Bloomberg Businessweek

June 10, 2019

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◀ A technician working with gene therapy cultures at the St. Jude manufacturing facility in Memphis

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THE SOONER THAN YOU THINK ISSUE

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212 617-8120
Ad Sales
212 617-2900
731 Lexington Ave.,
New York, NY 10022
Email
bwreader
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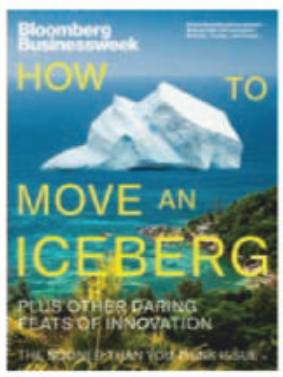

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● Shares of Google parent Alphabet, Amazon.com, and Facebook slumped as top U.S. antitrust officials and lawmakers prepare to investigate their business practices and whether digital platform companies are using their market power to hurt competition. ▷ 38

● Venezuela defaulted on a gold swap agreement with Deutsche Bank valued at

$750m

according to two people with direct knowledge of the matter.

● The Arkansas River continued flooding as U.S. farmers contended with one of the wettest planting seasons ever, compounding their woes from the trade war. This was the scene in Pine Bluff, Ark., on June 4.

● Neil Woodford, a star fund manager in the U.K., froze redemptions in his flagship LF Woodford Equity Income Fund after assets tumbled. The move leaves about

£3.8b

($4.8 billion) trapped in the fund while Woodford works to increase its liquidity.

● Merger Monday, June 3, saw a total of $40 billion in deals announced.

They included Blackstone's $18.7 billion bet on warehouses owned by Singapore's GLP; Infineon Technologies' $9.4 billion deal to buy Cypress Semiconductor; and JPMorgan's $2.78 billion purchase of El Paso Electric.

● Boeing's troubled 737 line hit another snag. After the company notified the Federal Aviation Administration that some wing components are prone to cracking, the FAA told airlines to replace the parts within 10 days. The 737 Max, the latest variant of Boeing's best-selling model, has been grounded since mid-March following two deadly crashes.

● Federal Reserve Chair

Jerome Powell signaled that the first rate cut since 2008 may be in the cards, saying he's keeping a close eye on signs that disputes between the U.S. and its trading partners are denting the outlook for the world's largest economy.

● "I would have sued, but that's OK. I would have sued and settled, maybe, but you never know. She's probably a better negotiator than I am."

At a press conference in London with U.K. Prime Minister Theresa May, President Trump discussed his advice that the government sue the European Union to get a better Brexit deal. May said she decided to negotiate rather than litigate.

● China issued a travel advisory to the U.S. through the end of the year, warning citizens of frequent recent shootings, robbery, and theft.

Tiffany said sales to Chinese tourists have deteriorated in recent months, with the country's visitors to the U.S. spending 25% less.

● Apple pushed into a new pricing stratosphere with an updated Mac Pro desktop. It can set buyers back $12,000 if they opt for a package consisting of the computer, a monitor, and a screen stand that alone costs $999.

● Algeria scrapped a July 4 presidential vote after the country's constitutional council cited a lack of candidates.

● Volkswagen said it's pushing ahead with an IPO of its Traton heavy truck division. It will list in Frankfurt and Stockholm.

● The *MSC Opera* crashed into a smaller boat in Venice, Italy, renewing calls to ban cruise ships from the Giudecca Canal.

● An Edinburgh family revealed it owned a missing piece of the medieval Lewis chessmen. It may be worth $1.25 million.

ARKANSAS RIVER: DRONEBASE/AP PHOTO. POWELL: TAYLOR GLASCOCK/BLOOMBERG. MAC PRO: COURTESY APPLE

▶ China's Trade in the Balance

Beijing releases its international trade balance on June 10, providing insight into how the escalating trade war with the U.S. and slowing domestic demand are affecting Asia's biggest economy. Economists still see the risk of recession as low in the next 12 months.

▶ The Bank of Russia announces its key rate on June 14. The bank has said a cut is possible after two surprise hikes last year helped control inflation.

▶ Tesla holds its annual general meeting on June 11. The stock has lost about 40% in value this year as demand slides for its cars and its debt load takes a toll.

▶ Inditex, parent of the Zara fashion chain, reports first-quarter earnings on June 12. Retailers are struggling to emerge from a prolonged shopping malaise.

▶ The Swiss National Bank reveals its rate decision on June 13. Switzerland has the world's lowest interest rates, and economists don't see an increase anytime soon.

▶ The SuperReturn private equity conference convenes in Boston on June 10-11 to discuss investment trends in the energy sector.

▶ Entertainment memorabilia, including a Beatles-era guitar played by George Harrison, go on auction at Bonhams in London on June 12.

■ BLOOMBERG OPINION

End the Qatar Embargo

● Constraining Iran will require Arab unity and resolve. The U.S. must reconcile the feuding Saudis and Qataris

It's now almost two years since a coalition of Arab countries imposed a misguided economic embargo on Qatar. The group—Bahrain, Egypt, Saudi Arabia, and the United Arab Emirates—said it was punishing the gas-rich emirate for its ties with Iran and the Muslim Brotherhood, but it's widely seen as part of a larger competition for preeminence in Arab affairs.

Ending it should be a priority for President Trump. Of the Arab world's many divisions, none is more damaging to U.S. interests. The Saudi-led group's objectives haven't been met. On the contrary, denied food supplies from—and air routes over—the sanctioning states, Qatar has grown more dependent on Iran, while its economy has easily weathered the embargo.

Meanwhile, the dispute is putting U.S. allies Kuwait and Oman in an awkward position. Both have strong relationships with Qatar and maintain wary ties with Iran, which is close enough to menace their security. But neither can afford to antagonize Saudi Arabia, the region's most powerful nation.

More important for Trump, the impasse is now obstructing his broader Middle East policy, in particular his maximum-pressure campaign against Iran. Effectively confronting Iran and its proxies would require the Arab states to unify behind the U.S. Instead, America finds itself in the middle of an internecine Arab conflict: While Saudi Arabia is its most important ally in the region, Qatar hosts the giant Al Udeid Air Base, forward headquarters of U.S. Central Command, which is essential to keeping pressure on Iran. The rift has also handicapped Trump's efforts to create an "Arab NATO" to guard against Iran's mischief-making.

Resolving the quarrel is therefore imperative, and the U.S. would be the natural mediator. Unfortunately, after some early, desultory passes, the Trump administration has largely abandoned its efforts to intervene. Anthony Zinni, the special envoy assigned the role, stepped down early this year, having failed to get much traction in Doha and Tehran, or much support in Washington. He hasn't been replaced.

Trump should now redouble the effort. He should state—if necessary, directly to the Qatari emir and the Saudi king—that ending the rift is a priority. He should appoint an envoy to take Zinni's place. And he should prevail on the sanctioning nations to drop the maximalist and deliberately offensive list of demands they've made of Qatar. The Qataris, for their part, need to offer convincing reassurances they won't allow relations with Iran to threaten their neighbors.

Arab unity and resolve is crucial to constraining Iran's malign activities, which the U.S. has rightly identified as the most pressing concern in the Middle East. Saudi Arabia knows this: King Salman Abdulaziz rang the right alarm bells at emergency meetings of Arab and Muslim nations in Mecca at the end of May. There can hardly be a better moment for the U.S. to press for an end to lesser squabbles. Ⓑ

Written by the Bloomberg Opinion editorial board

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Open for Business

● Trump, unlike his predecessors, hasn't started wars, but he has sown disruption by weaponizing the U.S. economy

● By Ben Holland

Donald Trump has become quite comfortable deploying the U.S. economy both as lure and as threat. In London on a state visit, he tweeted that the U.K. could expect a "big Trade Deal" with the U.S. once it "gets rid of the shackles" to the European Union. In the previous week, a short one in Washington because of the Memorial Day holiday, he still found time to escalate hostilities in America's economic war with just about everyone.

The countries of the EU had already been in that firing line. On May 29 news broke that Trump had threatened them with sanctions on the grounds that they're attempting—not very successfully—to trade with Iran, as they are entitled to do under international law. The next day, Trump warned Mexico that he would impose tariffs on all its exports to the U.S. and steadily ratchet them up until Mexico shuts down the northward flow of migrants. On June 1, he removed India from a list of developing countries that receive special trade privileges because it hasn't done enough to open its markets to U.S. companies. The *New York Times* reported on June 2 that Trump had considered tariffs on Australian aluminum until the Pentagon objected.

The salvos were sideshows to what's becoming the main event in the second half of Trump's term: his campaign to rewrite the rules by which the U.S. trades with China. But all of Trump's tariffs, sanctions, and trade policies show how the president has broadened his definition of national security to include the U.S. economy, which he's turned into a weapon to use against allies as well as his main strategic rival.

Tariffs and sanctions aren't the same thing, of course. One is a trade instrument, intended to calibrate the interests of producers and consumers, and imposed by most countries on friends as well as enemies. The other is openly punitive, a form of international criminal justice. But they work in similar ways for Trump, who's using them in tandem on an unprecedented scale, because they both leverage the global desire to do business in the U.S., the world's richest consumer market.

America has enjoyed that status for generations, a key element of its leadership. Until recently, access has mostly been dangled like an inviting carrot. Trump wields it like a cudgel. He thinks it was made available too easily in the past, and the U.S. has benefited less than others—becoming, as he tweeted on June 1, "the 'Piggy Bank' Nation that foreign countries have been robbing and deceiving for years."

Tariffs make access to that market more expensive, though how the bill gets shared is an open question. Overseas manufacturers, import-export companies, domestic retailers, and consumers could all shoulder some of the cost, depending on the product and the market for it. In a May 20 open letter to the president, 173 shoemakers, including hugely profitable giants such as Nike Inc. and Adidas AG, protested the footwear tariffs, saying, "As an industry that faces a $3 billion duty bill every year, we can assure you that any increase in the cost of importing shoes has a direct impact on the American footwear consumer."

Sanctions often mean you can't get access to the U.S. market at all. Trump is ready to deploy both tariffs and sanctions even when his goals aren't really economic. They're becoming the essential tools of "America First," applied from Mexico to Venezuela, from Turkey to Iran—as much about politics and diplomacy as trade and finance.

That's a high-risk approach, says Jeffrey Sachs, professor of economics at Columbia University. "Open systems can become closed or divided systems," he says. "It happened after the chaos of World War I and the Great Depression." An open world economy is a vulnerable one, he says, and "if the U.S. abandons this system, others will too."

Sometimes Trump's economic moves are reminiscent of military tactics, according to Ben Emons, a managing director at research firm Medley Global Advisors in New York. The president is always looking for the element of surprise, with dawn raids via Twitter. He'll try to compel enemies to behave the way he wants them to or paralyze their political leadership—methods known in military theory as "coercion" and "decapitation." In the latest move against Mexico, the tariffs were a workaround. "He wants to shut down the border," Emons says. "They wouldn't let him. So he figured out a different way of doing it."

Trump's long-game strategy, Emons says, is based on the belief that "ultimately our demand for goods is so large that nobody can go around the U.S." In the immediate future, that's probably true, he says, and investors are betting that way. "Our stock market is outperforming the rest of the world. Markets feel the economic impact will be larger in the case of Europe or China than in the case of the U.S."

But in the longer run, it may not be. Two or more can play at the president's game. China has drawn up its own ▶

ILLUSTRATION BY JACI KESSLER LUBLINER

◀ blacklist of U.S. companies in response to Trump's ban on Huawei Technologies Co. It "could become more reliant on trade with other countries, not the U.S.," Emons says, "and more dynamic at home." Apart from tariffs and sanctions, the panoply of tools at the disposal of both countries—indeed all countries—is broad: investment restrictions, export controls, consumer boycotts, blacklists, antitrust actions, even criminal indictments. China, which successfully used the threat of suppressing tourism against South Korea, has hinted at using similar tactics against the U.S.

As disruptive as his economic onslaughts have been, Trump clearly prefers this kind of fight to the tanks-and-troops conflicts (sometimes called "kinetic") that the U.S. has been engaged in for most of the last half century as it worked its way toward global hegemony and the role of world cop. Almost all his recent predecessors went to war. Even Barack Obama, winner of the Nobel Peace Prize, bombed Libya into regime change. Trump hasn't entirely neglected that tradition, ordering two missile strikes on Syria. He's plowing more money into the Pentagon, and he'll cheerfully talk about raining fire and fury on other nations—even, in Iran's case, putting an "end" to them. But he's also been trying, with limited effect so far, to pull troops out of Syria and Afghanistan. He campaigned against foreign military adventures, and most of his overseas counterparts are still betting that he means it. In Europe, for example, leaders didn't much enjoy a visit in May by Trump's secretary of state. Mike Pompeo was trying to get them on board for the U.S.'s "maximum pressure" campaign against Iran. The backdrop was ominous, with headlines about U.S. aircraft carriers being dispatched to the Persian Gulf and echoes of the buildup to the invasion of Iraq in 2003. The Europeans, however, consoled themselves with the thought that the president, the decider, didn't really want to start a war.

Trump says so, too. But he hasn't shied away from exerting economic power over Europe in a way that isn't consoling at all. The Europeans want to keep the 2015 nuclear agreement with Iran alive after the U.S. pulled out a year ago. They've been trying to set up a special vehicle that will enable trade to flow without any dollars involved—essentially barter—so that it won't trigger sanctions. But the Trump administration has signaled anyone associated with it could be barred from the U.S. financial system anyway.

The threat of U.S. sanctions, enforced in a way that means they effectively have global jurisdiction, dwarfs any incentives Europe's politicians can offer their own companies to engage with Iran. Brian Hook, U.S. special envoy for Iran, spelled it out on May 30: "If a corporation is given a choice between doing business in the U.S. and doing business in Iran, it's going to choose the U.S. every single time."

Also causing vexation in Europe are existing and potential curbs on trade with Russia, a much more important partner of the EU than Iran—and a competitor for American natural gas, recently rebranded as "molecules of U.S. freedom" by the Department of Energy. The biggest market Moscow and Washington are fighting over is Germany. The Trump administration has warned it's ready to impose sanctions that could hobble a proposed $11 billion pipeline to carry gas there from Russia. But it dialed back the threat this year after Germany announced it will build two terminals that could receive U.S. tankers. The U.S. "strongly supports" the idea, Deputy Energy Secretary Dan Brouillette said during a visit to Berlin in February. As for sanctions, he said, "I cannot today tell you that the U.S. has specific plans."

Maybe the best example of Trump's dual use of sanctions and tariffs came when Turkey got whacked by both last summer. Its offense had nothing to do with trade. President Recep Tayyip Erdogan, when he was rounding up tens of thousands of alleged conspirators after a 2016 failed coup attempt against him, made the mistake of detaining an American pastor in his net. Trump and his evangelical allies were infuriated. On Aug. 1, 2018, the U.S. president slapped sanctions on two Turkish cabinet ministers. Nine days later, he unloaded the other barrel. "Our relations with Turkey are not good at this time," Trump observed demurely, in a tweet that was at least somewhat self-fulfilling because it also doubled tariffs on Turkish exports of steel and aluminum, sending Istanbul's financial markets into a once-in-a-generation nosedive. The pastor was released, and some of the penalties have been lifted. But others may soon be on the way, as NATO member Turkey prepares to buy a Russian missile defense system, a sanctionable offense in U.S. eyes.

What's striking about all these broadsides is that, like military commands, they're the work of a moment. There's no need to cajole or threaten legislators to build a coalition. And the effect is instant, too, which is one reason the process has become disturbing for many investors, Emons says. "You get on your phone at 3 a.m., and there's the announcement, and the consequences are very large," he says. "It would be different if the market wasn't listening to Trump or taking him seriously. But because he can actually do it, and he did do it, the markets are like: 'We believe you!' "

The strategy is a stark contrast with the more than two years it took to negotiate the Iran deal under Obama—or the Nafta overhaul, which, as a frustrated Trump learned in the first half of his term, has turned into a marathon that's not done yet.

In the longer term, the repeated use of such high-impact economic weaponry—and its scattershot targeting—may have different effects. The Trump administration says it's focused on China, which is closing in on the U.S. as the world's biggest economy, and by some measures has already surpassed it. Since China isn't shy about flexing its own economic muscle, and many countries share Trump's suspicion of its trade practices, there's potential support for a firm approach—but it's undermined when those could-be allies are under the same kind of pressure themselves, and have no idea what to expect next. Trump's weaponization of the U.S. economy, and his creation of a rolling emergency that's invoked to justify each move, is likely to "create real problems down the road," says Sachs. "It's a very bizarre way for a $20 trillion economy, and a supposed democracy, to operate." Ⓑ —*With Ladane Nasseri*

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CAN THIS 10-YEAR-OLD SAVE THE OLYM

● Organizers bet that adding skateboarding whizzes like Sky Brown will lure younger viewers

The Olympic Games have long been among the world's premier marketing events, with hundreds of millions of people worldwide tuning in to watch the human drama as athletes from more than 200 nations compete for the gold. Yet this decidedly mass-market broadcast event has been losing younger viewers, who increasingly spend time on social media and online entertainment. So organizers of the 2020 Tokyo Olympics are counting on skateboarding to help bring back millennials as fans, and it may be a 10-year-old girl who steals the show.

With key measures of television audiences down from 2008 levels and interest among the key youth demographic waning—viewership among 18- to 35-year-olds fell at least 25% for the 2016 Rio Games from four years earlier—organizers of the 2020 Games have added skateboarding as a medal event for the first time. Youth-friendly surfing and sport climbing will join the games as well.

