penile bugs and their biological purpose remain more mysterious to researchers.

[8] Hamlets of Derma
Skin-dwellers ***Staphylococcus epidermidis***, ***lugdunensis***, and ***capitis*** are tribes that, for the most part, just take up space. Thankfully, they don't welcome outsiders like ***Staph. aureus***, which can cause infections and pneumonia in hosts.



TALES

FROM X THE

FIELD

AT THE EXTREME

Reaching the Past Through a 7-Inch Chute

MARINA ELLIOTT, BIOLOGICAL ANTHROPOLOGIST AT UNIVERSITY OF THE WITWATERSRAND IN SOUTH AFRICA



In 2013, I was finishing my doctorate in biological anthropology when my supervisor sent me an intriguing Facebook post. Paleoanthropologist Lee Berger was seeking a team to excavate hominin remains in South Africa's Rising Star Cave, a network of chambers that covers more than 9 acres. He wanted people who were not only trained anthropologists, but also climbers who could squeeze through a 17-cm-wide space. I wrig-

gled underneath my bed to make sure I could do it. Within a month, I was heading to South Africa with five other researchers. To reach the fossils, you belly-crawl through a 30-cm-high passage, climb 15 metres up a rocky formation, and slip

down a 12-m chute into what we call the Dinaledi Chamber. That chute isn't just a crack in the rock—it's studded with points like shark teeth. I couldn't turn my head to see where I was going, and many points were so tight that by inhaling, I could hold myself in place without my hands. When I dropped down and entered the chamber for the first time, it was awesome in the true sense of the word. Everywhere my headlamp shone, I saw fragments

of bone. We expected to find a single individual, probably a species we already knew. But there were 18 hominins, each around 300,000 years old. We later learned those remains came from a previously unknown human cousin, *Homo naledi*. We believe this species deliberately disposed of their dead there. I expected to spend a month in South Africa, but five years later, I'm still working on the site. The descent never gets easy—I've probably worn through 15 overalls

scraping through that jagged chute—but negotiating tight spaces is more about knowing how to move than anything else. You need to be strong, smart, and determined (and a little bit crazy), but not necessarily tiny.

AS TOLD TO RACHEL FELTMAN

illustration by Britt Spencer

TRY AGAIN

Dust-Mite Queen

RUBABA HAMID SHAFIQUE, RESEARCH ASSOCIATE AT INSTITUTE OF BIOMEDICAL AND GENETIC ENGINEERING IN ISLAMABAD, PAKISTAN

➔ Dust mites are microscopic creatures that live in rugs, blankets, and cushions, triggering skin rashes and asthma in millions of people worldwide. In Pakistan, physicians started diagnosing people with dust allergies, in the mid-1990s. But no one knew if these allergy-inducing bugs actually lived there! Knowing which species—if any—lived in Pakistani homes could help doctors make more accurate diagnoses.

So in spring 2011, I collected dust from 300 homes in urban areas of Pothwar. People aren't accustomed to strangers showing up at the door with a vacuum cleaner! I used my network of friends to reach as many subjects as possible.

But I didn't find any mites. I thought the entire project was a failure. Then I remembered the pests like humid air, and spring in Pothwar is dry. So I tried collecting again during the rainy weather that summer—and this time I saw loads. They belonged to two fairly common strains, which confirmed that doctors could diagnose allergies with Western kits. I learned so much about the mites that people now call me for advice about infestations. I'm regarded as the "dust-mite queen."

AS TOLD TO LINA

illustration by Britt Spencer



MY EUREKA MOMENT

Spore Power

OZGUR SAHIN, BIOPHYSICIST AT COLUMBIA UNIVERSITY

➔ When a bacterium gets stressed out, it stashes some of its DNA in a hardy structure called a spore, which can stay dormant for years before reactivating. Back in 2006, I started studying the spores made by *Bacillus subtilis* because a colleague told me they expand significantly in size when they come into contact with moisture. I wanted to harness that mechanical power.

First, to see how much the *subtilis* grew with water in the air, I put some spores in a special microscope that can measure minuscule movements. Before I added moisture, I leaned in to look. Immediately, I saw a huge readout—the spores had already got-

ten much bigger. My mere breath had caused them to grow! After some calculations, I knew these would be able to power really strong motors.

We built a little spore-powered 100-gram toy car to showcase *subtilis*. It isn't the fastest—it takes a minute to cover about 10 centimetres—but it's the only vehicle ever to run on evaporated water. Its rotary motor turns as the spores grow and shrink. Going forward, I'd like to turn their size-changing ability into electricity. The method? If we place large sheets of spores on a body of water and connect them to a generator, evaporation could produce renewable power much the same way wind does.

AS TOLD TO JESSICA BODDY



illustration by Britt Spencer

SEPTMBER
1981

From The
Archives

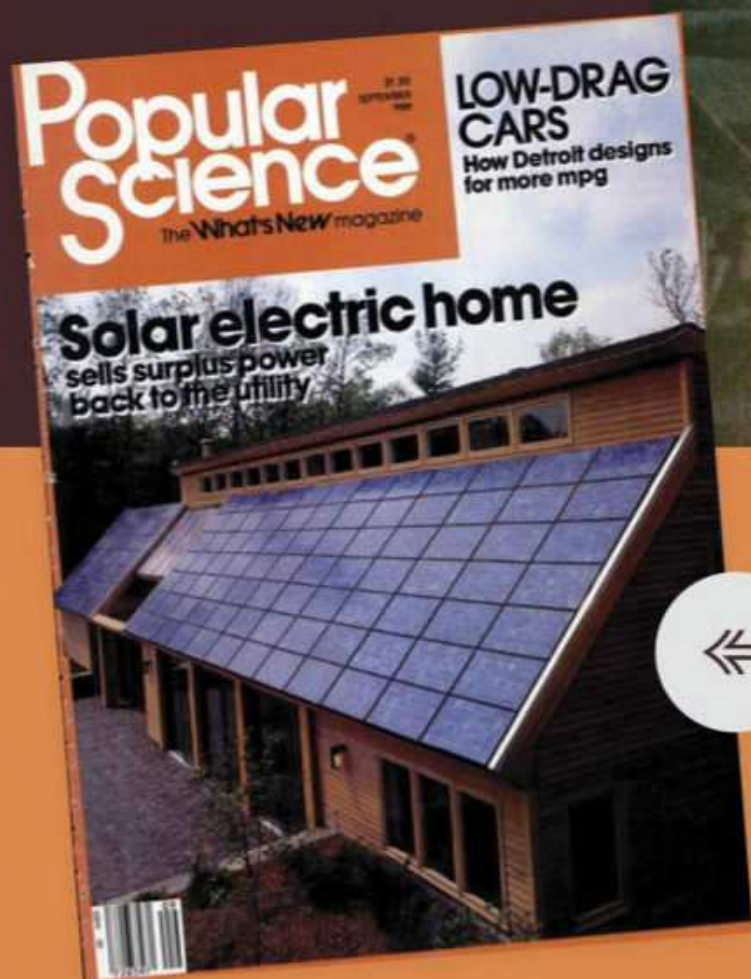
An Exercise in Overconfidence

THIS ACCOUNT OF THE FIRST Space Shuttle launch makes for uncomfortable reading, now. Not just because of all the dismissive talk about how thermal tile damage couldn't hurt the orbiter, and how they "could have taken that spacecraft, filled it up again, and reflown it." No, fate would prove crueller than that.

Because not only did thermal tile damage lead to the deaths of all seven crew on STS-107 in 2003... it was this very spacecraft, Columbia, that was lost. The exact same thing that everyone said was fine in 1981 turned tragically not-fine 22 year later.

Forewarnings and foreshadowings of that awful future are all through this piece. See how many your hindsight can spot.

by ANTHONY FORDHAM



Nothing New Under the Sun

SEPTEMBER 1981

Welcome to the 1980s where technology was starting to get computers in it, and anything was possible. Power your home with solar panels and make money selling electricity back to the grid? Ha ha, that sounds CRAZY! Also, the article about low-drag cars is offset by all the cigarette advertising. Geddit?

Columbia's triumph

—the inside story of
a near-flawless mission

While the world sat breathless before TV sets, here's what was happening — at liftoff, in orbit, and on landing

By **JIM SCHEFTER**

John Young drifted down through a hatch from the Space Shuttle flight deck to the mid-deck, a snaky communications line undulating after him. Brushing the cord aside, he grinned at Bob Crippen and slowly rolled into a perfect midair somersault. For the veteran astronaut, making an unprecedented fifth space mission, it was good to be weightless again.

For the machine they were putting through intensive flight testing, they were glad it was weightless at last. In 54 hours of April, the U.S. Space Shuttle Columbia brought dawn to a new age, when orbiting the Earth will be not so much adventure as routine travel. A reusable vehicle, Columbia is the first true space transportation system.

Commander Young and pilot Crippen devoted years of preparation to the mission NASA called STS-1 — so many, in fact, that Young joked they might be called "Old" and "Crippled" before they got off the ground. Then, in barely more than two days, they rode through an amazing flight that tested—and fulfilled—all of its major objectives. Examples:

- Columbia's rockets turned out to be more powerful than predicted.
- The Thermal Protection System tiles, which caused long delays during Shuttle development [PS, April '80] and safety worries during the mission, did their job.
- Shuttle avionics, the computers and software that control the ship, earned a "remarkable" rating from Young.
- In every case, from hydrazine for attitude-control rockets, to Freon and water for cooling, to hydrogen and oxygen for the fuel cells, Columbia consumed less than expected and gave better performance.
- Columbia returned from space to a runway landing at Edwards Air Force Base, Calif., with textbook ease. A powerless "brick with wings" on landing, it flew even better than its designers at Rockwell International hoped.
- Life aboard Columbia was generally comfortable—even enjoyable.

The thundering ascent

There had never been a space mission like it. Columbia was easily the most complex flying machine ever built. When it was fired into motion at 7 a.m., Sunday, April 12, I watched from the closest possible vantage point, about three miles from the launch pad. I saw the fire and smoke erupt, then watched Columbia rise. The yellow-red flame of the twin solid rockets scorched earth, pad, and sky.

Nobody quite knew what to expect when the rockets ignited. They were new, developed for the Shuttle, and had the most thrust of any rocket engines ever built. Young had ridden two Titans and two Saturns on earlier missions, experiencing sharp vibrations and jolts each time. But the Space Shuttle was designed to transport scientists and payload specialists who have not undergone rigorous astronaut training; thus a degree of comfort was important. Would it be an easy ride?

"The vibration in the cockpit was very low after the engines lighted," Young said later. "When the solids lit, there were a couple of thumps, and we started moving up very slowly. Then it really got up and moved out—just as smooth as glass."