"Young people still have an incredible interest in the Olympic Games," says International Olympic Committee Sports Director Kit McConnell. "But the way they are consuming the Olympic Games—the type of content they are watching and the ways and the platforms on which they are watching—are fundamentally changing."

Enter Sky Brown, the Anglo-Japanese skateboarder who was named in March to the British Olympic squad. The elementary schooler has already drawn millions of views to internet videos of her fearless, technically advanced skating—an alluring statistic for an event that's looking to persuade online fans to tune into revenue-earning TV network coverage. "With skateboarding becoming an Olympic sport I think it's super exciting," says Brown, who will turn 11 in July. "It's going to be really cool with people doing super-gnarly tricks, and really fun to watch."

Part of the challenge is how to present

BROWN: PHOTOGRAPH BY EMILY SHUR FOR BLOOMBERG BUSINESSWEEK; WHITE: RYAN MILLER/GETTY IMAGES

Edited by
James E. Ellis

◀ Brown goes through her moves at a skate park in Oceanside, Calif.

skateboarding and its rule-breaking ethos within the sporting prestige of the centuries-old Olympiad. Take uniforms. While companies have sponsored skate teams in extreme sports competitions such as ESPN's X-Games, Olympic-style team uniforms haven't been part of boarding.

"It is what it is," says Gary Ream, chairman of the World Skate Skateboarding Commission, which is in charge of producing the street and park terrain events at the Tokyo Games. He won't say what the standards will be for competitors but acknowledges that there will be rules regarding what can be worn. "They will be wearing something showing their team and country," he says.

The marketing potential of skateboarding hasn't gone unnoticed by sports apparel giants Nike Inc. and Adidas AG, which are looking to capitalize on the sport's youthful edge and broaden the exposure they've gotten by sponsoring the U.S. and U.K. Olympic teams, respectively.

At the Tokyo Games, the Nike and Adidas logos may well predominate at the Aomi Urban Sports Park, a special venue set up for skateboarding and BMX bicycling. Adidas declined to comment, and Nike didn't respond to emails seeking a response.

Not so for niche skater brands. California-based Vans, now a unit of VF Corp., built a reputation as a supplier of shoes and gear for skateboarders that helped turn it into a multibillion-dollar business. The brand even sponsors a professional tour. But Vans and others like it will struggle to be seen at the Tokyo Games as the Olympic committee works hard to prevent giving exposure to nonsponsoring brands. Ream expects such branding restrictions to apply to individual skateboarders, too.

The inclusion of skateboarding has also raised concerns about drugs, with the U.S. Anti-Doping Agency testing skaters in anticipation of the games. At least one competitor, Cory Scott Juneau, has accepted a six-month suspension after testing positive for the main active ingredient in marijuana, the U.S. agency said in January. "The strength of skateboarding is that it has been a very protected environment, created for kids by kids who have expressed their desires through the sport with no adult intervention," Ream says. "With the Olympics, you can look at this as now we are entering the adult world."

There's already some very adult money in skateboarding. American Tony Hawk, considered the sport's richest star, has a net worth reported to be as high as $140 million by Money Inc., which featured the 20 richest skateboarders on its website last year. The next wealthiest on the list is Jamie Thomas, also from the U.S., with $50 million.

Hawk and Thomas made most of that money by selling their own branded gear and, in Hawk's case, video games. Managing their own businesses sets skateboarders apart from many other athletes, who typically take paychecks for representing big global sports brands. Skateboarders "have always figured out how to be on the edge with video and music to promote themselves," Ream says. "That's how this sport has grown from its earliest days, with skaters themselves creating their own media."

Skateboarding competitions involve doing a series of so-called tricks, which can be ideal for short videos that fans can spread fast on social media, says Shawn McBride, executive vice president of sports at Ketchum, a communications and branding house. "That's been really critical for engagement, and it's going to continue to be critical," he says.

McBride says the Olympics is moving especially quickly to increase TV viewer engagement, marketing speak for luring consumers to interact by sharing video clips or personal messages related ▶

● White

◀ Brown, also an avid surfer, practices before school

● 2016 Rio Olympic events

On the most-watched day

Canoeing
Diving
Equestrian
Fencing
Gymnastics
Judo
Shooting
Swimming
Weightlifting

On the least-watched day

Athletics
Badminton
Basketball
Boxing
Canoeing
Cycling
Diving
Golf
Handball
Pentathlon
Rhythmic gymnastics
Soccer
Taekwondo
Triathlon
Water polo
Wrestling

◀ to an event. Skateboarding offers "snackable" moments, short clips of stunts that grab the attention of users scrolling through social media. These viral videos can help big-spending companies such as NBCUniversal—its parent, Comcast Corp., paid $12 billion for exclusive U.S. broadcast rights to the Olympics through 2032—because the clips can also draw viewers to full-length telecasts and give advertisers more exposure.

At the 2016 Games in Rio, NBC was forced to give advertisers "make goods," or free commercial time, after providing separate guarantees for TV and online audiences and then coming up short on television viewers. Such promises become daunting as more consumers watch programs both ways. One way NBCUniversal has responded to the pressure is by changing how it counts viewers to include those who watch online in a total it uses to price advertising. Still, the focus on pulling in younger viewers, including those online, is intense.

"We are maniacally focused on the generations to come," says Jenny Storms, chief marketing officer for NBC Sports Group. "The numbers prove that they are engaged and part of the Olympics, and what we have to ensure is that we are meeting these younger consumers on their platforms of choice."

The IOC's earlier attempt to capture young viewers by adding snowboarding in 1998 drew scorn from some of the activity's purists, who insisted its culture was incompatible with a competition such as the Olympics. But snowboarding became one of the most popular Winter Games events. At Pyeongchang in 2018, a video of American snowboarder Shaun White winning an historic third gold medal on the half-pipe led online coverage of the games, with almost 1 million views on YouTube.

White, who also won gold as a skateboarder at X-Games 17 in 2011, says he's considering competing for a spot on the U.S. team for Tokyo 2020. The prospect that he could become one of the handful of athletes to win gold medals at both Winter and Summer Games could add to the buzz in Tokyo.

Yet it's Brown, who was born in Japan and has lived there, who's creating the most noise in the runup to the games. If the British team qualifies, she'll be 12 when she competes in Tokyo. "I am super excited about skating and surfing finally becoming an Olympic sport," says Brown, who currently lives in California and says she wakes at 5 a.m. so she can go surfing before school. "It makes me really happy to know that I'm inspiring people. It's just really cool to see more girls skating."

Organizers of the games are hoping viewers will agree. Yet even if skateboarding doesn't bring younger viewers back, it won't be the end of the Olympic Committee's search for street cred: The 2024 Olympics in Paris is considering adding a medal competition for break dancing. —*Dave McCombs and Marika Katanuma*

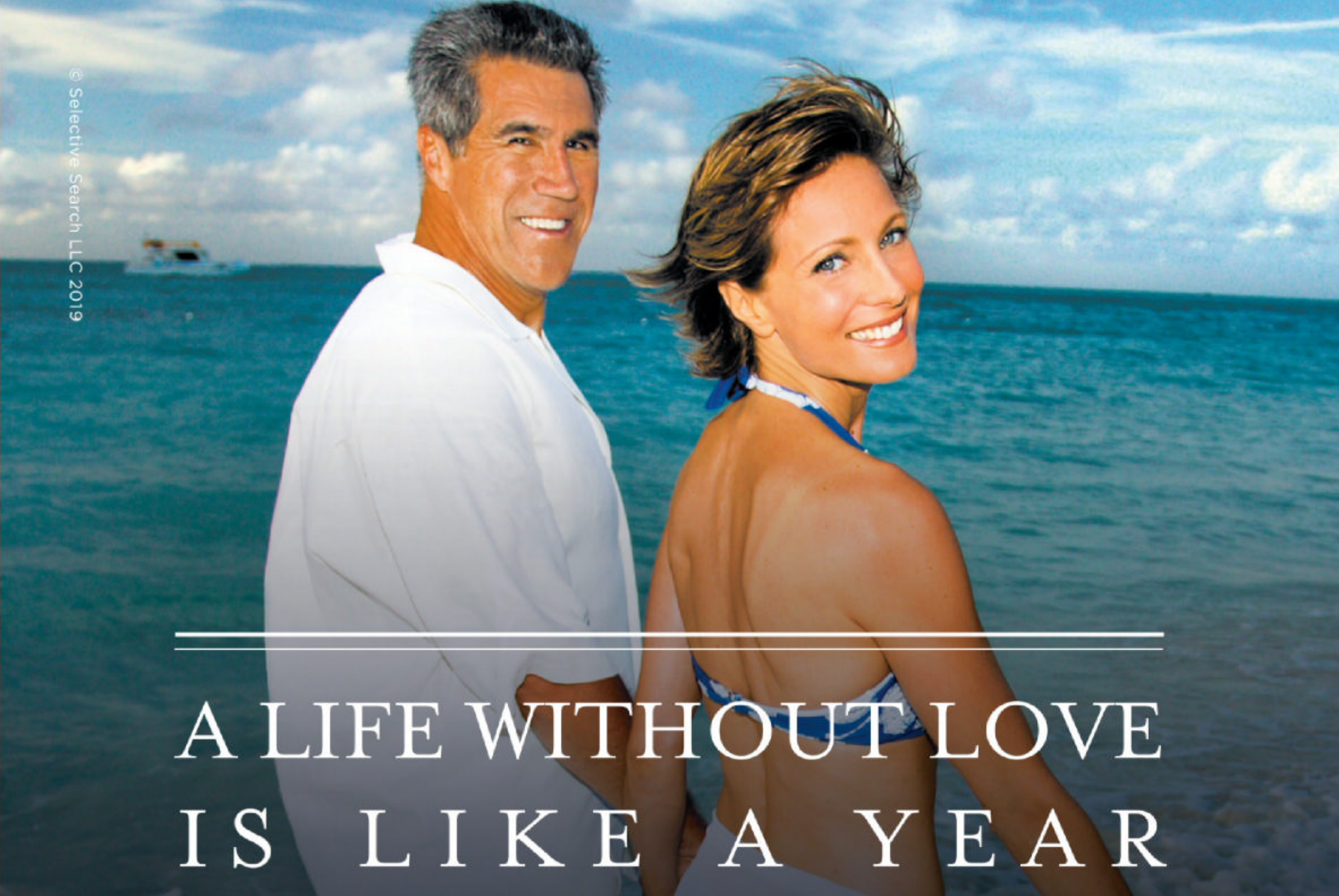
THE BOTTOM LINE Viewership for the 2016 Summer Olympics fell at least 25% among 18- to 35-year-olds from the previous games. So the Olympics will add youth-friendly sports, such as skateboarding.

ILLUSTRATION BY EVA CREMERS. BROWN: PHOTOGRAPH BY EMILY SHUR FOR BLOOMBERG BUSINESSWEEK. DATA: INTERNATIONAL OLYMPIC COMMITTEE

China's Discount Cancer Drugs

● Local companies are rolling out rivals to new Western tumor medicines—at a third of the price

Western companies last year began selling some of their hottest cancer drugs, called PD-1 inhibitors, with much fanfare in China. But rather than quickly conquering the mainland market, American drugmakers Merck & Co. and Bristol-Myers Squibb Co. have found themselves facing a surprising ▶



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◀ challenge: local competitors. Chinese companies are introducing patented cancer therapies in their home market based on PD-1 inhibitors, which use the body's immune system to fight tumors. They're doing it at far lower prices—sometimes a third of what U.S. drugmakers charge—which will likely give them a leg up at home. And their ambitions go far beyond the mainland, with several already preparing to sell their medicines in the U.S. and worldwide.

The push into PD-1 drugs marks one of the first forays by China's pharmaceutical industry into complex treatments. It's the coming of age for a local industry long focused on cheap generics and chemical ingredients, and it's being aided by Beijing's efforts to speed up drug approvals and channel more funding toward health care.

Developing a world-class pharmaceutical business is a priority for China's leaders. Beijing's Made in China 2025 plan identifies the drug industry as one of 10 sectors—along with aviation, electric vehicles, and advanced rail equipment—in which China will look for technological breakthroughs.

One way Chinese companies plan to elbow into the market is lower pricing. Shanghai Junshi Biosciences Co. began selling its drug, called Tuoyi in China, in December for 187,000 yuan ($27,105) for a year's dose for melanoma, a skin cancer. That's one-third the cost of using Merck's Keytruda in China for the same condition over the same period, according to data compiled by Guosen Securities Co. Junshi is conducting clinical trials to enter the U.S. market. (Merck does business as Merck Sharp & Dohme, or MSD, outside the U.S. and Canada.)

Chinese companies say their medicines are structurally different from what American companies offer. "We are very confident in our own patent around the world," says Wu Xiaobin, president of Beijing-based BeiGene, which has filed for approval for its PD-1 drug in China while it continues its international clinical trials, including in the U.S. "We have been well prepared on this because we've always planned to go global."

Jiangsu-based Innovent Biologics Inc., which also sells a PD-1 therapy in China that's cheaper than the two foreign brands, has a licensing agreement with Eli Lilly & Co. through which the U.S. pharma giant will also be responsible for clinical trials, further development work, and marketing the medicine overseas.

Other Chinese biotechnology companies are also preparing to enter local and overseas markets. Jiangsu Hengrui Medicine Co., one of China's biggest drugmakers, on May 31 said its PD-1 drug had received Chinese regulatory approval. "PD-1s are at the cutting edge of science and are transforming cancer care," says Brad Loncar, a biotech investor and chief executive officer at Loncar Investments in Lenexa, Kan. So the push by Chinese companies into these drugs won't just "transform care in China but also have global implications," he says.

China is new to developing innovative drugs, so managing their safety and efficacy remains a risk, says Zhang Jialin, an analyst with ICBC International. Chinese companies say their trials show their medicines are safe, and some are following up with larger studies.

First approved in the U.S. in 2014, PD-1 drugs have boosted survival rates for many patients. Although China sees about 4 million new cancer patients annually, PD-1 drugs are much less prevalent there. Such medicines will bring in only $170 million in Chinese sales in 2019, market researcher Frost & Sullivan estimates. Global sales for these therapies will climb to $78.9 billion by 2030, it says, with China projected to account for about a fifth of the total.

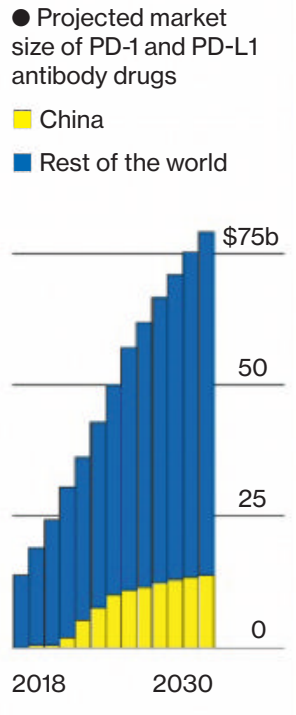
So far no PD-1 drug, domestic or imported, has made it onto China's public health insurance list, so patients would have to pay out of pocket. That's difficult in a country with a per capita disposable income of 28,228 yuan, or $4,090. Companies are willing to cut prices to get on the government reimbursement list, says Junshi CEO Li Ning.

The competition also suggests fresh challenges for foreign drug companies in China, the world's second-largest pharmaceutical market. Bristol-Myers's and Merck's PD-1 drugs are already far cheaper in China than in the U.S. *Global Oncology Express*, a trade publication affiliated with one of China's top oncology centers, calculated that a vial of Keytruda sells for 17,918 yuan in China, compared with 33,000 yuan for the same amount in the U.S. And both companies say they have special programs to offer the medicines at discounts for low-income patients in China.

In a statement, Bristol-Myers said joint efforts by local and foreign companies will help address patients' unmet needs in China. MSD says Keytruda, now the only PD-1 therapy approved in China for both melanoma and lung cancer, is well-positioned, partly because later entrants will face more hurdles.

Ronald Ede, Innovent's chief financial officer, says he's seen local drugmakers grab as much as 85% of the market for a generic drug or medical device from global rivals within only a few years. "This will happen in the PD-1 market as well, and it'll come faster," he says. —*Dong Lyu and Ludi Wang*

THE BOTTOM LINE Four million new cancer patients are diagnosed each year in China. That market growth is encouraging local drug companies to develop advanced cancer medicines.



Q&A

Cisco CEO Chuck Robbins

- Hired 1997; CEO since July 2015
- Previously worked at Bay Networks and Ascend Communications
- Graduated from University of North Carolina with a bachelor's in mathematics

Robbins appeared on *Businessweek Talks*, where he addressed how the trade war is affecting Cisco Systems Inc. and the competitive challenges facing the $49.3 billion tech equipment maker.

How has the trade war affected Cisco so far, and how are you managing the impact?

Because we have a globally distributed supply chain, we have the capacity to move things around on a regular basis. Our teams did such an amazing job optimizing our supply chain over the last eight months that they actually put us in a position where the latest 25% [tariff] really had a pretty nominal effect from a pricing perspective. My bigger worry is not the impact it will have on us at Cisco, but more on the macro and what it does to customers' overall sentiment.

How different will 5G be? What's the potential?

Think about where you are today and what you can do with your mobile device vs. what you could 15 years ago. This is no different. You're gonna see a steep change, and this one is probably exponentially better than what we felt over the last decade.

What kind of applications could we see?

With speeds of four, five, six, eight, 10 times [current levels], you're going to see more than my 18-year-old son putting his phone in the middle of a table and having eight of his friends around, playing real-time gaming because the phone is serving as a hotspot. We also should be able to deliver real-time health care into rural areas in ways that we haven't been able to. That's because we'll be getting [very high] speeds out into these environments over spectrum as opposed to having to go pull fiber and run terrestrial circuits. Hopefully, it will change the economics for our carriers on a global basis.

What's the biggest challenge facing Cisco?

The irony for us is that six years ago there were seminal threats that were believed to be fatal to our company. And what's turned out to be the case is that we've actually embraced many of those shifts and turned them into advantages. The transition to cloud that was viewed as being very negative has turned out to be very positive for us. As one of my engineering leaders says, "We moved the applications to the cloud, we didn't move the employees to the cloud." Our biggest challenge is prioritizing areas to invest in right now, which is a good place to be.

What do your customers say has changed the most in how they conduct their businesses?

Technology is no longer some optional cost center; it's now at the heart of the strategies that they're deploying, whether it's delivering citizen services in government or whether it's the way a bank interacts with its customers in the branch. But technology is in the middle of everything. So our customers don't say anymore, "Oh, it's a little tough, so I think I'm going to slow my spending here."

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2 TECHNOLOGY

The Privacy Hawk Who Took On Big Tech

Edited by
Dimitra Kessenides

● A California lawmaker's bill went after Amazon and its peers. They fought back

The push to confront the power of big technology companies recently reached an inflection point. Federal regulators have divided up antitrust responsibilities over Amazon, Apple, Facebook, and Google, and both Democrats and Republicans are opening congressional inquiries into allegedly anticompetitive behavior in the industry.

A preview of a challenge to the tech industry, at least through legislative action, has been playing out in California. The state has often served as a testing ground for policy ideas stuck in Washingtonian gridlock. Last summer it passed the California Consumer Privacy Act (CCPA), which gives residents the right to know how their data is being collected and shared and allows them to deny companies the right to sell it. The law is seen as a potential model for other states or for national rules. Since its passage, lobbying groups for the tech giants have backed several bills to shape the law in their favor.

One person attempting to stand in the way of the companies is Buffy Wicks, a freshman member of the California Assembly who sits on the Privacy and Consumer Protection Committee. Wicks has opposed industry-backed legislation and introduced her own bill to make the CCPA more restrictive. Separately, she promoted new rules to govern Amazon.com Inc.'s relationship with companies that sell their products on its platform. "I think we can push the envelope here in California, regardless of what happens in D.C.," she says. But Wicks's experience has also served as a reminder of how formidable the industry can be as a political opponent.

Elected in November, Wicks arrived in Sacramento just as business interests were pushing to liberalize the CCPA in various ways, from carving out special protections for companies that use targeted advertising to changing the definition of personal information. Consumer groups have been overwhelmed by what they see as an attempt to reverse the gains made with the original law, says Elizabeth Gettelman Galicia, vice president of Common Sense Kids Action, one of the groups pushing for stronger privacy laws. She says the groups had been "looking around for who we can turn to."

Wicks didn't paint herself as a tech skeptic during her campaign. After protesting the invasion of Iraq and Walmart Inc.'s low wages during the George W. Bush years, she joined Barack Obama's 2008 presidential bid and worked in the White House, organizing grassroots efforts. She went on to manage Rahm Emanuel's Chicago mayoral campaign. Working in Obama's orbit placed Wicks firmly in the pro-business wing of the Bay Area's Democratic circles. Her intraparty opponent for the 15th Assembly District—including Berkeley and parts of Oakland in the East Bay—made sure to raise the point during the campaign.

In Amazon, Wicks saw echoes of Walmart, another company with a reputation for being a brutal partner to its suppliers. Amazon's critics now argue that its real abuse of market power can be seen not in its relationship with customers, who are only too happy with their discount toilet paper subscriptions and Amazon Prime web series, but in how it squeezes merchants. Third-party sellers complain about seemingly arbitrary suspensions and mysterious delays in payment. Even those in good standing fear that Amazon is gradually shifting costs and risks onto them. They're doubly suspicious, given how the company often sells its own competing products.

Wicks's bill sought to prohibit Amazon from requiring merchants to turn over customer information and forbid it from using that data for its own advertising purposes. She also wanted to place limits on how long Amazon could delay paying vendors. The bill didn't name Amazon explicitly but applied only to e-commerce sites with more than 200 million active customer accounts, a very short list.

Amazon and tech trade groups such as the Internet Association and TechNet argued that the bill was, effectively, targeted harassment. "It is not good public policy to single out one company and impact the competitiveness of the e-marketplace industry, without any clear benefit or policy rationale," wrote a coalition of industry groups opposing the bill. Wicks didn't understand Amazon, they argued, saying that sellers had no customers of their own and were in fact customers of Amazon.

The Amazon bill passed the Assembly in May, but by then it had been stripped down to a set of rules requiring all marketplaces to write merchant agreements in plain language and to give specific reasons when they withhold funds from sellers. "I do love the spirit of it," says Paul Rafelson, who leads an advocacy group for businesses that sell through Amazon called the Online Merchants Guild. "It just seems it's missing the teeth it was intended to have."

Wicks's privacy bill, meanwhile, was basically dead on arrival. While she presented it as a way to strengthen the CCPA, it was mostly an overhaul. It would've required companies to get customers to opt into data collection, instead of allowing them to opt out, and also would've allowed counties ▶

◀ California Assemblywoman Buffy Wicks

"The technology industry has privatized the privacy committee"

PHOTOGRAPH BY JESSICA CHOU FOR BLOOMBERG BUSINESSWEEK

◀ and cities to sue violators, a right restricted to the state attorney general in most cases under the CCPA. The Assembly's privacy committee never brought it up for a hearing.

Privacy advocates say the law will probably be significantly weakened by the time it takes effect next year. Their most pressing concern is legislation that would narrow the definition of personal information, creating larger categories of data that wouldn't be held to stringent standards. "The technology industry has privatized the privacy committee," says Chris Conley, a lawyer with the ACLU of Northern California.

Despite Silicon Valley worries about other states following California's lead, no others have passed laws adopting a similar privacy framework. While momentum for antitrust investigations is on the rise, privacy legislation hasn't moved beyond the conceptual stages. The time to advance a federal bill before the 2020 presidential election is running short, according to experts who follow the issue. Privacy advocates lament that the momentum they expected from the California law has already receded.

For her part, Wicks says she's considering reintroducing her original proposal, or some new form of it, in January. "We're going to figure out what my privacy bill is for next year," she says. "Obviously what I had wasn't catching fire." *—Joshua Brustein*

THE BOTTOM LINE California is ground zero for the fight over how to regulate Big Tech. A recent effort to enact a strong privacy law illustrates just how formidable the opposition still is.

Huawei Mobilizes Its Troops

● China's biggest tech company is preparing for a long, drawn-out fight as American supply dries up

Step through the gates of Huawei Technologies Co.'s sprawling campus in southern China, and you'll see a workforce in frenetic motion. Neon-green minivans ferry workers between offices around the clock. Fluorescent lights burn through the night. Employee canteens are open until near midnight.

China's largest technology company has thrived on what some employees and outsiders call its "wolf culture." The take-no-prisoners approach is amplified now that Huawei is at war with President Trump, fighting back against his efforts to cut off its markets and customers and deprive it of critical technology. On May 17, the U.S. Department of Commerce added Huawei to a blacklist of companies that blocks it from buying American software and components it needs to make its products.

Huawei has assigned as many as 10,000 of its developers to work across three shifts a day in offices in Shanghai, Shenzhen, and Xi'an to try to eliminate the need for American software and circuitry, according to people familiar with the matter. From janitors to drivers, everyone has been drafted into the struggle and told to brace for escalating political and market pressure. Huawei has declined to comment beyond saying it's had contingency plans in place for just such an occasion.

Developers in some groups haven't gone home for several days, one person says, asking not to be identified when discussing internal matters. Engineers are reducing American parts in base-station antennas, made by U.S. companies such as Rogers Corp. Huawei also is tweaking the design of entire 4G base stations, the person adds, which compete toe-to-toe with products from Ericsson AB and Nokia Corp.

"It's not a question about if we can win—we have to win," says a Huawei engineer, the head of a small research and development team responsible for communication chips who requested anonymity because employees have been warned not to speak to the press. "This is a war about China having an independent communications technology industry." On an online employee forum, the following message was posted: "Warriors in golden armor shall never return home until they defeat Trump from America."

▲ New employees at Huawei's training facility in Dongguan, China

The U.S. government's actions could throttle what has been a period of tremendous growth for Huawei. The company is the world's top provider of networking gear and the No. 2 smartphone vendor after Samsung Electronics Co. The U.S. ban is unsettling chipmakers from the U.S. to Europe as the global supply chain comes under threat. It could also disrupt the rollout worldwide of 5G wireless, undermining a standard that will power everything from autonomous cars to robot surgery.

Trump has said the restrictions are a necessary response to Huawei helping Beijing spy on other governments. The company for years has been accused of—and sued for—stealing intellectual property from several big companies, including Cisco Systems Inc. and T-Mobile; Huawei has denied all charges. "We are ahead of the U.S. If we were behind, there would be no need for Trump to strenuously attack us," Huawei founder Ren Zhengfei told Bloomberg Television on May 24.

Huawei brass watched the Commerce Department bring another Chinese company, ZTE Corp., to its knees in 2018, noting how Washington forced ZTE to revamp management, pay a 10-figure fine, and give U.S. observers access to its inner workings. They swore then that, when the time came, Huawei would be prepared. "We are on the right side of history," the company wrote in an internal memo after the ban was announced. "After every storm, there is a rainbow. We expect every one of you to stay confident, remain dedicated, and diligently fulfill your duties."

Huawei is said to have stockpiled enough chips and other vital components to keep its business running for at least three months, according to people familiar with the matter. Some of its 180,000 employees remain optimistic that Beijing will resolve its dispute with Washington. Others are confident the Chinese government will step in with either capital or policy changes to prop up the company.

On May 17, the same day Huawei was blacklisted, China announced a tax waiver for local chip design and software companies. That means HiSilicon, the secretive chipmaking division that's leading Huawei's efforts to wean itself off American semiconductors, won't be required to pay any taxes over the next two years.

Still, anxiety is creeping through Huawei offices from Tokyo to Sydney, employees say. "We can't deny that it's had a negative impact, as bad news around Huawei is reported every day," one of them says. "But employees in Japan are rallying, and we're just trying to keep working as usual. Some of our customers are even trying to cheer us up."

As Huawei marshals its troops, the U.S. continues to exhort governments around the world to shun its equipment. Australia and New Zealand have banned its gear, and Japan has effectively done so, while others, including the U.K., are weighing their options. Trump has said the restrictions on the company could be lifted as part of a trade deal with China, but negotiations have stalled. "The fundamental question here is, is this a negotiating lever as part of a trade deal?" says Chris Lane, a Sanford C. Bernstein analyst. "If the ban goes on a long time, Huawei will lose a lot of market share."
—Bloomberg News

THE BOTTOM LINE The Chinese tech giant is working on contingency plans, operating 24 hours a day to overcome the restrictions imposed by being on Trump's blacklist.

● Companies and people banned by the Commerce Department in the past year, by country of origin

QILAI SHEN/BLOOMBERG; DATA: COMMERCE DEPARTMENT

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3

FINANCE

The Solar Company That Went Dark

● The feds allege that DC Solar was a Ponzi-type scheme that scammed even Berkshire Hathaway

ILLUSTRATION BY 731

Edited by Pat Regnier

Jeff Carpoff had a lot to celebrate at his company's Christmas party last year. The onetime auto mechanic and his wife, Paulette, had started a business about a decade earlier that was doing so well it could count Warren Buffett's Berkshire Hathaway Inc. as an investor. Their business, making mobile solar generators, had afforded them lavish goodies. They owned more than 90 cars, from classic Fords to Bentleys, at least 20 properties, and even a professional baseball team in Martinez, Calif.

Now as the year came to a close, here was the rapper Pitbull headlining their party at the swanky Fairmont hotel in San Francisco, according to people familiar with the event. Kyle Larson, a racecar driver once sponsored by a Carpoff company, tweeted that the event was the "best holiday party I've ever been to by far!!"

A few days later, when FBI agents showed up at the Carpoffs' front door, their extravagant life came crashing down. It was largely built on an alleged fraud—a Ponzi-type scheme, in essence, said federal authorities in court filings related to corporate bankruptcy proceedings. Their company, DC Solar, is now out of business. Their 4,100-square-foot home in Martinez is in foreclosure. When the agents came knocking that day in late December, they took many of the luxury cars. They also seized a pile of cash—$1.8 million in all—that had been secreted in one of the couple's offices.

The Carpoffs, authorities contended, had managed to parlay an incentive to encourage solar investments into an $800 million fraud scheme. Promising big federal tax credits and profits, their pitch enticed sophisticated investors, even though it came from an enterprise little-known outside California and the car-racing world. Not only did Berkshire bite, investing $340 million alone, but so did insurer Progressive Corp. A half-dozen or so regional banks were financial backers too. All put their money in funds set up by DC Solar that offered significant tax credits and possible profits.

The company was supposed to use the money to build mobile generators, which supply power at sporting events and other outdoor venues. But evidence suggested DC Solar "engaged in nearly no legitimate business," the government said. The company built and leased out only a fraction of the more than 12,000 mobile units it had claimed were in use, the FBI said. Instead, the company allegedly used much of the money from new investors to pay off old ones—and to fund the Carpoffs' spending.

DC Solar's precipitous fall is forcing many of the investors to take charges on tax breaks that they thought were worth millions of dollars. Progressive had to reverse tax benefits worth more than $150 million stemming mostly from its DC Solar investments.

The federal tax credit has helped fuel since 2006 solar's shift from an alternative electrical resource to the U.S. mainstream. While the program has been largely free of irregularities, the DC Solar tale stands as a warning of how investors, perhaps too hungry for the credits, may be lax in scrutinizing the health of the underlying business. The alleged scam started to crack only when federal authorities were alerted by a former employee who believed the number of leased mobile units claimed by DC Solar was false, according to a court filing.

Jeff Carpoff didn't respond to inquiries seeking comment. "DC Solar Solutions was an innovative, substantial and credible solar-energy business. It manufactured thousands of mobile solar generators, which were examined and physically delivered," Carpoff attorney Malcolm Segal said in a statement. "Any allegation that there was a Ponzi scheme or anything illegal about the operation of the business is without merit." The Securities and Exchange Commission and the FBI have said they are investigating, according to separate February filings. Representatives for the FBI and SEC declined to comment.

◀ Larson and his DC Solar-sponsored car after winning a race in Bristol, Tenn.

Carpoff once ran a company servicing Land Rovers and Jaguars, according to his LinkedIn page. He founded DC Solar more than a decade ago, building a line of generators and light towers. Veering from the usual bets on panels scattered across large farms or atop homes, he offered portable units that could be placed on wheeled trailers.

"Within a short time, we were doing over $60 million in sales," he told *Inc.* magazine, in an interview published before reports emerged about the federal raids. The key was the investment tax credit. It "helped us create a financial model that enabled us to keep growing." There seemed little reason to doubt any of this at the time. A 2016 U.S. Transportation Department press release described DC Solar as among "some of the most innovative

folks in the private sector." To boost the brand, the couple relied heavily on auto racing. They'd agreed to sponsor Chip Ganassi Racing in the Nascar Xfinity Series and drivers including Ross Chastain.

Overall, DC Solar attracted at least a dozen investors in complex transactions that raised money through special funds, according to government allegations. In a typical DC Solar deal, filings showed, investors bought each mobile unit for $150,000, paying only $45,000 in cash—the maximum amount of the tax credit they could claim. They were told that the company would then lease the equipment to end-users such as telecom companies. The lease money would pay down the remainder of the $150,000 cost plus provide any profit to the investor.

DC Solar, it turns out, didn't usually lease the generators to third parties as described by the company, the filings said. Instead, about 90% of the money one of its affiliated companies claimed as lease revenue was actually new investors' money. In 2016, for example, that sum amounted to $50 million of the claimed $55 million in revenue, a former employee told authorities. As for the generators themselves, DC Solar allegedly made it appear it had leased more than it did. Employees placed GPS transponders meant to confirm the presence of generators in spots where, "in truth, they were not located," according to the government filings. Investigators later said they did find many generators, though not where the company claimed. Some were stored at locations including the Las Vegas Motor Speedway. Others were sitting, unused, outside DC Solar's offices.

Berkshire said it was "more likely than not" that the tax benefits it received from certain investments from 2015 to 2018 were invalid, according to a May filing that didn't name the sponsor. It later identified that sponsor as DC Solar. The company took a $377 million charge in the first quarter to reverse the tax benefit. Progressive spokesman Jeff Sibel says the company believes it was defrauded after investing in three funds with DC Solar. The goal was to earn "attractive investment returns" and to support the environment, he says.

The DC Solar building is now shuttered. In the darkened reception area, just one item is still visible: a lone silver Christmas tree. —*Brian Eckhouse, Katherine Chiglinsky, and Mark Chediak*

THE BOTTOM LINE Investors including Berkshire Hathaway and banks were drawn to DC Solar in part by federal tax incentives. Now many of those investors are having to reverse those credits.

● Buffett

A Bull Market for Wonks

● Blindsided by populism, investors are trying to understand how politics will affect their portfolios

Better Markets, a left-leaning Washington think tank, describes itself as a watchdog over Wall Street. Nowadays, many of the people seeking its advice are Wall Streeters themselves.

There's been a "very big uptick" in fund managers reaching out to talk, says Dennis Kelleher, co-founder and chief executive officer of the group, which advocates for financial-services reforms. He says his unanticipated visitors tend to have one thing in common. They're alarmed—very belatedly, in Kelleher's view—by the populist turn in U.S. politics, and they're struggling to figure out where things are headed next. Talking to groups with alternative views is one way to get a sense of that. "You have this ongoing economic insecurity that is eroding confidence in Wall Street and the American economy," he says.