The solid rockets produced enough extra thrust to send the Shuttle on

a straighter, more vertical trajectory than expected. Columbia's onboard guidance system and computers adjusted the steering to keep it within safety limits, though the craft was about five miles too high at one point.

The extra rocket thrust was a welcome discovery. Initial postflight calculations indicated that the extra power could mean that at least 1,000 pounds could be added to the Shuttle's payload on operational missions.

At the same time, another surprise greeted the ship—this one not so welcome. Enormous amounts of whitish debris pummeled down on it. "I was seeing that debris coming off the nose (of the external fuel tank) and hitting our windscreen," Crippen said. "Maybe it was ice, maybe SOFI." (SOFI is spray-on foam insulation. It covers most of the external tank to help keep the liquid hydrogen and oxygen propellants inside at cryogenic temperatures.) Whatever it was, the debris clobbered Columbia.

On cue, the recoverable solid rockets cut loose from the external tank, "still firing," Crippen noted with some surprise. The rocket casings fell into the sea. Both were recovered, and after refurbishing will be reused.

The last piece to go was the huge external fuel tank. "There were sheets of ice and SOFI flying all around," Crippen revealed. Columbia again was pummeled with debris. One chunk hit the windshield, leaving a mark that melted out during reentry.

The crew performed two maneuvers with their small rocket engine to establish an initial orbit at 130 miles. Once weightless, Crippen was enthralled with the sensation and with the magnificent view from Columbia's large windows: "It's fantastic what we could see: cities, ships, runways—and with a three-dimensionality and color differentiation the film just doesn't show." Old-hand Young barely concealed his own enthusiasm.

Down (up?) to business

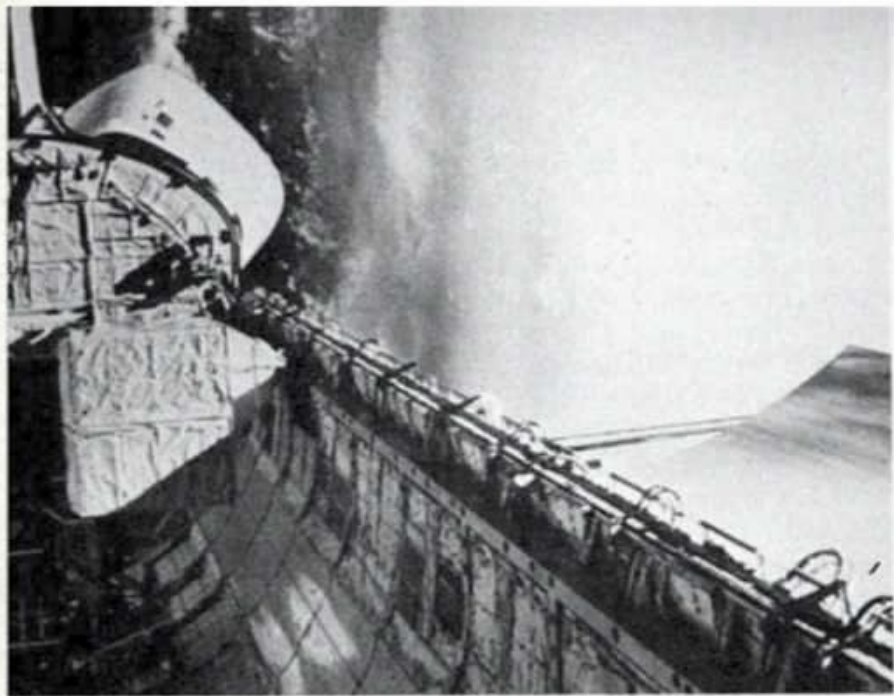
Now they were up there, and their exhilaration was tempered by the workload. Systems required precise checking, with switches to turn on or off, gauges and dials to monitor, cathode-ray-tube displays to be compared with each other and with predicted readings. Young did most of the tests from his left-side commander's seat on the flight deck. "I think I spent 53 hours sitting in that seat," he said later. Systems checks were what this first mission was all about, but the routine was pretty boring. "A little bit of that will last you about six months," Young sighed.

While Young ran through the tests, Crippen handled most of the chores. That included preparing meals (no cooking, just adding water to bags of space food) and changing filter canisters in the environmental control system. Lithium hydroxide and charcoal filters scrubbed carbon dioxide from the air, and helped reduce one of the unpleasantnesses of space flight: odors. In zero g and reduced atmospheric pressure, just about everything outgasses.

Crippen was also responsible for trying—unsuccessfully—to fix the few items that failed. An important tape recorder jammed, probably when a loose washer floated free in zero gravity and lodged in its mechanism. Among the data lost are exterior temperature readings during the fiery blackout period of reentry through the atmosphere. When Crippen tried to open the electronics-bay door to trouble-shoot the balky machine, he couldn't get the fasteners to turn in zero-g. Crippen floated. The fasteners didn't budge.

Other minor problems: A toilet malfunctioned, a problem later traced to a fanlike suction device. The tangle of communications cables continually threatened to wrap

Continued



Columbia's cargo bay is huge—15 by 60 feet. During most of the mission, its doors were open to expose radiators for cooling. Opening them gave the astronauts their first view of the rear rocket pods, where thermal tiles were missing (black spots).

around the floating astronauts. “It was like working in a spaghetti factory,” Crippen said. Wireless mikes and pocket receivers will be used on future flights.

Outside, a small panel on a rocket pod delaminated and some excess heat built up. It was the only known spot on Columbia's exterior where temperatures exceeded expectations. In most areas the temperatures were lower than expected.

That included the cabin, which Young found chilly. The reason: The cabin thermostat was between two heat-producing electronic boxes. “If I'd have known where they were, I'd have gone over and stood by them,” Young quipped later.

Open doors to space

One crucial system checked was the payload-bay doors. These must open to expose radiators that dissipate the heat generated within the Shuttle. On operational missions, they will also be opened to expose instruments, deploy or retrieve satellites, and do other such tasks. The long clam-shell doors opened on command and closed—twice—without a hitch. “I wasn't looking forward to going out there to fix them,” Crippen said.

It was on the first opening that Young and Crippen—and the world below, watching on live television saw that a few thermal tiles were missing from the aft rocket pods. Whether the tiles vibrated loose, were knocked off by debris, or tore away in the supersonic slipstream of launch may never be known.

The missing tiles would probably not cause trouble, experts at NASA in Houston and Rockwell in Downey, Calif., decided. But if any were missing from the belly or the underside of Columbia's wings, the 2,300-degree reentry heat could reach the aluminum skin. The result could be disaster.

NASA quickly worked out a deal with the Air Force to photograph Columbia both with high-powered ground cameras and with orbiting spy cameras. But clouds obscured the former, and results of the latter, officially not discussed but widely leaked, were said to be inconclusive. Either way, the astronauts had no choice but to bring Columbia home as planned.

Later, technicians would find an eight-inch gash crossing through

three tiles on a landing-gear door. Another gash on body-flap tiles at the rear showed evidence of slight melting. In the final analysis, however, only 40 tiles required replacement.

“We had estimated that as many as two or three thousand would have to be replaced,” Rockwell's George Merrick told me. “Instead, we could have taken that spacecraft, filled it up again, and reflowed it.”

Much of Columbia's success was due to the precise entry flown jointly by Young and the computers. “We were right down the middle of the corridor all the way,” Crippen said. The computer-controlled rocket thrust that brought Columbia out of orbit cut just 200 mph from its 17,500-mph speed. That's all it takes. From entry interface, an arbitrary point 400,000 feet up, the computers kept Columbia right on course.

Coming home

Entering the atmosphere nose high and upside down, Columbia whipped through a series of roll maneuvers that twisted it first left, then right, and ultimately left it with its black belly down to absorb the high heat. The astronauts let the computers handle Columbia, knowing that no human could react fast enough to keep the ship's position exactly right at ultrasonic speeds.

But once out of the communications blackout—that short period when temperatures outside are so hot that radio messages can't get through—Young switched to a control mode that let him share piloting chores with the computers. Columbia was still more than 20 miles high, but only about 500 miles from Edwards. Young and the computers adjusted Columbia's attitude to let the atmospheric friction slow the ship.

In the denser atmosphere, the computers turned off the rocket system and Columbia's aerodynamic surfaces—elevon, body flap (on the back of the wing), and speed brake—became the controlling devices that responded to Young's piloting. They worked perfectly.

Young brought Columbia on line with runway 23 at Edwards. “Those controls are electronic, and it's remarkable,” he said. “When you move the wings somewhere, they stay there. When you put the nose somewhere, it stays there ... It does exactly what you want it to.”

Young held his airspeed indicator at 185 knots and touched down only a few thousand feet past his aiming point for a landing any pilot would call a greaser. An hour later, the jubilant astronaut bounded around Columbia, jabbing his arm upward in victory, pointing at the scant tile damage, and talking as fast as he had just flown.

“She's a beauty!” he said later in Houston. “That's quite a capability—to return from orbit with a 99-ton spacecraft and get her back all in one piece.”

And up again

Columbia returned to Florida in late April, where it underwent top-to-bottom scrutiny. The inspections revealed no nasty surprises. “I kept waiting for the shoe to fall,” Rockwell's Merrick told me, “but it just didn't happen. The deeper we got into the data, the more we kept finding that everything was okay.”

With astronauts Joe Engle and Richard Truly at the controls, Columbia will indeed become the first spacecraft to be reused. Its second mission is scheduled for early autumn. During the summer, it was scheduled to be refurbished and fitted with the first remote-manipulator arm, the device that will lift payloads from the large bay or retrieve satellites from orbit. The first actual payload carried by the Shuttle, a series of instruments intended to demonstrate capabilities rather than gather much real scientific data, also will be carried on the five-day mission.

“It's an age-old goal to fly into and out of space,” Young remarked after Columbia's maiden voyage. “But we've got even more than that. We've got a way to get payloads into space economically. It's what we've been working toward for 10 years.”

Now you can buy a record-holding, 56.66-mph bullet bike

In the October 1980 issue we told you about remarkable human-powered vehicles (HPV's) capable of 60+ mph speeds. One of the pedal-powered speedsters — Vector Beta — set a world record for one-person-powered HPV's, flashing through the speed trap at 56.66 mph at the 1980 International Human Powered Speed Championships.

Now you can pedal your own HPV: Vector designer Al Voigt, a General Dynamics engineer, offers his sleek record holder through Early Winters Ltd. (110 Prefontaine Pl. S., Seattle, Wash. 98104) at, well, a record price: \$10,000. The tricycle features a slippery fiberglass and Lexan shell (total coefficient

of drag: 0.11), with two steerable wheels in front and one in the rear (behind the supine rider). It's 116 in. long, 25 in. wide, 32 in. high, and weighs 51 lbs. Steering, braking, and gear-shift functions are on a single joystick, which also includes a computer that gives time and distance traveled, average speed of trip, as well as instantaneous speed. Vector's power train is a six-speed derailleur, 100-tooth front chain wheel, and an 11-28-tooth rear cluster. With this gearing, the Vector is no hill climber: It's designed to do 60 mph with the rider pedaling at 82 rpm. What if you can't pedal that fast? "In the Vector," says designer Voigt, "30 mph is a nice, easy pace."