For decades, there was broad agreement in Washington that prosperity is built on unfettered global commerce, restrained federal budgets, and central bank independence. Those certainties were shaken by the financial crisis—and they've been largely abandoned under President Trump, who appears to disagree with them all. At the same time, more Democrats are embracing policies, such as universal, single-payer health care and wealth taxes, that were once regarded as radical.

Trumponomics has delivered decent returns for financial assets, so far. While trade war, an expanding national debt, and repeated sniping at the Federal Reserve have unnerved plenty of investors, stocks have soared under the new regime, contrary to predictions by some economists. Populist policies cut both ways, say analysts at Oxford Economics in London. Looser budgets boost growth and could help lift inflation, ▶

"It's a new uncertainty, it's very uncomfortable, and it's everywhere"

FROM LEFT: SEAN GARDNER/GETTY IMAGES; JOHANNES EISELE/AFP/GETTY IMAGES

◀ something central banks have been unable to do. At the same time, institutions and global agreements are under threat. "Longer term," the analysts wrote, "we fear populist policies may spur decay rather than regeneration."

In the shorter term, there's a presidential election coming, and investors who got sucker-punched in 2016 are starting to wonder if another, potentially less market-friendly phase of populism might be in store. There's a sense that the genie of economic change is now out of the bottle.

Think tanks aren't the only go-to source for investors worried about such matters. There's a small industry in Washington providing political analysis for investors, and they say they've been doing an unusually brisk business. Andy Laperriere, head of U.S. policy research at Cornerstone Macro LLC in Washington, says Wall Streeters typically wait until Labor Day in an election year—when the vote is a mere couple of months away—to start placing bets on ballot outcomes. Right now, they're running more than a year ahead of that schedule, he says. They're riveted by candidate proposals and hungry to know how in-party sentiment is swinging. "When I do a piece on 2020, people are all over it," Laperriere says. And health-care stocks have already been hammered, thanks to rising support among Democrats for Medicare for All.

To be sure, legislation for universal health care, even though it has about 100 House sponsors, may end up going nowhere. Many investors are betting that the center will hold. They can point to early polling that shows former Vice President Joe Biden the clear front-runner among Democrats. His association with the Obama administration, whose policy agenda is already a known quantity, is reassuring to some investors. "Many more ideas are likely to be aired," says Ellen Hazen at F.L.Putnam Investment Management in Wellesley, Mass. "But the ultimate path forward for policy may not be so different." Hedge funds expressed a similar view by snapping up battered health stocks.

But health care is just one of many live-wire issues looming in 2020, from climate change and deepening income inequality to the debt burden on U.S. students. The Democrats' proposed fixes aren't all well-defined at this stage—but even the watered-down versions represent substantial changes. Elizabeth Warren supports a wealth tax, and on June 4 proposed replacing the Department of Commerce with a Department of Economic Development focused on jobs. Bernie Sanders backs a Green New Deal, and both—along with Kamala Harris and Cory Booker—have signed on to plans for loan-free college. Meanwhile, Trump is intensifying his war on immigration by slapping tariffs on Mexico, a move that immediately rattled markets.

The sense that something's shifting in capitalism isn't confined to American investors. At Deutsche Bank AG, Chief Economist Torsten Slok finds his number crunching is regularly interrupted by clients from Copenhagen to Hong Kong asking about politics. Many of their questions are tough to answer because "we just don't know what form and what shape populism will come in," he says. "It's a new uncertainty, it's very uncomfortable, and it's everywhere."

In the U.S., discomfort has deepened, even though the economy is about to break records for the longest expansion ever, with inflation subdued, unemployment rates near historic lows, and wages finally picking up. How else to explain the

ILLUSTRATION BY MOLLY ROSE DYSON. DATA: FEDERAL RESERVE BANK OF PHILADELPHIA; BAKER, BLOOM & DAVIS

calls from champions of economic orthodoxy, such as Larry Summers and Olivier Blanchard, for closer cooperation between the politicians who draw up budgets and the central bankers who set interest rates? That was once a kind of taboo. Senator Marco Rubio, a Florida Republican, has even published a white paper ripping shareholder capitalism. That ethos, which says companies should act to maximize return to investors, has been dominant for decades. But Rubio says it "reduces investment in research and innovation, and undervalues American workers' contribution."

If investors have a nagging sense that all these problems will get addressed one way or another and that business models will likely be upended in the process, Better Markets' Kelleher says they're right. He predicts the 2020 outcome will hinge on who can tap into the insecurities eating away at American capitalism. "The view on Main Street right now is the economic and political system works for the well-connected—epitomized by the lords of Wall Street," he says. "There are tectonic shifts going on in this country." —*Craig Torres*

THE BOTTOM LINE With GOP politicians questioning shareholder capitalism and Democrats talking about sweeping reforms, investors are paying close attention to elections earlier than usual.

It's Tougher to Make A Buck on the Yen

● Global investors still consider Japan a safe haven, but the trade isn't paying off like it used to

On the morning of Friday, May 31, when traders in Asia starting their day were surprised by President Trump's move to impose tariffs on Mexico, there was a seemingly obvious course: Rush into the yen.

Buying Japanese currency when the world looks wobbly is a classic trade. Japan's current-account surplus means it doesn't need to borrow from anybody. Investors, including those in Japan who have accumulated overseas assets, are confident about parking money in Japanese bank deposits or government bills when they want to ride out a storm. That, in turn, is good for the value of yen. And going into yen is an easy trade to make: Dollar-yen is the world's second-most-traded currency pair.

But this textbook move isn't working quite as well as it used to. In the first 30 minutes of trading that Friday, as futures on the S&P 500 index of stocks fell 1%, the yen advanced only 0.2%. It took additional protectionist trade rumblings from China later in the day before the yen recorded a 1.2% rise.

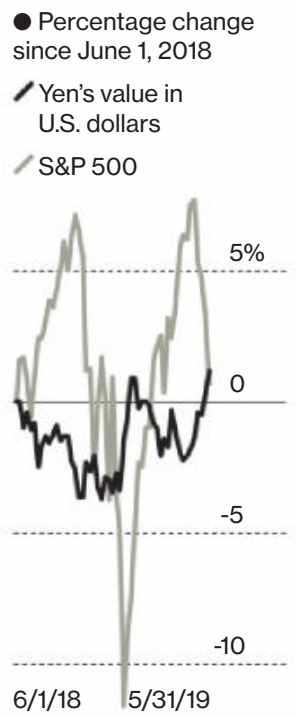
That modest-looking daily move turned out to be the biggest gain for the yen in two years. It's a notable contrast from the past, when Japan's currency could make a move that big—or bigger—in minutes. (For example, when the U.K.'s Brexit vote became apparent on a Friday in June 2016, the yen leapt as much as 7.2% against the dollar.) "This morning's news was shocking—suddenly Trump imposes tariffs on Mexico—so, a new agenda for the market," as Tohru Sasaki, head of Japan markets research at JPMorgan Chase & Co., put it. The dollar-yen should have responded immediately. "This is a kind of structural change."

Indeed, as Trump slapped tariffs on China in May, the yen proved the best-performing major currency. But take a step back, and it's barely up this year, with a dollar buying 108.09 yen on June 4, compared with 109.69 at the start of the year. Sasaki says a few things have changed. First is the widespread recognition in Japan that its central bank is still a long way from even contemplating normalizing monetary policy after an extended period with interest rates at zero. That means Japanese institutional investors have had to send much of their money abroad to earn a positive return, helping to boost demand for other currencies relative to yen. "It's a minor version of capital flight. It's not that people don't think it's safe to keep money domestically, it's that they think there is no return in Japan," Sasaki says.

Japanese companies' behavior is another consideration. They announced more than 1,000 offshore acquisitions last year, totaling a record $191 billion. Takeovers run the gamut from makers of pasta sauce and beer to banks and pharmaceutical companies. Businesses want to increase the external share of their revenue as Japan's population shrinks.

Strong demand for dollars and other foreign currencies means traders are happy to "buy the dip" in the dollar-vs.-yen whenever they see a move to Japan's currency as part of safe-haven trade. That slows the fall of the dollar and cuts off some of the yen's gain. "I think the flow into yen as a safe haven remains," says Jane Foley, head of currency strategy at Rabobank International in London. "But for us to see it go down to, say, 105, you'll need to see a major geopolitical shock happen." —*Chris Anstey and Ruth Carson*

THE BOTTOM LINE Japan's superlow interest rates have made it a less attractive place to park cash, and Japanese investors are looking for more ways to earn money abroad.



DATA: COMPILED BY BLOOMBERG

Please, Don't Sing

● The current expansion is 10 years old, but it looks pale compared with previous economic streaks

Tune out the trade wars. Pay no attention to the signal of a looming recession being emitted by the bond market. It's time for a birthday party!

This month marks the 10th anniversary of the U.S. economic expansion that began in June 2009. If the streak continues into July, it will make history, surpassing the 1991-2001 growth cycle to become the longest since 1854, which is as far back as economists have attempted to date business cycles.

The achievement is impressive, but few are in the mood to celebrate. It's partly a matter of timing. The risk of a downturn is rising, amplified by heightened trade tensions with China and now Mexico. IHS Markit's U.S. Manufacturing Purchasing Managers' Index fell in May to its lowest level since September 2009. On June 3 the yield on three-month Treasury bills exceeded that on 10-year Treasury notes by the most since 2007, a strong indicator that a recession is somewhere

ILLUSTRATION BY HELENA COVELL

Edited by Cristina Lindblad

on the horizon. JPMorgan Chase & Co. says the probability of one beginning in the second half of 2019 has risen to 40% from 25% in early May.

The other reason people are blasé about this milestone is that the expansion has been nothing to brag about. Like Lonesome George, the giant tortoise in the Galápagos Islands who lived past 100, it's clumped along slowly, never overheating, which is part of the reason for its longevity. Yet we've had peppier extended growth cycles before. In the first 39 quarters of the record expansion of 1991-2001, gross domestic product increased 43%. In the 39 quarters through this March, U.S. GDP grew just 22%. And the sluggish expansion has benefited capital more than labor: Workers' share of national income has fallen from 68.9% to 66.4% over the period.

At its present pace, this run would have to last six more years to match the aggregate growth of 1991-2001, and nine more to replicate the go-go growth of 1961-69, when GDP expanded 54%, according to calculations by Nir Kaissar, a Bloomberg Opinion columnist who's founder of asset manager Unison Advisors. "I characterize this as the recovery of fits and starts," says Michelle Meyer, head of U.S. economics at Bank of America/Merrill Lynch & Co.

The hallmark of this expansion has been underperformance. The Federal Reserve repeatedly predicted it would need to raise interest rates to temper excessively rapid growth—then repeatedly put off hiking because growth came in below expectations and inflation languished below the Fed's 2% target. The central bank finally did start ratcheting up rates in earnest at the end of 2016, by a total of 2 percentage points over two years. But it put its tightening campaign on hold after its December meeting, when plunging stocks, trade tensions, and a partial government shutdown rekindled fears of a slump. As of June 5, the federal funds futures market saw a 95% chance that the Fed would cut rates at or before its September meeting.

Growth is lukewarm despite stimulative fiscal policy from Congress and the White House. The federal budget deficit had shrunk to just over 2% of GDP at the end of 2015, but it's widened to almost 4.5% since, thanks to the big tax cut at the end of 2017 and more spending, particularly on defense.

The single best indicator of this expansion's weakness is the cost of money, as measured by the real interest rate, which strips out inflation. The yield on 10-year Treasury Inflation-Protected Securities fell from 4% during the effervescent dot-com boom at the end of 1999 to below zero in 2012 and 2013. It rebounded to just over 1% late last year but has sagged back to 0.4%. When money is this cheap, it indicates weak demand for credit or an overabundance of savings—or both.

To Harvard economist Lawrence Summers, the expansion has all the features of "secular stagnation." That's a situation of chronically weak demand, in which satisfactory growth can be achieved only by extreme fiscal and monetary stimulus. He figures that secular stagnation plagued the U.S. in the 1950s and early 2000s, in addition to the Depression of the 1930s, and believes it's now hitting much of the developed world, including Japan and Europe. In fact, he says, "We are doing by far the best."

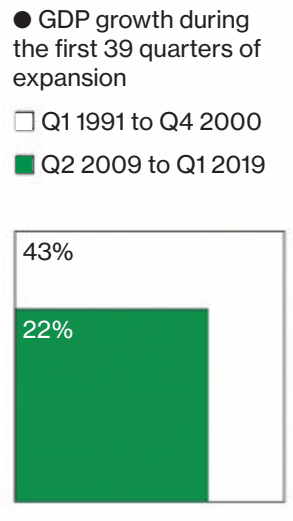
A Republican-controlled Congress turned down Obama's requests for continued fiscal stimulus but said yes to Trump. However, the 2017 tax cuts were tilted toward the rich, who don't tend to spend windfalls, and businesses, which haven't stepped up investment significantly. The National Association for Business Economics said in January that in a poll of its members, 84% said their companies hadn't boosted outlays or hiring in response to the tax cuts.

Kevin Hassett, chairman of Trump's Council of Economic Advisers, argues that the business tax cuts lifted spending on plant, machinery, and software onto a higher track. That will continue to pay dividends for the economy even if the growth rate of new investment returns to its pre-tax-cut pace, he says. Hassett, whose planned departure from the CEA was announced by Trump in a tweet on June 2, also credits the administration's policies with sustaining a high pace of job growth.

The indisputable achievement of the current expansion is the decline in unemployment: At 3.6%, the rate in May was the lowest in half a century. Employers' eagerness to hire is benefiting people who ordinarily have a hard time landing jobs—the less educated, the handicapped, racial minorities, and older workers, among others. Wages have started to rise as well. Average hourly earnings in April were up 3.2% from the previous-year period, outpacing inflation. The availability of jobs (along with a generally rising stock market) is lifting consumers' spirits. The Bloomberg U.S. Weekly Consumer Comfort Index this year has been fluctuating around its highest level since 2000.

Yet even on unemployment, there's less than meets the eye. People who've stopped looking for work or who are working part time even though they'd prefer full-time work aren't counted in the government's main measure of unemployment. Only 3.1% of men age 25-54 were officially unemployed in April, but an additional 10.8% were out of the labor force entirely, according to the Bureau of Labor Statistics. "The United States is still a long ▶

"The secular stagnation psychology has taken hold of the economy more than it's taken hold of economists"



way from full employment," says Dartmouth College economist David Blanchflower, author of *Not Working: Where Have All the Good Jobs Gone?*

The invisible reserve of labor keeps a lid on wages for those who are working. Summers argues that even with today's low unemployment rate, some workers remain afraid they'll lose their job if they ask for a raise. "The secular stagnation psychology has taken hold of the economy more than it's taken hold of economists," he says.

The task of dating the beginning and end of an economic expansion falls to academic economists who sit on the Business Cycle Dating Committee of the National Bureau of Economic Research. Unlike other countries, the U.S. has no simple rule of thumb, such as two consecutive quarterly declines in GDP mark a recession. The committee takes a wide range of economic data into account, including jobs and incomes. It judges an expansion to begin in the month when things remain bad but have stopped getting worse. Likewise at the top, even if things are very good but not quite as good as the month before, a recession may have set in. The committee generally waits a year or so to pinpoint the top or bottom of a business cycle.

Expansions typically end when the central bank raises interest rates excessively in an effort to stave off inflation caused by strong demand. Less often, they're cut short by a financial crisis, as in 2007-09, when irrational exuberance led to too much borrowing and then a wave of defaults and liquidations. Because of the tortoiselike pace of this expansion, price pressures have been muted. Also, there's little evidence of the kinds of bubbles that ended the last two expansions.

Still, our pretty-good times can't last forever. Merrill Lynch's Meyer says, "I do think we're in the late stages of the cycle." That seems to be the consensus as well among bond investors, who've driven the yield on 10-year Treasuries down to just 2.1%, the lowest in two years. (Stock investors, on the other hand, are relatively optimistic—see the next story.)

In 1931 the great British economist John Maynard Keynes wrote about the risk of a prolonged period of subpar growth: "the long, dragging conditions of semi-slump, or at least sub-normal prosperity" following a recession. Optimistically, Keynes said policymakers had the means to treat such a condition, but only if they choose to exercise their power. Blanchflower, who cites Keynes in *Not Working*, writes: "That quote sends shivers down my spine every time I read it." —*Peter Coy*

THE BOTTOM LINE The 10-year run of U.S. growth, possibly nearing its end, will be remembered as a long but tepid expansion. Its slowness probably prolonged its life.

Taking Stock

How the U.S. has changed since the start of the current expansion, in June 2009*

		Then	Now
Jobs	Unemployment rate	9.5%	3.6%
	Payroll employment	131m	151m
	Job openings	2.5m	7.5m
	Labor's share of national income	68.9%	66.4%
	Median duration of unemployment, in weeks	17.2	9.4
	Employment-to-population ratio	59.3	60.6
	Share who say it's a good time to find a quality job	11%	65%
	Share of men age 25-54 participating in labor force	90.0%	89.2%
	Employment, age 65 and up	27.1m	36.8m
	Manufacturing employment	11.7m	12.8m
	Federal minimum wage	$6.55	$7.25
	Share of the workforce in a union	12.3%	10.5%
Families	Net worth of households and nonprofits	$57.8t	$104.3t
	Real median household income	$60k	$64k
	Average income, bottom quintile	$11.6k	$13.3k
	Average income, top quintile	$171k	$222k
	Median usual weekly earnings of men	$818	$994
	Median usual weekly earnings of women	$652	$800
Housing	Homeownership rate	67.4%	64.3%
	Share of mortgages that are delinquent	9.2%	4.4%
	Black homeownership rate	46.5%	41.1%
	Median price of an existing home	$182k	$267k
Markets	S&P 500	924	2,803†
	Nasdaq Composite Index	1,816	7,527†
	Federal funds rate, top of range	0.25%	2.50%
	Yield on 10-year Treasury notes	3.8%	2.1%
Economy	U.S. GDP in current dollars	$14.5t	$21.3t
	Core annual inflation rate	1.7%	2.1%
	Budget deficit as a share of GDP	9.8%	3.8%
	Federal debt owed to the public as a share of GDP	52%	78%
	Current-account deficit as a share of GDP	3.6%	2.3%
	Leverage of risky corporations††	38.8%	40.4%

*FIGURES FROM JUNE 2009 AND JUNE 2019, OR CLOSEST AVAILABLE DATE; †JUNE 4 CLOSE; ††GROSS BALANCE SHEET LEVERAGE OF RISKY PUBLIC NONFINANCIAL CORPORATIONS, THOSE THAT HAVE SPECULATIVE-GRADE OR UNRATED DEBT.
DATA: DEPARTMENT OF LABOR, COMMERCE DEPARTMENT, INTERNATIONAL MONETARY FUND, FEDERAL RESERVE, GALLUP, BLOOMBERG

America First, America Forever

● How has the U.S. managed to elude the bear market that has the rest of the world in its claws?

The U.S. is celebrating 10 years of uninterrupted economic growth, but the rest of the world is suffering through a bear market that's now lasted 12 years. Stock markets around the globe, excluding the U.S., remain 25% below the peak they set on the ominous date of Halloween 2007, the eve of the financial crisis. The American S&P 500 benchmark has gained about 80% over that period.

Outside the U.S., stock markets have never come close to regaining their precrisis highs, and they currently appear to be locked into yet another downswing. The MSCI ACWI ex USA Index, which, as its name indicates, covers all equity markets minus the U.S., has dropped more than 17% since its most recent peak, early last year, when there was much excitement about a synchronized global economic recovery.

The disjunction between the U.S. and the rest of the world seems almost inexplicable. Globalization is now a fact of life. Consequently, tough times for Europe and Asia should create problems for American multinationals, and a comparatively booming U.S. should help them in the rest of the world. So why, exactly, are markets reeling everywhere but in America, where they're surging? Here are four different—though not mutually exclusive—explanations for what's driving the divergence.

1 It's the Economy, Stupid

The U.S. economy has logged a decade-long recovery, and though its fruits may not have been shared equally, what matters more to investors is that there's been growth in the aggregate. Beyond American shores, it's different.

In Europe, growth has been stifled by the sovereign debt crisis and the austerity measures many nations were forced to adopt either as a condition for bailouts or to reassure investors. Meanwhile, Japan continues to stagger along, unable to rid itself of a deflationary malaise that's lasted three decades. U.S. gross domestic product grew 34%, in constant prices, in the 10 years from the beginning of the crisis in 2008, dwarfing Japan's growth of 7% over the same period. In that time, the euro zone's GDP fell 2%, and the U.K.'s contracted a painful 15%.

But stock markets do not just follow the latest numbers on economic growth. If they did, money would have surged from the U.S. to emerging-market dynamos such as China (up 244% over the same time) and India (up 117%). In fact, both nations had unimpressive inflows. So the gap between the U.S. and the rest of the world is about more than economic growth.

2 The U.S. Dealt With the Crisis—Others Didn't

One big reason stock markets the world over are underperforming those in the U.S. may be that those countries didn't have their own Bernanke or Paulson or Geithner.

Ben Bernanke devoted his long academic career to working out how to stop debt crises from turning into economic depressions. Once at the helm of the Federal Reserve, he unleashed an aggressive response to the crisis, cutting rates to zero and expanding the money supply through purchases of U.S. Treasuries and other securities. Bernanke also worked with former U.S. Secretary of the Treasury Hank Paulson and his successor, Tim Geithner, to devise a series of stress tests that forced banks to reduce their leverage. The solution didn't go as far as many believed necessary, but U.S. lenders emerged with comparatively stronger balance sheets than those of many of their peers abroad.

Across Europe, banks were far more bloated than their U.S. rivals entering the crisis, and many still carry a debt load that crimps their ability to ▶

● Percentage change since Nov. 30, 2007

S&P 500

MSCI ACWI ex USA Index

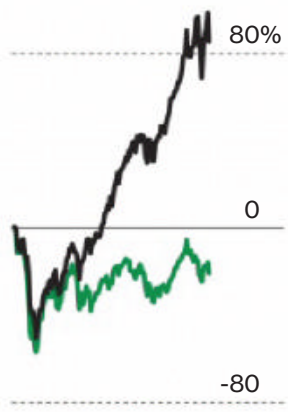


ILLUSTRATION BY HELENA COVELL. DATA: COMPILED BY BLOOMBERG

◀ lend and hampers profitability. Shares of banks in the euro zone now trade for far less than the book value of their equity, a sign that investors doubt they have their house in order. In Japan, banks have taken advantage of ultralow interest rates to ramp up lending to small and midsize businesses—even though a growing proportion are "zombies" that are unlikely to ever pay back their loans.

China, now the world's second-biggest economy, relied on old-fashioned stimulus to get through the crisis. A huge splurge of debt-funded investment cushioned the blow to its economy, though the massive increase in leverage has left the country susceptible, many say, to a financial crisis of its own.

The ideas of Bernanke and his allies at the U.S. Treasury and the Federal Reserve Bank of New York were deeply controversial at the time, and the U.S. may yet pay a price for them. But from our current vantage point, it looks as if their actions were key to a decade of renewed gains in asset prices for Americans.

3 The FAANGs Ate Our Growth

In a globalized world, it just so happens that the companies eating everyone else's profits all happen to be listed in the U.S. The FAANGs—originally coined for Facebook, Apple, Amazon.com, Netflix, and Google but nowadays often including Microsoft as well—have cleaned up by disrupting other businesses. No European or Japanese company is remotely comparable; Alibaba, Baidu, Tencent, and other Chinese counterparts mostly concentrate on their home market.

Some of the statistics that provide evidence of the FAANGs' dominance are breathtaking. Much of Amazon's stratospheric growth has come at the expense of existing retailers, for example. Over the past five years, its market value has risen from $151 billion to $853 billion. (At one point in September, it exceeded $1 trillion.) All the other retailers in the developed world tracked by MSCI saw their combined market value grow from $1 trillion to $1.2 trillion in that period.

The companies that dominate the internet all started in the U.S., which certainly tells us something about the dynamism of the American economy and the lack of innovation elsewhere. But there's far more to the rest of the world's bear market than its lack of FAANGs. Over the past five years, the S&P 500 without Facebook, Apple, Amazon, Netflix, Google, and Microsoft has gained 34%, while the MSCI EAFE, an index covering the major developed markets outside North America, is down 7%.

4 A Bear Market Is Only Natural

History does not necessarily repeat itself, but it does rhyme, as the saying goes. And markets follow a clear historical pattern after a major speculative bust, such as the one we witnessed after Halloween in 2007. The three biggest examples over the past century were the Wall Street Crash of 1929, the crash of the Japanese market after its peak on New Year's Eve 1989, and the dot-com bubble of 2000.

In all of those cases, a painful slide was followed by years of a sideways bear market. Stocks would gain for a while, buoying hopes, and then fall again. A decade on from their respective crashes, the Dow Jones industrial average, the Nikkei 225, and the Nasdaq Composite all looked strikingly similar. They remained far below their peaks, which they hadn't regained even once.

That's the usual process of finding a level after stock prices have been totally driven away from any value that makes sense. And it's what many market watchers (including this one) predicted would happen after the 2008 meltdown: There would be money to be made along the way, but it would take more than a decade before benchmark indexes climbed back to their peaks. That's exactly what's happened—everywhere except the U.S.

This in turn raises an uncomfortable question: Did the U.S. really avert the usual fate that befalls countries after a major crisis, or has it merely postponed it? — *John Authers*

THE BOTTOM LINE Stock markets around the globe, excluding the U.S., remain 25% below the peak they set on Halloween 2007, while the S&P 500 benchmark has gained about 80% since then.

● Amazon's market value over the past five years increased by more than

$700b

Wobbles Down Under

● Australia's central bank governor is battling to keep a 28-year growth streak going

Investors are giving up on the developed world's most enduring economic growth story. Australia hasn't recorded two straight quarters of economic contraction since the first half of 1991, meaning it's just a month away from overtaking the Dutch record and posting 28 years of continuous expansion. But with home prices sinking, households swimming in record debt, and the escalating U.S.-China trade war eroding confidence, bond and foreign exchange traders are betting that streak is now in jeopardy. "Australia's had the housing boom

and commodity boom, and there's a question mark hanging over what drives growth next," says Su-Lin Ong, head of economic and fixed-income strategy at Royal Bank of Canada in Sydney.

The Reserve Bank of Australia trimmed its benchmark interest rate to an historic low of 1.25% on June 4, and traders expect at least one more cut this year, as the central bank moves to buttress employment and nudge inflation to its target of 2% to 3%. U.K. and European investors, who've watched their own central banks push down rates, are certain that RBA Governor Philip Lowe isn't done easing, Ong says. "They've seen that movie, and they doubt Australia is really any different."

Just like all the rest. That's something Australia isn't used to hearing, particularly after it managed to avoid being swept up in the Asian financial crisis, the early 2000s tech wreck, and the 2009 global recession. "The next world shock, we don't escape," says Bob Gregory, a professor at Australian National University in Canberra who's studied the economy for half a century. "But even without that, I'd say there's a 90% chance the economy and employment growth slow from here because our boost from China and immigration is waning."

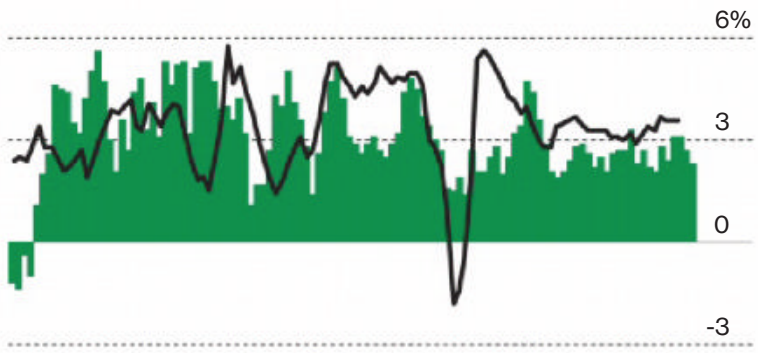
Doubts about the country's prospects are evident in the Australian dollar, which has lost 25% of its value against the U.S. dollar in the past five years. Growth decelerated sharply in the second half of 2018 and remains subpar. Gross domestic product expanded by an annual 1.8% in the first quarter, almost a percentage point below the economy's speed limit. The escalating trade war further clouds the outlook: Australia is the most China-dependent economy in the developed world. Nearly 40% of the country's exports are destined for China.

Lowe, who's kept the benchmark rate at 1.5% since assuming his post in September 2016, used the record-long pause to try to deflate housing prices and stem a surge in household debt. He's also spoken out about nonmonetary ways to bolster growth, urging companies to seize on investment opportunities, governments to embrace a reform agenda that prolongs the expansion, and workers to set aside fears over job security and demand higher wages.

Apart from persuading federal and state governments to take advantage of cheap financing to increase spending on infrastructure, Lowe has had little success. That doesn't mean the RBA chief hasn't won admirers along the way. "Those speeches have been very interesting, sort of 'Get your act together, you guys,' which is remarkable for a bank governor, because 20 or 30 years ago that would've caused a stir," says Gregory, who was on the RBA's board for 10 years.

The surprise reelection of Australia's center-right government may pave the way for productivity-enhancing measures, such as scrapping remaining tariffs and doing away with burdensome quotas and licensing requirements in some industries. Prime Minister Scott Morrison's victory gives him immense authority within his party and may close the chapter on a decade of leadership instability that made it tough to pull off ambitious reforms, such as curbing greenhouse-gas emissions and overhauling the tax code. Putting a floor under the housing market—where prices are down almost 15% from their 2017 peak in Sydney—and more cash into households' pockets will be near-term priorities.

The world's most important central banker still believes in the Australian growth story. Federal Reserve Chairman Jerome Powell has consistently rebutted questions about the inevitability of the record U.S. expansion coming to an end by pointing to the experience Down Under. "Business cycles don't last forever, I guess unless you're Australia, where they're in Year 27 of their expansion, which sounds like forever," he told attendees at an event organized by the Economic Club of New York in late November. —*Michael Heath, with Garfield Reynolds*



DATA: AUSTRALIAN BUREAU OF STATISTICS, INTERNATIONAL MONETARY FUND

THE BOTTOM LINE Australia's remarkable 28-year-long growth run is losing steam because of slowing immigration, falling housing prices, and the U.S.-China trade war.

● Lowe

ILLUSTRATION BY HELENA COVELL. BRENDON THORNE/BLOOMBERG

Anti-Wall Street

● Big tech companies have dodged strict regulation for years, but they're the perfect target in a heated political season, and investors are spooked

Edited by Madeleine Lim and Jillian Goodman

Washington—and specifically its antitrust power—was back on investors' radar with a vengeance this week, erasing in a single trading day almost $140 billion in the market value of the big four tech companies: Amazon, Apple, Facebook, and Google parent Alphabet. Combined with the uncertainty caused by spreading trade tensions—Mexico and India were added to a list of targets that remains dominated by China—and the need to watch for presidential tweets at all hours, the reports of potential antitrust investigations into the four companies served to remind investors just how much the game has changed under the current administration.

"This is sort of a gut punch to investors at the exact time that you did not need it, given the China worries," Dan Ives, an equity analyst at Wedbush Securities, told Bloomberg TV. "Part of the problem that I think Apple is facing, as well as other tech players, is what's the ballgame and what are the rules? Is this a baseball game where we're in the third or the first? I think that's the frustration."

The trouble in the markets began when the first reports broke that the U.S. Department of Justice was opening an antitrust investigation of Google, while the Federal Trade Commission would probe Amazon.com Inc. and Facebook Inc. As Monday progressed, Reuters reported that Apple Inc. may also be scrutinized by the Justice Department, and the House Judiciary Committee said it's planning antitrust hearings to investigate competition in the technology industry. The stocks were down 3% to 10% at their lows of the day.

The shares made up much of their losses the following day, helped along by some soothing words from Federal Reserve Chairman Jerome Powell, who signaled the central bank would consider cutting interest rates if the economy needed help. And the recovery made sense even without the Fed chair's words. As analysts pointed out, antitrust investigations can take years to conclude. And just dominating your market isn't against the law. "Obtaining a monopoly by superior products, innovation, or business acumen is legal; however, the same result achieved by exclusionary or predatory acts may raise antitrust concerns," reads the FTC's *Guide to Antitrust Laws*.

U.S. regulators have in the past been mostly hands-off when it comes to tech, a stark contrast to Europe, where regulators have been aggressively pursuing antitrust cases. That appears to be changing. Law enforcers are on the verge of opening broad investigations that could yield significant changes to how the companies do business and potentially lead to a breakup of a company. "It has been building to a fever pitch over the last six to 12 months," says Michael Carrier, a law professor at Rutgers University. "There's general unease these companies have too much power, and it really crosses the political aisle."

While Europe slapped Google with almost $10 billion in fines as a result of antitrust probes, remedies in the U.S. in such cases often center on making narrow changes to a company's conduct rather than imposing huge fines, according to Bloomberg Intelligence. Then there's all the cash that Big Tech has spread around Washington. Greg Valliere, chief U.S. policy strategist for AGF Investments, says money spent on lobbyists and political contributions will limit the repercussions to minor wrist slaps and some fines.

Yet until that resolution comes, there will be plenty of opportunities for negative headlines. Big Tech makes a handy punching bag for politicians looking to garner votes going into the 2020 elections. Already, Massachusetts Senator Elizabeth Warren has made breaking up big tech companies an element of her campaign for the Democratic presidential nomination. "I think investors have just been too complacent about the policy risks to this part of the market," says Lori Calvasina, head of U.S. equity strategy at RBC Capital Markets. "At least up until this week."

In a market so focused on growth stocks, any weakness of these heavyweights and the lack of a clear leading sector may make it harder for the market to keep climbing. That's particularly true while the administration's trade policies continue to create uncertainty. The dent to business confidence from trade tensions could linger, and quantifying the drag on the economy is especially difficult, J.P. Morgan economist Michael Feroli wrote in a client note, the title of which flicked at Trump's MAGA acronym: "Making Abysmal Growth Attainable."

Trade tensions mean that corporate managements could freeze investment plans and decision-makers will factor in a greater risk of policy uncertainty when dealing with the U.S., according to Kim Catechis, who manages emerging-markets equity funds at Martin Currie Investment Management in Edinburgh. "The world has spent the last 75 years working on very clear rules-based commerce, and that meant we ended up with supply chains in all industries that are defined down to the last minute of delivery," he says. Because of the shake-up in global trade, he adds, "I don't think company managements ever again will go back to what we had." —*Michael Regan*

"There's general unease these companies have too much power"

THE BOTTOM LINE Word from Washington of antitrust inquiries into the tech industry gave Wall Street one very bad day—maybe not for the last time.

The Leftist Turns Right

● Ecuadorian President Moreno wants to keep his country from becoming Venezuela

For WikiLeaks founder Julian Assange, the morning of April 11 arrived as most others had over the almost seven years he'd lived as a refugee at the Ecuadorian Embassy in London. Granted asylum there in 2012, he was hiding from British authorities after jumping bail to avoid extradition to Sweden on rape allegations and to the U.S. for publishing secret government documents. Australian by birth, Assange had been granted Ecuadorian citizenship and was therefore officially an Ecuadorian sleeping on Ecuadorian soil. He was untouchable.