—R. L. Stepler



**ITEM:**

Zipper slider

INVENTED:

1851

USE:

Zipping



The ubiquitous fastener we all use (and some fashion designers overuse) has undergone more than a century of refinements. It began with Elias Howe's 1851 patent for "a series of clasps united by a connecting-cord... running or sliding upon ribs." Kind of awkward. So, 40 years later, engineer Whitcomb Judson replaced the clasps with hooks and eyes joined by a slider. Better. But in 1913, Otto Frederik Gideon Sundback added a reliable interlocking system made of oval teeth. The then-president of B.F. Goodrich, Bertram Work, bestowed the "zipper" moniker to a company-made boot that featured one. The name stuck; the footwear did not. Like cola, the battle for the \$16 billion+ international zipper market dominance became fierce. China is currently winning.

by Bryan Gardiner / photograph by The Voorhes



AE



«
Retro
Invention»

Micro Machines

A brief and necessarily unsatisfying exploration of the cultural reasons that tiny cars still exist...

by ANTHONY FORDHAM

WHEN IT COMES TO CAR CULTURE, Australia is one of the most cosmopolitan markets... *in the world*. Our automotive origins are in the UK, which gives us a tolerance for mid-sized sedans and diesel hatchbacks, but we have the wide open spaces and looong road trips that, last century, justified the larger, American-style saloon. We have some of the most demanding off-roading in the world, we embrace the likewise US-idea of hauling kids around in an SUV. We're not even above a van or two. The only thing we don't go for in great numbers is the huge "pickup". And there are

even a few of those around these days.

That right-hand drive legacy from the UK gave us something else as well: access to grey market and personal imports of Japanese domestic cars. And when it comes to eclectic taste in cars, Japan might have us all beat.

Take the *kei jidōsha* or kei class cars (it means "light automobile"). These tiny rides were built to give the long-suffering Japanese motorist a tax break. If he was prepared to have a car no longer than 3.4 metres, no wider than 1.48 metres, and with an engine no bigger than 660 cc outputting 47kW or less... well then he didn't

have to pay as much tax, insurance, or assure the Japanese government repeatedly and in writing that he had a parking space. This is a big thing in Japan. Even tiny cars are big in Japan.

That was in the 1950s, and these days Japan also produces domestic-market luxu vans with 325kW+ V6 engines for highway cruising, so you might think the K-car has become little more than a memory, or at best a collectible. But apparently this class still accounts for a third of Japanese domestic vehicle sales. That's how much people hate paying tax.

There's a giant list of JDM kei models, but a few do get exported. In Australia, the Suzuki Alto and Jimny aren't exactly rare, but they do have larger engines fitted for our market, presumably out of sympathy. Driving 500km behind the Jimny's 1.4L engine is rough enough. Imagine a 0.6L. Reece...

Outside Japan, tiny cars do pop up from time to time in the history of "good" automotive ideas. In 1957, Fiat's 500 got a then-poor Italy

1



2



5



6



1/1953 BMW Isetta

The best-known "bubble car"—post-World War II whips that were so small that their windows looked huge—had a single front door, two seats, and no meaningful storage.

LENGTH: 2.2 metres

2/1957 Fiat 500

This two-door sported a more conventional design, but its engine sat over its rear wheels. A station-wagon version turned the block on its side for increased storage space.

LENGTH: 2.9 metres

3/1973 Reliant Robin

Known as the "plastic pig" in British pop culture, thanks to its fibreglass body, this three-wheeled ride had a single tyre up front, which made it prone to tipping over.

LENGTH: 3.3 metres

5/1998 Smart ForTwo

At well under three metres long, two of these city cars could fit in one parking spot. A steel cell surrounded passengers, but the ride lacked crucial crumple zones.

LENGTH: 2.5 metres

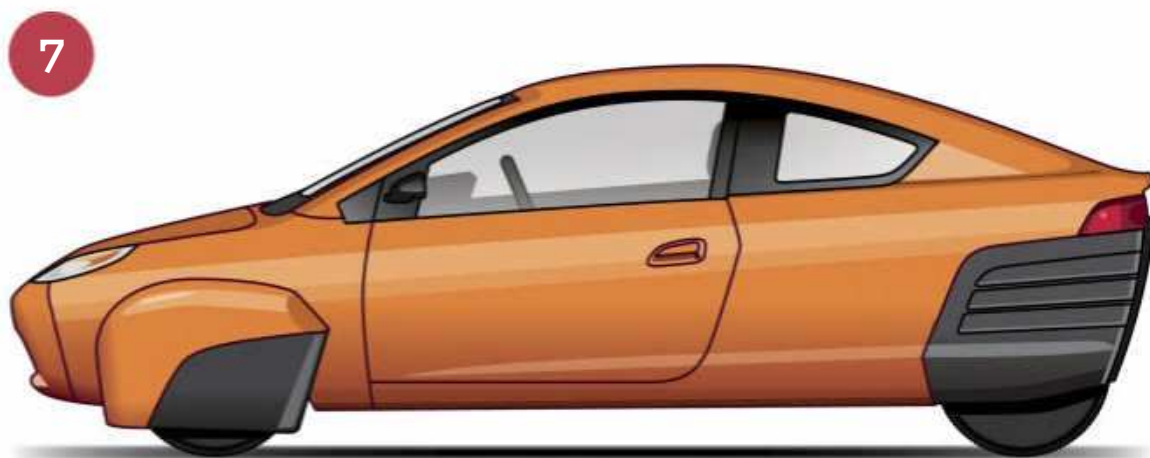
driving. The Indian-built REVAi (or G-Wiz as you may know it) was the world's most popular electric car until 2009 - although it was classified as a heavy quad bike in Europe. The Smart FourTwo... is a thing.