At 9:27 a.m., police entered the embassy and arrested him. The question most have asked since is whether Assange, viewed as either a free-speech icon or a Russian-sponsored nihilist, will be extradited first to Sweden or to the U.S., where he was recently indicted on 17 counts of violating the Espionage Act. Less attention has been paid to the man who, half a world away, made the decision to expel him: Ecuador's president, Lenín Moreno.

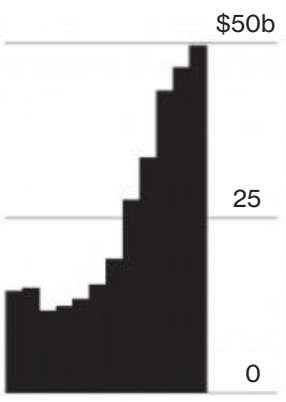
Moreno's shift on Assange was the latest but also the most dramatic signal that Ecuador, previously linked with the authoritarian Left in Bolivia, Nicaragua, and Venezuela, is moving in a new direction—and back into the good graces of the U.S. Following a trip to Ecuador last summer by Vice President Mike Pence, the first such visit since Richard Nixon's in the late 1950s, other governments whose relations with Ecuador had been cool have joined in supporting Moreno. In recent months, Moreno's government has hosted German President Frank-Walter Steinmeier, South Korean Prime Minister Lee Nak-yeon, and U.K. Trade Minister George Hollingbery, who in May became the first British cabinet minister to visit the country in almost a decade.

Rafael Correa, the president's former mentor and predecessor, thought he'd selected a seat warmer in Moreno. From 2007 to 2017, Correa embarked on a string of ill-considered public works projects, including power plants, refineries, pipelines, airport terminals, and a railway. Having intentionally defaulted on $3.2 billion of bonds in 2008, he turned to China to fund many of the projects, with plans to repay in oil shipments. By the time Moreno took office two years ago, only three of the eight hydroelectric power plants Correa had started building, costing a combined $3.7 billion, were operating. Ecuador owes China a total $6.7 billion.

Today, Correa is living in Belgium to avoid facing charges at home that he had a political opponent kidnapped. Moreno, who's 66 and the world's only elected head of state in a wheelchair, has established a different tone. He pushed through a referendum that established term limits for elected officials and set the stage for judicial reformers to replace a constitutional court so discredited that several members were under suspicion of money laundering. He reoriented the country's economic policy, including appointing a young business leader as finance minister, which led to a decrease in yields on Ecuadorian bonds and a deal with the International Monetary Fund to restore dollar reserves and stabilize public debt. He nudged his country away from China and welcomed private investment. And he's begun a cleanup of hundreds of oil spill sites that had been allowed to fester for a generation while the previous government sponsored unsuccessful international litigation against Chevron Corp.

Moreno has also denounced Venezuelan President Nicolás Maduro—who was known as "comrade" in Quito, the Ecuadorian capital, as recently as a year ago—and recognized U.S.-backed opposition leader Juan Guaidó. This in particular is a victory for the U.S. "Having a government elected on a left-wing platform in favor of American

● Ecuador's government debt



● Assange

policy is really important for making it look like this is acceptable to the region and not just built up by Donald Trump's team in Washington," says Francisco Rodriguez, a Venezuelan who runs economic and political analysis of the region for Torino Capital in New York.

In an interview at the presidential palace, Moreno describes himself as a "former cafe socialist" who, until he was shot in a bakery robbery in 1998, liked to "read a lot of dialectical materialism." After the shooting, he went through four years of searing pain and depression. When he emerged, he says, it was with a conviction that joy, jokes, and helping others were life's salvation. He became a motivational speaker, then a scholar of the healing power of humor, and finally he was pulled into Correa's orbit by mutual friends. Moreno had been active in left-wing circles since high school, but his first run for office was on Correa's presidential ticket in 2006, when he was elected vice president. In the beginning, like many, he believed in the former president. Now he says that under Correa, Ecuador was "like a frog in water slowly heating up. The frog gets used to it," including "limits on association and speech."

Moreno says his turn to the U.S. is in keeping with his appreciation for democracy and human rights. Although he says he has his criticisms of U.S. policies, he didn't specify what they were. So far he's secured $10.2 billion in loans to be disbursed over three years from the IMF, the World Bank, and the Inter-American Development Bank, which he'll use to fund public housing and clean water delivery, in addition to the economic stabilization program. Moreno says socialism gets one thing right: that helping those in need and pursuing economic equality are indispensable. "That's why my government will produce with the right and distribute from the left," he says.

In the predawn chill one morning, he demonstrates what he means. After being wheeled onto the narrow streets of Quito's historic center, in the shadow of Ecuador's neo-Gothic national basilica, he holds the hands of the elderly and homeless sleeping under blue plastic tarps. His government is going to build them homes and give them dignified funerals, he says. (His aides confirm that some 200,000 units for the homeless are already being built.) "Moreno's great strength is his apparent weakness," says Simon Pachano, a political scientist at Quito's Latin American Faculty of Social Sciences, or Flacso. "He places himself outside the political struggle and presents himself as someone working for the people."

Ecuador's most dogged investigative journalist, Fernando Villavicencio, offers a dissenting view. Moreno has eased up on repression, he says, but he's also corrupt, citing alleged kickbacks from Chinese construction company Sinohydro, the purchase of an apartment in Spain through an offshore shell company, and a Swiss bank account belonging to the president's wife. Moreno has denied the accusations and said he'll open accounts he had while in Geneva to investigators; prosecutors have begun to review the matters.

Ecuador, which has $51 billion in national debt—representing almost half of the country's economy, with only a decade to repay much of it—isn't going to recover quickly. Still, there's a fair amount of optimism. Moreno has committed to serving a single term, which adds to his credibility.

▼ Moreno greets residents of Latacunga, a mountain city south of Quito, in April after the inauguration of a government water program

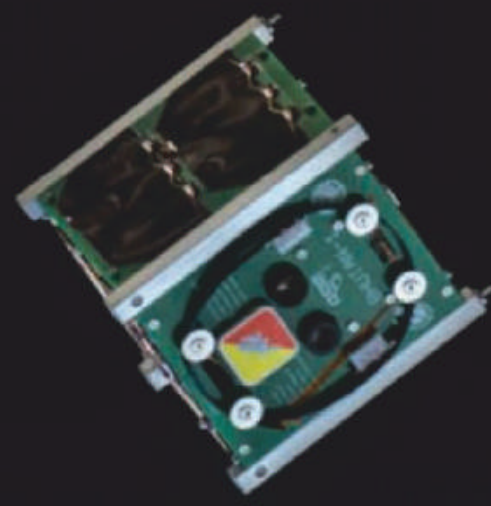
Susan Segal, a former banker who's president of Americas Society/Council of the Americas, draws a parallel with Chile, where Patricio Aylwin was a one-term president starting in 1990, following the dictatorship of Augusto Pinochet. Aylwin restored key institutions, setting an impoverished country on the path to stable prosperity, Segal says.

Jean Cano, a press freedom activist, says that had Correa remained in power, he and other journalists would be abroad or in prison. Fabricio Villamar, a conservative member of Congress and an opponent of Moreno's, puts it more poetically. "There's no question that things have changed for the better," he says. "You can feel the liberty in the air." —*Ethan Bronner and Stephan Kueffner*

THE BOTTOM LINE While Ecuador faces potentially crippling debt, Moreno has put in place reforms that have helped reopen the country's diplomatic relations and stabilize its economy.

ASSANGE: LUKE MACGREGOR/BLOOMBERG. MORENO: DOLORES OCHOA/AP PHOTO. DATA: IMF

WE NEED A NEW VISION O TECHNOLOGIC PROGRESS.



SOONER THA

Shoebox-size cubes like these—one of which was Bhutan's first satellite to enter orbit—may one day blanket the globe for near-real-time coverage

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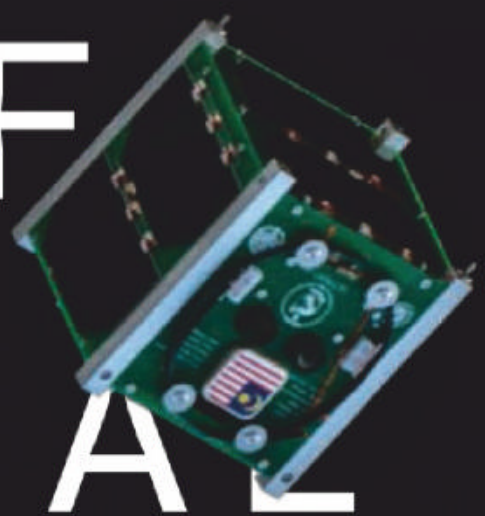


CAL

WE'VE GOT OPTIONS

N YOU THINK

The world is full of innovations more important than ad algorithms. You just need to look outside Silicon Valley

By Ashlee Vance

The scene played out much like you see on television, only scarier. It was May 2017, and a fight between young Palestinian men and Israel Defense Forces soldiers broke out on a street in Ramallah. A handful of troops were barricaded behind two military vehicles stopped in the middle of the road, and now and again the young Palestinian men would rush up, sling rocks at the soldiers, then retreat. This back-and-forth went on for 20 minutes before the youngsters grew more brazen, lighting a dumpster on fire and pushing it toward the IDF position. Standing amid other onlookers on a dry, scrub-covered hill about 100 yards away, I wondered what would happen next, when a flood of IDF soldiers appeared out of nowhere. They peppered the area with rubber bullets and charged the Palestinians and those of us on the hill. People ran for cover. The acrid smell of tear gas hit nostrils. Ambulances reversed in haste with bleeding rock hurlers inside.

I dashed from the hill and made my way through a few city blocks where people drank tea outside cafes and tried to act as if nothing out of the ordinary had happened. My destination was Leaders, a kind of industrial park for startups, which had a banner day planned. Patrick Collison, the billionaire co-founder of the online payment company Stripe Inc., had come to Ramallah to speak with young entrepreneurs about his experience building a startup and about how technology could bring them economic opportunity. Dozens of people packed the conference room, many of them Arabs from East Jerusalem who needed to wait for several hours at security checkpoints to hear Collison. The red-haired Irishman began by apologizing for not speaking Arabic, then explained how he'd grown up in a rural setting and could perhaps relate to a feeling of isolation and the struggle to make an impact on the world. "There is that sense of comparative inferiority," he said, recalling his own childhood in Dromineer, a village in central Ireland. "You are clearly much less significant than the bigger forces around you."

More than a third of the attendees were women. One was the founder of a Middle Eastern online lingerie company, Kenz Inc., that counts Saudi Arabia as its largest market. Another worked as the chief technology officer for RedCrow, a service that alerts people to attacks and violence happening near them. One person everyone wanted to know was Dina Zabaneh, a connector who had her finger on the pulse of the Palestinian startup world and knew all the major players.

I spent a couple of days with Collison visiting startups and investors in Ramallah. Their stories were inspiring and heartbreaking. Some of their hardships—the violence, the walls and fences, the travel restrictions—were obvious. Others were not. Israel has banned 3G networks in the Israeli-occupied territories, which has forced people to develop smartphone apps on old technology and then head to hilltops to find a faster connection and to test how

18+

WHAT IS AVAXHOME?

AVAXHOME-

the biggest Internet portal, providing you various content: brand new books, trending movies, fresh magazines, hot games, recent software, latest music releases.

Unlimited satisfaction one low price
Cheap constant access to piping hot media
Protect your downloadings from Big brother
Safer, than torrent-trackers

18 years of seamless operation and our users' satisfaction

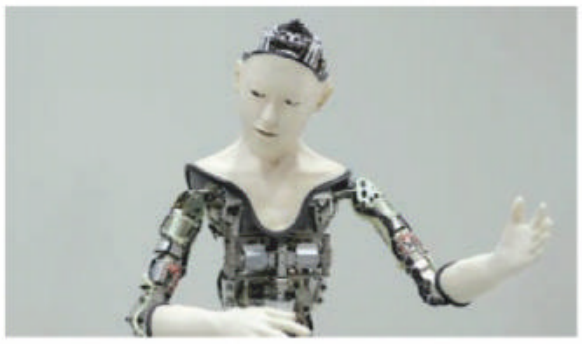
All languages
Brand new content
One site

AVXLIVE.ICU

AvaxHome - Your End Place

We have everything for all of your needs. Just open https://avxlive.icu

Australian biohacker Meow-Ludo Disco Gamma Meow-Meow took his name from these glowworms



A Japanese android that speaks its own language and interacts with humans

An exoskeleton made by New Zealand's Rex Bionics

their services would work in the rest of the world. Money is hard to come by, too. Arab culture tends to favor traditional family businesses rather than high-risk startup ventures. While failure is celebrated in Silicon Valley, it comes with a real cost here both in terms of lowered social status and in making ends meet.

You might think being part of the 21st century tech gold rush would feel like an impossible goal under such conditions. And yet the people I met reminded me how technology can still inspire optimism. Wherever Collison went, young entrepreneurs pumped him for information, and you could see that they imagined they might end up just like him. They might make something that people in far-off lands would use every day. They might get ahead.

For the past two years, I've visited technology hubs in places such as Palestine, Israel, China, Russia, Australia, Iceland, and Chile. The story is the same the world over. There's a degree of Silicon Valley mimicry. But there's also an impressive number of fresh ideas and approaches to sculpting the future. The monoculture that's arisen in the Bay Area is being challenged by something new, diverse, and perhaps more powerful.

The energy overseas is reminiscent of what used to exist in the Valley. Dial all the way back to the early 1900s, and you find the San Francisco Bay Area already full of hobbyists pushing the limits of what radio, vacuum tubes, and other mind-blowing new technologies could do. They were followed by physicists, chemists, and electrical engineers who manipulated matter to make it come alive and think for us. And then came the builders—the people who created the vast, complex communications infrastructure on which the modern world runs. All of this bubbled up from what used to be known as "the Valley of Heart's Delight," because of its endless farms full of pears, apples, and nuts, and it did so in an historical instant.

The undercurrents of Silicon Valley's hope and idealism still linger, though these concepts have been perverted. Somewhere along the way, the Valley lost sight of technology as a tool, or what Steve Jobs liked to describe as "a bicycle for the mind." The notion of unlocking human potential faded, and things tilted much more toward entertainment, filling people's free time with diversions, and seeing how much money could be made off convenience.

This didn't happen all at once. The Valley felt a lot different after Netscape went public in 1995, ditto after the dot-com boom and bust a few years later. But for me, the Valley's new, post-idealism era really took hold with the arrival of Google. The company had a noble mission of making the world's information accessible to everyone, and it did a remarkable job at exactly that. People can now tap into an infinite stream of knowledge. But it's what pays for all of this that feels like the underlying flaw of the modern Silicon Valley.

Peering inside a social robot from Sweden's Furhat Robotics

An underwater drone built by Abyss Solutions explores a reef near Sydney

At their cores, Google, Facebook, Twitter, and their peers are advertising companies. Their job is to design addictive services and have you spend as much time on them as possible. Your time, your data, your virtual self is the product. Many of the world's smartest people have been funneled to the Bay Area to accomplish this with ever-increasing efficiency. This isn't Don Draper trying to win over the public with a catchy jingle. It's the greatest assembly of brainpower ever harnessed, aiming to pull you out of the real world into an invented one that's measured and manipulated with shocking precision.

Even so, I think we've become too myopic in our haranguing of social media and search engines. These services are technology, but technology is much more—and it's still as powerful a tool as ever. It's just that Silicon Valley isn't the only place where the future is being made.

Look at the aerospace industry. Rocket and satellite operations are popping up in Australia, China, Denmark, Israel, Japan, and New Zealand. Small teams of people are building things that used to require the resources of national governments. Similar shifts have taken place with transportation, as improvements in electric batteries and motors, software control systems, and artificial intelligence have given people the belief that their sci-fi dreams are possible.

The improvements in technology have been helped along by tools developed in Silicon Valley—especially cloud computing and open source software. And they've been accompanied by some promising social and cultural shifts, too. Take the case of Naomi Kurahara, a Japanese electrical engineer. In 2016 she founded a company called Infostellar Inc. that's creating a cheaper way for satellites to deliver information around the world. In years past, Kurahara likely would have stayed in academia after receiving her Ph.D. or gone to work at a large Japanese tech conglomerate. Instead, she took a risk, formed a startup, and raised capital from investors while toting her newborn baby to pitch meetings and having him sleep in a box next to her. "I didn't think much about it," she says. "I'm a CEO and a mom. They're both my jobs."

One of her backers, Lewis Pinault of Airbus Ventures, has lived in Japan for many years and read far more into the moment. He's watched the great Japanese industrial and tech empires struggle and seen the society adapt in imaginative ways. "There has been a big societal dislocation, where the idea of lifetime employment and trusting and relying on a big company is gone," he says. "People have been forced to be more creative and figure out things for themselves, and they have started self-organizing. It was inconceivable years ago that someone in Naomi's position would start a company."