With the exception of the Fiat 500, none of the cars below were hugely popular. Tiny cars suck. So why do companies like Elio (no.7) keep trying? Because the tiny car makes sense on paper. Most commuters are alone in a giant box. Why use all that petrol? Why struggle with parking? Why have so much of your property taken up by a 1.5 tonne lump of steel most of the time when you're not driving?

Because cars aren't utilitarian, is why.

Cars are a culturally complex thing. We Aussies will suffer all kinds of inconvenience to have what is, for each of us, our dream car. Still, in other parts of the world, tiny cars can exist because petrol prices and the narrow, twisting streets are less accommodating. Also the tax. Don't forget about the tax.

▶ **Tractor Trailer**
A 3.1-metre-tall
Volvo VNL 760,
for scale



5/ 2012 Renault Twizy

The Twizy is what the REVAi should have been. Driver and passenger sit piggyback along the center. The entire steel vehicle structure could protect the occupants in an accident.

LENGTH: 2.3 metres

6/ 2001 REVAi (G-Wiz)

The REVAi was the best-selling electric car for nearly a decade. However, early models lacked safety features like a reinforced chassis and failed crash tests at as slow as 40 km/h.

LENGTH: 2.5 metres

7/ Now/future: Elio

A US-based startup has plans for its new three-wheeled, US\$7,450, single-seat commuter car: The company claims 2.8 l/100km from its three-cylinder engine.

LENGTH: 4.0 metres (!)

8/ 1962 Peel P50

Certified by Guinness as the smallest production car, the P50 had one rear wheel and no reverse. To back up, drivers pulled the 58-kilogram jalopy by a handle on its derrière.

LENGTH: 1.3 metres



BEST OF: The Pill Cycle

Like cutting off your ear to distract from the pain in your leg.

[When I sat down this month to write about all the amazing scientific tests I've been a part of since I ballsed up that sweet gig with Eier Labs, I instead got a headache. This reminded me that codeine is now prescription-only in Australia, and that made my headache worse. I went down to the chemist anyway and noted with interest that the stuff in the codeine pills that really messed up your liver - ie the ibuprofen or paracetamol - was now cheaper than ever and available together in a single pill for double the hit. Which reminded me of the following incident from 2014...]

NOW YOU'RE GOING TO LOOK AT ME WITH YOUR not-addicted-to-OTC-painkillers face and say I should have known better than to take those pills the man in the disused parking lot gave me. But honestly, how else could I have made \$125 by just swallowing something?

Anyway, a couple of weeks ago *[actually it was back in 2014, how time flies - Ed]* a post on a forum caught my eye because it said "male/female pairs required, big \$\$\$". I assumed the post meant human pairs, which is not always a safe assumption, but this time it was.

All I had to do, it said, was bring a woman to a city location and be prepared to test something medical. Not just on the woman, on myself as well, a follow-up post hastened to add. There was also a follow-up post to the follow-up post about how the woman couldn't be under any kind of duress or anything. Then there was a final post that said after taking legal advice they'd decided not to do the tests after all, and the whole thing was cancelled. However, there were a bunch of coded phrases and particular usage of punctuation that told me this was just a smokescreen, and really the test was still on, but it would be all off the books, no insurance, and all knowledge would be disavowed etc. What the hell I thought, it gave me a chance to speak to Atalanta.

Several short bus rides later and I was at a place I vaguely remembered where her friend who I didn't get along with lived, and an hour after that I'd convinced the friend to tell me where Atalanta was, and to cut a long story short, at dusk the pair of us turned up at a bone-white demountable in a disused parking lot.

"Money up front!" Atalanta shouted at the man in the grubby white coat who peered at us through the demountable's mesh door. Money up front, I thought. There's an idea. Why didn't I ever think of that?

A bunch of currency sproinged through a ragged gap in the mesh, followed by two bottles of pills.

"Take 'em!" said the man. "Write your reactions down on something and get it back to me somehow." He slammed some kind of inner door.

"Heh," I said. "This must be the only time someone got PAID to take a bottle of pills from a guy in a disused parking lot." There was a pause. "Instead of us having to pay him, yeah? Like... like we were buying drugs?"

Atalanta just glared at me and stalked away. So I shrugged and took a couple of pills.

Turns out the guy and his demountable were actually government agents of some kind and the pills were a new pain-reliever nicknamed Prism - the real name was just an acronym with -nyl on the end - designed to get all the oxy-heads off oxycontin. Which is ironic because oxycontin, as everyone knows, is a government scheme to get all the cough-syrup heads off codeine. Which is, as well documented, the poor man's heroin. Which is in turn the rich criminal's way to make more money off morphine. Point is it all metabolises into the same stuff. Well, not really. But that's not important.

What is important is that the pills the guy gave me and Atalanta were powerfully addictive. Turns out their main function is in fact to get the user addicted and any incidental pain relief or euphoria is a side-effect. Pretty soon, the effect of NOT taking the pills is so intensely adverse that taking them feels really awesome even though, technically, they don't do anything.

See, this is how big pharma and the government works. Treat the symptom, not the disease. And if there is no disease, induce more symptoms and treat those.

But I broke the cycle, yes I did. Even though every time the bottle of pills ran out a new bottle appeared mysteriously next to the weird bundle of wires that stuck out of my, I thought, disconnected landline. I threw the eighteenth bottle right in the bin. Then I fished it out, but the NINETEENTH bottle, I flushed those.

Then I went down to the chemist and pretended I'd never used Nurofen Plus before, and I went outside and gobbled all 30 at once. The codeine took the edge off my Prism withdrawal while the ibuprofen took the lining off my stomach. *[Note medications like Nurofen Plus are now prescription only. This is a small part of why. - Ed]*

So then I was pretty much addicted to codeine again which was a thing I hadn't done since uni. I recalled, dimly, that pot used to help me break the codeine addiction but these days I had absolutely no idea where to get pot. I looked at Aristides but all he was addicted to was licking his own particulars.

Then Atalanta knocked on my door. "I'm not visiting you," she said, looking at the floor. "I just wondered how you were getting along with your sugar pills."

I made one of those sort of faces.

"Yeah," she said. "Didn't you take yours to a lab somewhere? I always take the weird pills to a lab. Mine were sugar. Were yours sugar?" She looked up, saw the dark circles around my eyes and my flat full of empty pill bottles and punched-out blister-packs of Nurofen Plus. "I guess not," she said. Then she saw Aristides. "Oh! You didn't tell me you had a cat!"

So the sweats and the constipation turned out to be worth it. More or less.

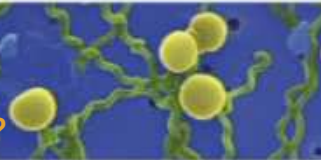


BY
SUBJECT
ZERO

"Didn't you take yours to a lab somewhere? I always take the weird pills to a lab. Mine were sugar. Were yours sugar?" She looked up, saw the dark circles around my eyes. "I guess not," she said.

BRAIN KILLERS

Are you smart? Or is it just a fluke?