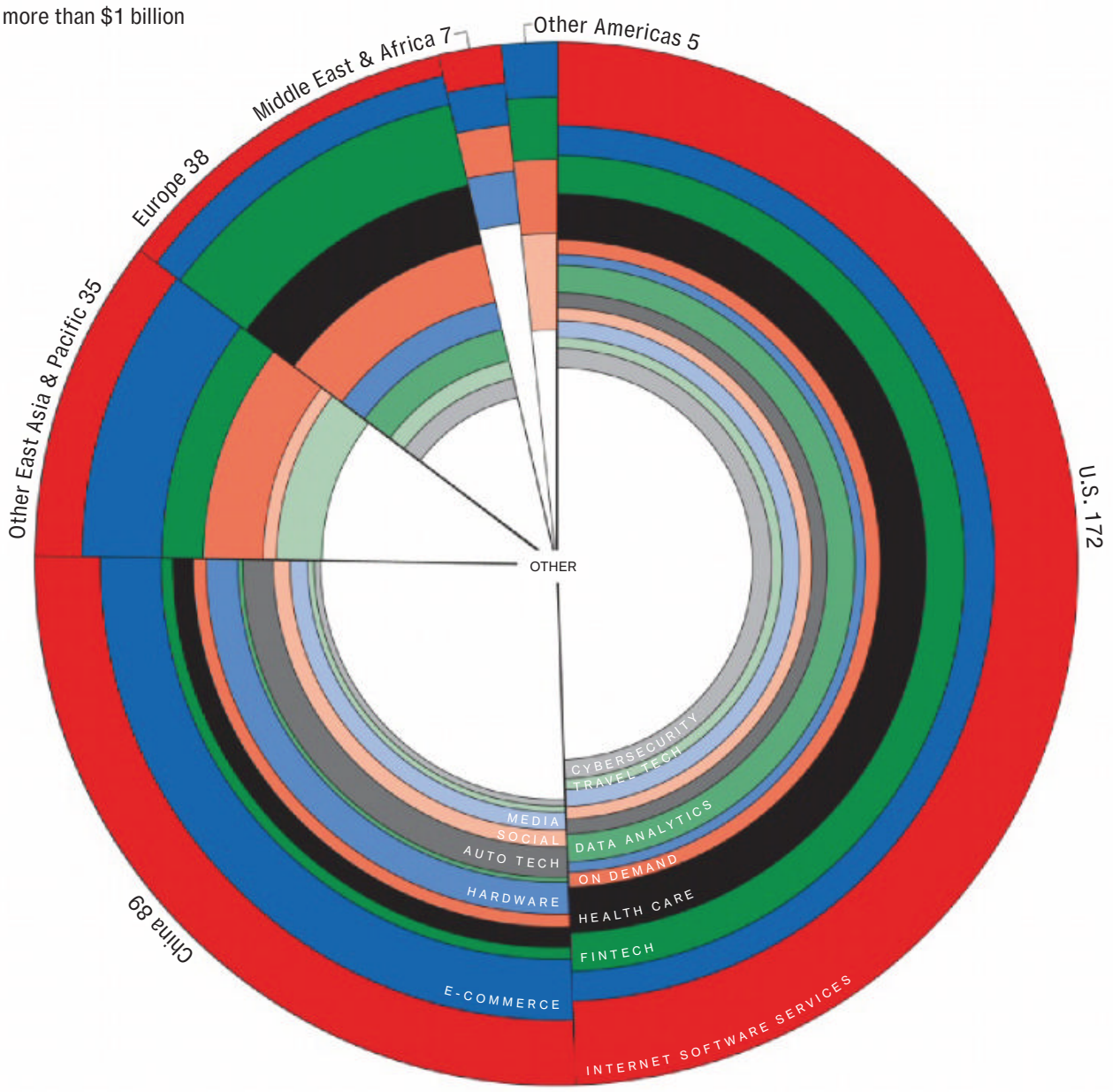
To its credit, Silicon Valley set the example for this. Its culture of unbridled ambition and the relentless pursuit

of what others deem impossible is infectious and spreading. There are plenty of reasons to be frightened by this but, I think, many more reasons to be optimistic. It's cliché now in the Bay Area for everyone with an app or online store to claim they're changing the world for the better. Elsewhere, though, this belief carries real meaning. It certainly does in the labs in Jerusalem making artificial organs, and for the engineers in the Atacama Desert producing devices that pull clean water from the air, and for the scientists in Siberia working to generate clean energy from fusion. People who were once limited by geographic isolation and poverty now aspire to sell products and services to the world. The tolerance for risk, nurtured and perfected in the Valley, has made its way to new homes.

If fantastic riches got Silicon Valley off track, there's a chance the rest of the world can shove it back. New voices can rise alongside new ideas, and people can form a new relationship with technology. To think otherwise is to believe far too much in the power of the algorithm over human agency and creativity. Ⓑ

Unicorn Industries

Private companies valued at more than $1 billion as of May 9, by industry



DATA: CB INSIGHTS

Simpson with her son, Omarion, whose gene therapy treatment has allowed him to leave hospital isolation

‘MIRACLE CURES’ IN YOUR GENES

One-time treatments appear to be curing once-incurable patients like “bubble boy” Omarion Jordan. Most people can’t afford them

By Michelle Cortez
Photograph by Tamara Reynolds

Omarion Jordan spent almost all of his first year of life in hospital isolation rooms. The nightmare began with what looked at first like diaper rash, a string of red marks that quickly spread across his body when he was just shy of 3 months old. Creams and ointments failed, as did the eczema shampoo treatment an emergency room doctor prescribed. Last July, hours after Omarion's pediatrician injected his three-month vaccines into his thighs, the boy's scalp began weeping a green pus that hardened and peeled off, taking his wispy brown curls with it. His head kept crusting over, cracking, and bleeding, and his mom, Kristin Simpson, started to panic. "His cries sounded terrible," she recalls. "I thought I was going to lose him."

She took her son back to the ER two nights in a row, only to have the doctors send them home each time to their apartment in Kendallville, Ind. "They thought I was some antivaccination person," she says. "They looked at me like I had a foil hat on my head." The next day, however, the boy's pediatrician diagnosed pneumonia and sent them back to the hospital for a third time, at which point they got more attention. A battery of tests revealed a rare genetic disorder called severe combined immunodeficiency syndrome (SCID), better known as the "bubble boy" disease, which makes 40 to 100 American newborns each year extremely vulnerable to infections, like John Travolta in the old TV movie. Omarion, transferred to an Ohio hospital three hours away, was confined to an isolation room with special air filters.

Left untreated, SCID kills most children before they turn 2. Simpson spent five months waiting for a bone marrow transplant for her son, the only conventional treatment and one that the doctors told her carried serious risks. Then they told her about an alternative: an experimental gene therapy that just might cure Omarion outright. "It was kind of like a leap of faith," she says, but she figured that if it didn't work, they could go back to praying for the transplant.

It worked. In April, Omarion was released from the St. Jude Children's Research Hospital in Memphis, where a team of researchers had taken stem cells from his bone marrow, bathed them in trillions of viral particles engineered to carry the gene missing from SCID patients, and reimplanted them in the boy to begin replicating, repairing the errors encoded in his cells. A preservative in the cell treatment left him smelling like creamed corn for days afterward, Simpson says, but his immune system has begun working normally, his white blood cell count rising like those of the other nine kids in his study. *Bloomberg Businessweek* watched Simpson and Omarion venture for the first time outside of their St. Jude housing facility to play. Inside what's known as the Target House, they'd spent months in a filtered, isolated apartment for children with compromised immune systems. "He's just a healthy baby now," Simpson says in the house's Amy Grant Music Room, sponsored by and lined with photos of the Christian pop singer. "It's definitely a miracle."

This is the tantalizing promise of gene therapies, the potential cures for dozens of once-incurable illnesses. The U.S. Food and Drug Administration issued its first approval of a systemic gene therapy, a Novartis AG treatment for spinal muscular atrophy, on May 24 and says it expects to approve 10 to 20 therapies a year starting in 2025. There are more than 800 trials under way, targeting diseases including rare metabolic disorders, sickle cell anemia, hemophilia, and Parkinson's. As the list grows, such treatments have the potential to fundamentally remake the health-care system at every level.

There are two big caveats. First, most studies haven't run longer than a few years, so it's impossible to know yet whether the therapies will remain effective for life, help everyone the same, or yield side effects decades in the future. Only about 150 children have received the Novartis muscle treatment, Zolgensma, and at least two have died, though the therapy doesn't appear to have been to blame.

The other problem is cost: These treatments are expected to run several million dollars a pop. Zolgensma is the most expensive drug ever approved in the U.S., with a price tag of $2.1 million for a one-time infusion.

"The cures are coming," says Alexis Thompson, a gene therapy pioneer who heads the hematology department at the Ann & Robert H. Lurie Children's Hospital of Chicago, "but there are still a lot of considerations." Safety, efficacy, fairness, and long-term follow-up care top her list. "Even if someone undergoes gene therapy and is cured of a disease, we need to ensure that they have access to a health-care system that will allow us to follow them for conceivably 10 to 15 years," she says. Then there are the more ghoulish concerns about returns on investment that tend to come with pricey research and development projects. "While this proposition carries tremendous value for patients and society, it could represent a challenge for genome medicine developers looking for sustained cash flow," Goldman Sachs analyst Salveen Richter wrote last year in a note to clients titled "Is Curing Patients a Sustainable Business Model?"

Every human has about 20,000 genes, half each from Mom and Dad, that make proteins to break down food, maintain cell health, provide energy, pass signals to the brain, and so on. A defect in a single gene can cause any one of about 7,000 potentially devastating or life-threatening diseases. Viruses have been

Manufacturing facilities like the one at St. Jude can spend months growing, purifying, and testing therapies

thought to offer a solution since the 1980s, when an MIT researcher first modified one to deliver a healthy gene into a human cell. In 1990 the National Institutes of Health used such a treatment to save 4-year-old Ashanthi DeSilva from an immune disorder that would otherwise have killed her in a matter of years.

A handful of early disasters temporarily halted progress on gene therapies. In 1999 an overwhelming immune response to one treatment killed an 18-year-old from Arizona, turning his eyes yellow and spiking his fever above 104F. Researchers abandoned a SCID trial in France in 2002 after one of the 10 bubble boys developed leukemia; eventually, four of them did. Still, scientific work continued, and as researchers created better technology, they started delivering remarkable results. In 2007 patients with a genetic form of blindness saw their vision improve. Blood cancer patients given only weeks to live in 2012 went into remission after their immune systems were reprogrammed to attack malignant cells. Hemophiliacs started producing clotting proteins. The past five years have been revolutionary, says Lindsey George, a hematologist who leads gene therapy trials at Children's Hospital of Philadelphia. "This is a transformative time," she says. "It isn't just a hope and a whim. It's supported by data and significantly so."

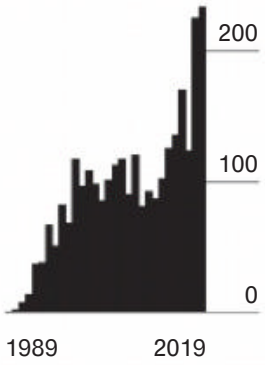
George cautions that it's tough to identify rare side effects with samples as small as most of the studies so far have used. Part of the problem is the supply of the therapies themselves, which require months of growing, purifying, and testing at manufacturing facilities such as the one at St. Jude. In Memphis, 200 1-milliliter vials of the master cell line used to target SCID sit in a stainless-steel tank of liquid nitrogen 4 feet in diameter, kept at a temperature of -256F. After thawing one of the tubes, technicians covered in sterilized clothes feed and nurture the cells for weeks in enclosed cabinets, moving the treatments from vials to flasks to stacked trays as they grow. Eventually, trillions of particles, tested for months to ensure their potency and safety, can be distilled into treatments for as many as 600 infants with the most severe form of SCID.

St. Jude spent millions of dollars to develop a bank of cells so it can treat new patients in a little more than a week at a cost of tens of thousands of dollars per case. For less practiced facilities, the manufacturing process for each treatment can cost $500,000 or more.

Researchers and doctors want to cure diseases that affect the most people, and the industry is focused on developing those treatments to sell. Novartis says Zolgensma doses are worth more than double the $2.1 million the company is charging. Spark Therapeutics Inc. has set the price for Luxturna, its treatment for an inherited form of blindness, at $425,000 an eye. "We really tried to focus on what is sight worth for a young child or an adult," says Spark Chief Executive Officer Jeff Marrazzo, "as well as what we needed to charge to be able to reinvest."

For some patients, gene therapy would be cheaper than current lifelong treatments. Take Tim Sullivan, a 63-year-old computer programmer born with hemophilia. Sullivan's earliest memories involve lying in a hospital bed, looking up at a bottle of blood slowly dripping essential clotting proteins into his veins. Even though medical advances eventually made it easier to extract the proteins from donated blood, such treatments left Sullivan infected with HIV and hepatitis C, the diseases that killed his two younger brothers, also hemophiliacs. He suffered almost every day with pain that came with even minor bumps and bruises and with inflammation from his weakened joints. "It's been my life," he says. "Pain was my constant companion." ▶

Number of gene therapy clinical trials approved worldwide



COURTESY ST. JUDE. DATA: THE JOURNAL OF GENE MEDICINE

Since birth, Sullivan's care has cost millions of dollars. He estimates that the drug he used from Pfizer Inc., BeneFix, and a longer-lasting version called Alprolix from Sanofi SA, cost an average of about $300,000 annually. The year he underwent a knee replacement, which required substantially higher doses of the drugs, the bills soared to more than $1 million.

Then, a year ago, Sullivan enrolled in a clinical trial for a gene therapy in development from Spark and Pfizer, and most of his symptoms disappeared, as did his routine drug costs. "It's life-altering," he says. "I haven't had to stick a needle in my arm for a year."

Sullivan, like Omarion, didn't have to pay for his experimental treatment. Once the dozens of coming gene therapies are approved and on the market, they may well be unavailable to most Americans, even those with insurance, says Steven Pearson, founder and president of the nonprofit Institute for Clinical and Economic Review, which assesses the value of medicine. "Employers will feel they can't cover it, especially smaller employers," he says. "It's like a freight train running against a brick wall."

In countries with centralized health coverage, such as the U.K., drugmakers don't sell their products unless the government agrees to cover them. In the U.S., drug companies sometimes step in to help struggling patients, giving them medications for free or reduced prices, but it's unclear whether this will be the case for all gene therapies. "As we start getting into diseases with more people, like hemophilia and beta thalassemia, access to care is going to be an issue," says Harvard medicine professor Jonathan Hoggatt.

Gene therapy developers including Novartis, Spark, and Bluebird Bio Inc. are starting to pitch novel and controversial payment plans. These include annuity models that allow insurers to pay off the treatments over time. So far, the programs aren't broadly covered by Medicare or Medicaid; developers must negotiate them individually with insurers. "The way the payment system is set up in the United States, we pay by episode of care, and we happen to be delivering a one-time therapy," says Spark's Marrazzo. "Ultimately, I think we should get paid a smaller amount, over time, as long as it's working. We should be standing behind these products."

Critics argue that longer-term payment plans could just as easily lead to price escalation and abuse. "If we just turn every single treatment into a home mortgage, all we do is kick the can down the road," Pearson says. "Prices will be too high because they will think we can pay for it later."

For patients suffering from these kinds of rare diseases, many of which generally prove fatal, there may not be time to resolve all the questions of supply and demand. Some academics are willing to build gene therapies to order, but that means patients need to raise the money themselves. Amber Freed, a former equity analyst in Colorado, is trying to raise $1 million to cover the development costs of a treatment for Maxwell, her 2-year-old son, who suffers from a rare, newly discovered genetic disease. She's $600,000 short, and he has a year, maybe two, before the worst of the symptoms, severe seizures, may cause permanent damage. "His birthday was so bittersweet," Freed says. "Time is not on his side."

The pharmaceutical industry appears confident that gene therapy's market problems will sort themselves out. The likes of Roche Holding AG and Bristol-Myers Squibb Co. are paying billions or tens of billions of dollars to acquire promising companies. Novartis, too, got access to Zolgensma through its $8.7 billion purchase of a tiny startup that, at the time, had no products on the market.

Still, big hopes are being pinned on small studies with few patients. Sarepta Therapeutics Inc. went all-in on a therapy for Duchenne muscular dystrophy after it had been tried on only four boys. "For the next 24 months, we'll be spending many hundreds of millions of dollars to support this," says CEO Doug Ingram. "We'll have to build more manufacturing capacity in the next two years than all the gene therapy manufacturing that exists in the world today."

Ingram says it's a moral imperative given that 400 boys in the U.S. and 3,000 around the world die from the disease every year. Although the study hasn't yet been published, he says preliminary findings for the first four patients are unprecedented, with improvement at every time point and across every test. "All the markers would lead one to believe these kids are transformed," he says.

At home in Indiana, where she lives with Omarion's father and his family, Simpson still takes many of the same precautions she did when Omarion was suffering from SCID, including wiping down all his toys daily to ward off germs. "I'm still very paranoid," she says. "I'll be really overprotective." But she recognizes how far they've come from only a few months ago, when he was stuck in the isolation chamber where he took his first stumbling steps. "He's started to develop really fast, because he can just crawl anywhere on the ground and play with whatever," she says.

His favorite activity is chasing a ball around a park near their home. Again and again, he'll throw it as far as he can, then fast-crawl after it, without having to worry about the germs in the grass or the dirt. Ⓑ

For more on the future of health care, go to Bloomberg.com/prognosis

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SCANNING

A small swarm of drone subs that rapidly found two missing wrecks may offer solutions to other mysteries of the deep

Last November a small seabed-exploration company out of Houston called Ocean Infinity made the discovery of a lifetime—or so it seemed, until it made another three months later. First, Ocean Infinity successfully located the remains of the *San Juan*, an Argentine navy sub that had vanished while on patrol. Then it found the wreck of the *Stellar Daisy*, a South Korean bulk ore carrier. Both vessels had been missing for more than a year, which often means a wreck won't ever be found. The two-year-old company's secret was teamwork: a set of eight drone subs working in tandem to scan a much larger area in record time.