Hydrogen vs Batteries

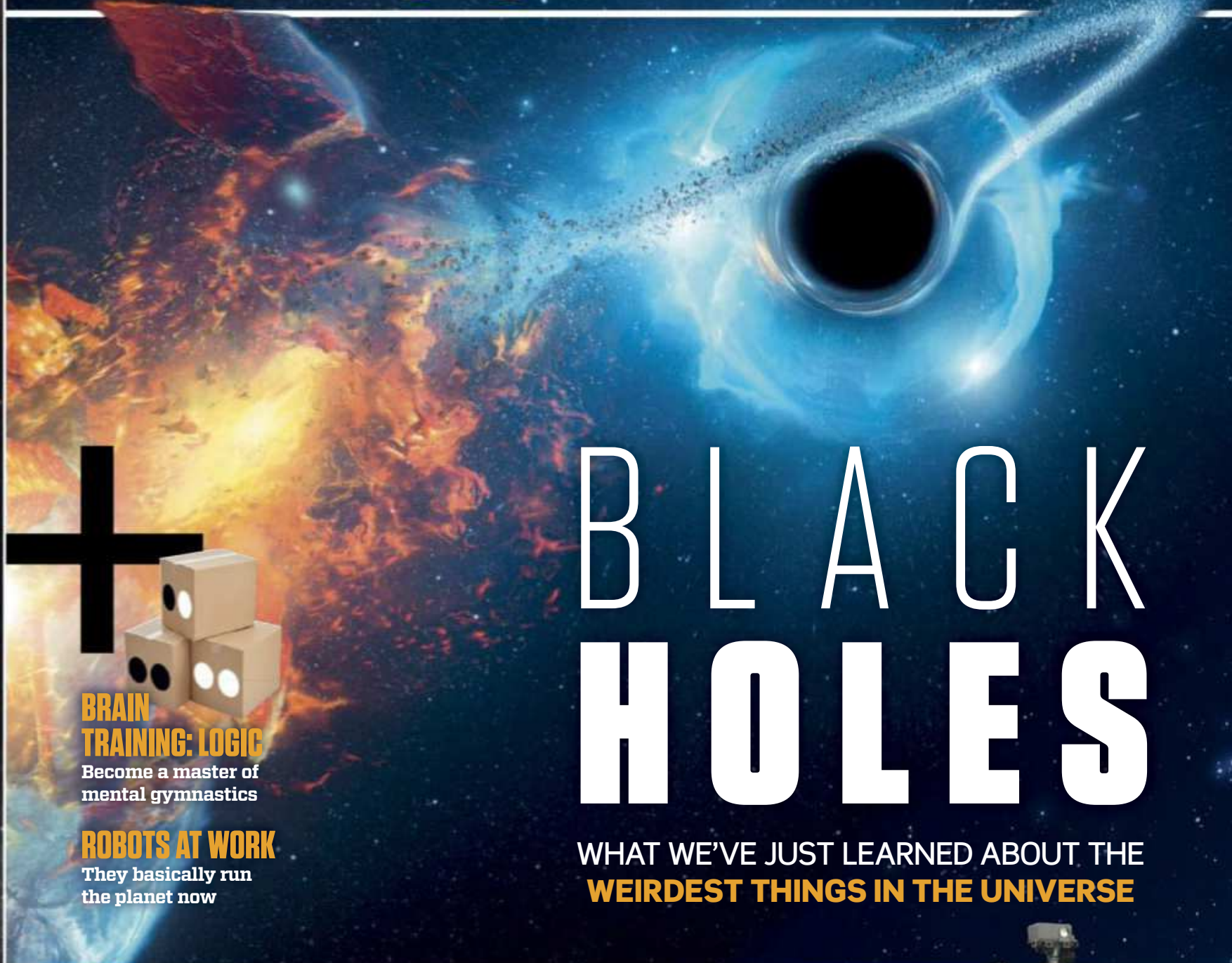
The ultimate electric-car showdown



AUSTRALIAN

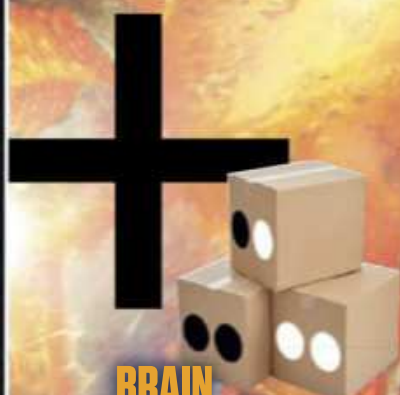
SCIENCE

ILLUSTRATED



BLACK HOLES

WHAT WE'VE JUST LEARNED ABOUT THE WEIRDEST THINGS IN THE UNIVERSE



BRAIN TRAINING: LOGIC

Become a master of mental gymnastics

ROBOTS AT WORK

They basically run the planet now



9 771836 517000

61

ISSUE #61 \$9.99 NZ \$10.99
SCIENCEILLUSTRATED.COM.AU

> MYSTERY ANIMALS

There are plenty of (undiscovered) fish in the sea



> CARS ON MARS

The full lineup of future rovers



SCIENCE
ILLUSTRATED

ON SALE NOW

at your newsagent or on subscription in print or digital at mymagazines.com.au

TRAILER

Next Issue!

POPSCI#118, OCTOBER 2018, ON SALE 27 SEPTEMBER 2018

SAND

You probably know sand is silicon dioxide, and that silicon is what microchips are made out of. But sand plays an even bigger role than that, when it comes to the foundations of our technology. So it's no wonder you can make decent money in 2018, hiring yourself out as an arenophile...

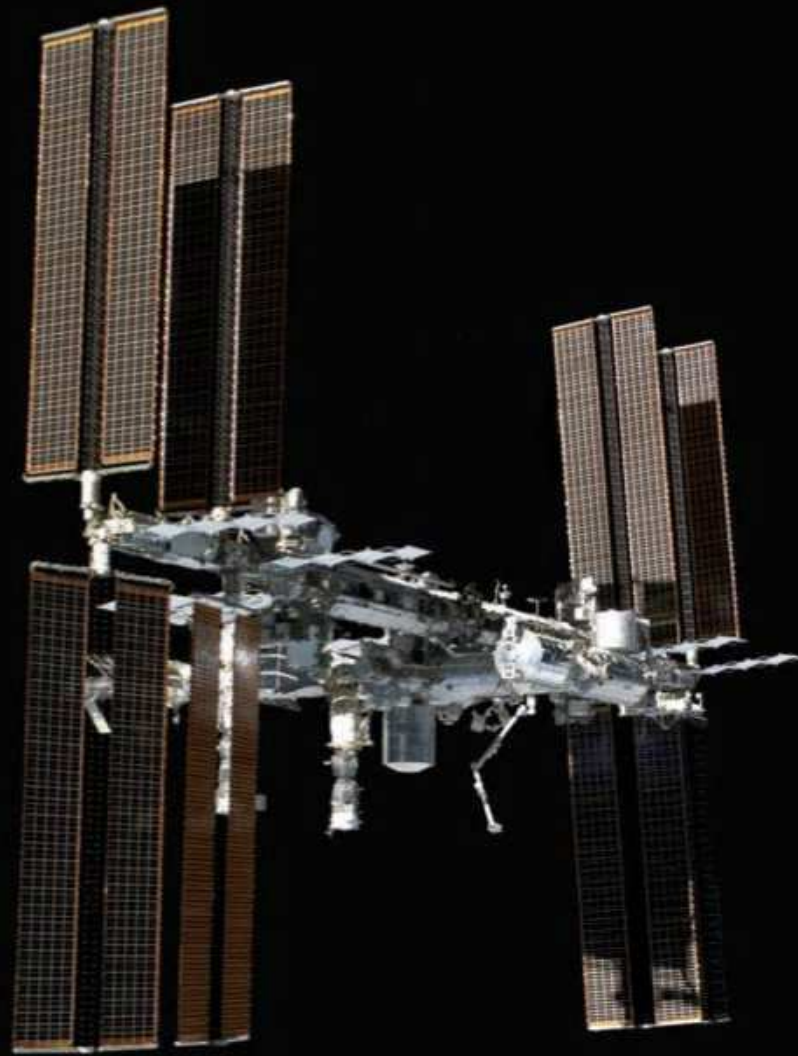
PLUS**Are tablets still a thing?**

Can termites help us build arcologies?

How bug poo makes bread better

The uncertain future of your TV

+AND MUCH MORE!



THE SKY IS NO LONGER THE LIMIT.

The screens of the Future are available today!

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

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

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

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



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



screeninnovations.com/SPACE