These successes could be part of a broader shift in how humanity understands the sea. We know far more about the surface of Mars than we do about the bottom of the ocean, but seabed-scanning technology is growing sophisticated enough to render the inky depths much more transparent. Seabed 2030, a joint project of two nonprofits, aims to map the entire ocean floor by its namesake year. Key to that effort is Kongsberg Maritime AS, the Norwegian company that made Ocean Infinity's subs.

Bjorn Jalving, senior vice president of Kongsberg's subsea division, says the Hugin, its flagship drone, is a testament to advances in robotic strength and stamina. Hugins can dive as deep as 20,000 feet and stay underwater for 72 hours at a stretch. Costing $5 million to $10 million apiece depending on the onboard instruments they have and the depths they can handle, the drones are hardy enough, Jalving says, that "you let them out in the ocean, and you know that they'll come back." They're also packed with sensors, including

Jalving with Hugin drones, which have helped almost triple the area of surveyed seabeds since 2017

The drones can dive as deep as 20,000 feet and stay underwater for up to 72 hours

THE SEAS

By Jeff Wise
Photography by Ivar Kvaal

sonar that can cover five times the area of models from a decade ago, with 10 times the detail.

The subs can also transfer, process, and share much larger amounts of data with distant control centers than was possible before. Five years ago, Fugro NV, the Dutch survey and geosciences company responsible for searching the Indian Ocean for the downed Malaysia Airlines Flight MH370, relied on crewed survey boats that towed sonar gear on long cables up and down the seafloor as shipboard analysts monitored incoming data. Today the company streams field data to command centers onshore and plans to do away with some crews entirely.

Since 2017, Seabed 2030 has single-handedly increased the percentage of the seabed that's been surveyed from 6% to 15%, mostly by compiling data from the likes of Fugro and Ocean Infinity. Fugro keeps mapping even when it's moving ships between jobs. Beyond potential benefits such as finding clearer routes for undersea internet cables or energy pipelines, the extra intel will help answer big scientific questions related to climate change, says Larry Mayer, who contributes to Seabed 2030 as director of the Center for Coastal & Ocean Mapping at the University of New Hampshire. "How heat is distributed has to do with currents, and where those currents go is determined by where there are ridges and valleys and things," he says. "It's the most fundamental information that we can get."

Just as the first sequencing of the human genome led to businesses sequencing many other people's genomes, seabed mapping could one day become routine, or even just an ongoing process, helping to track things such as pollution, ocean warming, and fish stocks. "It will enable the world's decision-makers to sustainably manage the oceans," Jalving says.

For now, though, the oceans are keeping a great many secrets. After Fugro failed to find MH370, Ocean Infinity gave the search a shot last year, scanning 43,000 miles in five months—about 15 times the pace in 2014. That team, like Fugro's, found nothing. Ⓑ

HOW TO CON
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$20

NNECT LION H A PHONE

In rural Africa, a phone's battery life tends to be a higher priority than screen size. Those markets may finally get an internet connection tailored to their needs

By Shira Ovide
Photograph by Sarah Waiswa

KaiOS phones put smartphone brains in longer-battery-life bodies

A few short years ago, the perennial corporate quest for the Next Billion Internet Users seemed like a strong pitch. Tech companies would put the sum of human knowledge in the pockets of the world's poor, all while pulling in ad dollars from big multinationals that would pay to reach them. These days, though, the costs of this business model are clearer. Social media apps have been blamed for stoking a genocide in Myanmar, lynchings in India, and electoral interference around the world. They've also contributed to a creeping, grinding addiction to our glowing, rectangle-shaped dopamine drips. Do we really think the 50% of humanity without an internet connection would be better off with one?

Well, yeah. Greater internet access correlates directly with improved health care, ▶

education, gender equality, economic development, and lots of other goals well-financed nonprofits struggle to achieve. Boosting a poor country's mobile internet use by 10% correlates with an average 2 percentage-point increase in gross domestic product, and electronic channels have proved capable of making governments more responsive to civic complaints, too. By contrast, women and people living in rural areas lag behind in online use, which limits their access to government services, banking, and job opportunities.

Nowhere is that clearer than in Africa, which has the world's lowest share of people using the internet, under 25%. The cohort of 800 million offline people spread across the continent's 54 countries is younger and growing faster than most, but incomes are lower and a larger share of residents live in rural areas that are tough to wire for internet access—or, for that matter, electricity. Now, however, a handful of phone purveyors are trying in greater earnest to nudge internet-ready upgrades into African markets, with models designed with an eye toward rural priorities (first those of rural India, where they're already hits), rather than battered thirdhand flip phones from the heyday of the Spice Girls.

Two of the biggest mobile phone operators in Africa, MTN Group Ltd. of South Africa and France's Orange SA, this year started selling quasi smartphones for as little as $20. Previously the floor had been around $40, well out of reach for many people. These devices, which have a smartphone brain in the body of 1990s candy bar phones, are powered by software from KaiOS Technologies Ltd., a three-year-old spinoff of a Chinese electronics giant that picked up the pieces from a failed effort to produce cheap internet devices.

Most companies are trying to make internet-connected devices ever more powerful and capable, but KaiOS went the other way. It rethought everything to keep the essential capabilities of smartphones but strip out costs and preserve battery life for people who likely have spotty access to electricity. MTN said in a statement that its KaiOS phones are designed to pull down barriers to the internet's benefits. Bertrand Gouze, a vice president for Orange's operation in Africa and the Middle East, says the KaiOS devices offer an alternative to the more expensive phones that remain "out of reach to many Africans and contribute to the digital divide."

The body of a KaiOS phone is as basic as it gets. There's no touchscreen, which tends to be the priciest smartphone component and a battery hog. The models that Orange sells—named Sanza, after a handheld musical instrument typically found in central and eastern Africa—have a screen that's less than half the size of the latest iPhone's and controlled with an old-school keypad. The keys are made from the least expensive plastic possible. In Nigeria, Rwanda, and other countries where MTN has just started selling KaiOS phones, they're designed for 3G networks, because 4G coverage doesn't reach two-thirds of MTN's 230 million regional customers.

To save money, KaiOS also shrank the memory to about one-quarter or less that of the cheapest Android smartphone. That means the phones can handle only one task at a time—no hopping back and forth from your group text to look up stuff on the web. For some KaiOS models, Qualcomm Inc. refashioned an old version of its processor, the phone's brain, at an estimated cost of about $3, compared with the roughly $50 version found in top-end smartphones. In total, KaiOS-powered phones are made from about $15 worth of parts, estimates Wayne Lam, an analyst with researcher IHS Markit Ltd. Materials for the next-cheapest comparable phones cost at least twice as much, and Apple Inc.'s top-of-the-line iPhone has $390 worth of stuff.

That doesn't mean these scaled-down phones aren't capable. All the cut corners result in a device that uses so little power, Orange says, it can last as long as five days on a single charge. The lack of a touchscreen also makes voice commands more valuable, so there's a giant button in the middle of the phone that activates a version of Google Assistant adapted for local markets. Google invested $22 million in KaiOS last year and contributed to a fresh $50 million funding round announced on May 22.

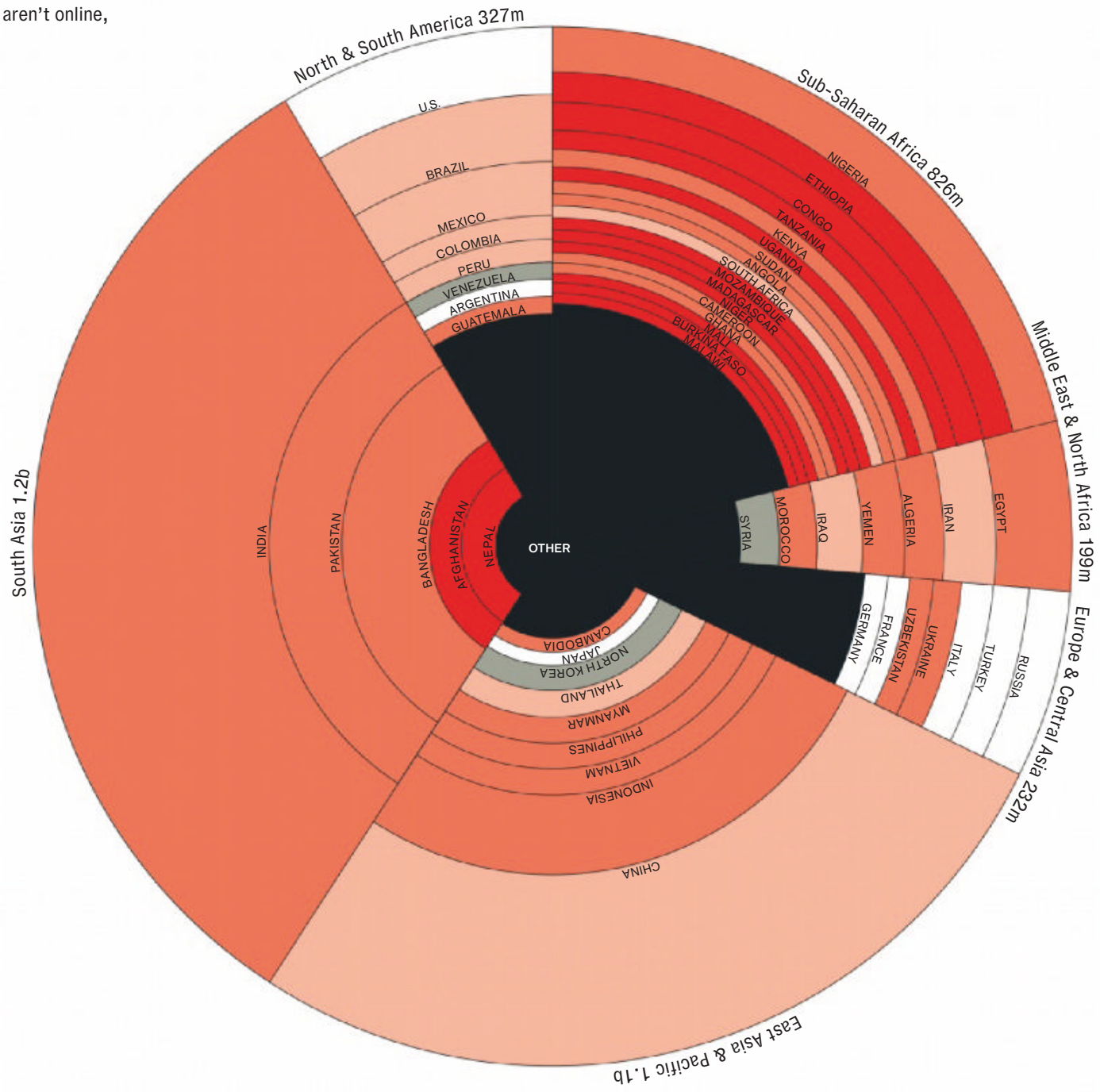
In ways both high-tech and low-tech, internet providers are putting in the effort to make getting online feasible in conditions that tend to beat up on silicon. Nairobi's BRCK Inc. builds computers with cheap off-the-shelf parts to beam out connectivity from

All the cut corners result in a device that uses so little power, Orange says, it can last as long as five days on a single charge

The World of No Internet

Number of people who aren't online, by region and country

GDP per capita
- Less than $1k
- $1k - $5k
- $5k - $10k
- More than $10k
- Not available



solar-powered rural cell towers and to serve as Wi-Fi hotspots on informal commuter buses called *matatus*. To make sure the machines can survive both hot expanses and the possibility of being hosed down by matatu drivers, BRCK houses the computers in aluminum cases that can guard against the elements.

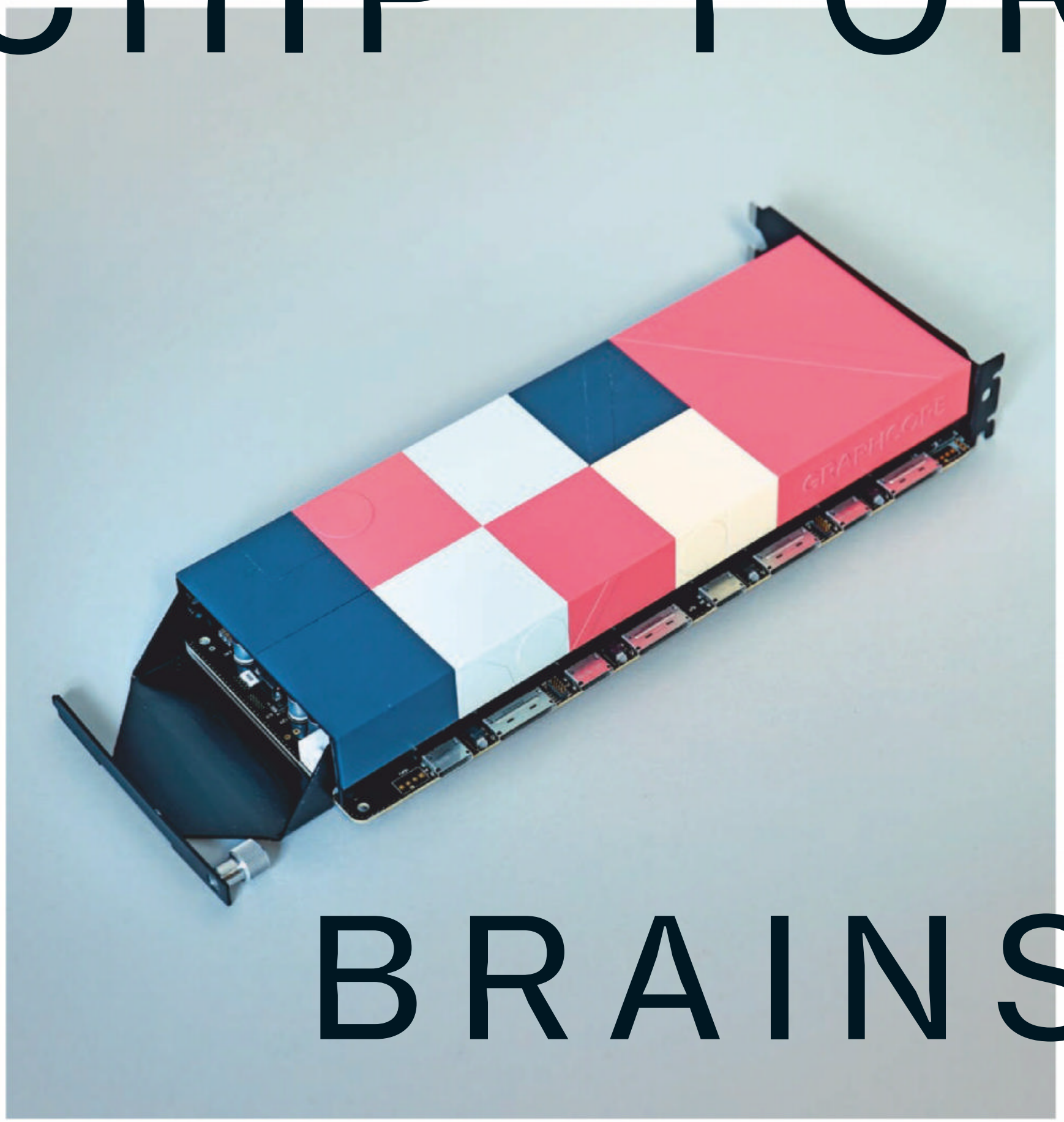
One problem the carriers haven't solved is the high price of mobile data. Every gigabyte costs the average African a relatively massive slice of monthly income—about 9%, compared with less than 0.5% in the U.S., according to the Alliance for Affordable Internet, a coalition of companies, governments, and advocacy groups. Facebook Inc. has developed special software for mobile carriers that it's giving away in a bid to lower costs to consume its content.

Market-research company Strategy Analytics Inc. expects sales of phones powered by KaiOS to jump 50% this year, to 105 million devices, making it the fastest-growing major phone OS in the world. Most of that growth will likely come from India, where the billionaire head of conglomerate Reliance Industries Ltd. spent tens of billions of dollars to build a nationwide mobile internet network from scratch and extensively subsidize the phones.

Like India and the rest of the world, Africa can't afford to ignore the poisonous downsides of the internet, notably its capacity for spreading hate speech and misinformation. Yet like energy and transportation, internet access has become an essential component of infrastructure, economic development, and social empowerment, so much so that authoritarian governments in parts of the continent have tried to block access to it entirely. The growing sweep of KaiOS offers a reminder that the most important innovations aren't always the driverless cars, the pilotless planes, or the sailorless boats. Sometimes they're a $20 phone. Ⓑ

DATA: WORLD BANK

CHIP FOR BRAINS



Graphcore's "intelligence processing units" have attracted attention from just about everyone who's going to need superfast AI

By Austin Carr
Photographs by Catherine Hyland

Simon Knowles, chief technology officer of Graphcore Ltd., is smiling at a whiteboard as he maps out his vision for the future of machine learning. He uses a black marker to dot and diagram the nodes of the human brain: the parts that are "ruminative, that think deeply, that ponder." His startup is trying to approximate these neurons and synapses in its next-generation computer processors, which the company is betting can "mechanize intelligence."

Artificial intelligence is often thought of as complex software that mines vast datasets, but Knowles and his co-founder, Chief Executive Officer Nigel Toon, argue that more important obstacles still exist in the computers that run the software. The problem, they say, sitting in their airy offices in the British port city of Bristol, is that chips—known, depending on their function, as CPUs (central processing units) or GPUs (graphics processing units)—weren't designed to "ponder" in any recognizably human way. Whereas human brains use intuition to simplify problems such as identifying an approaching friend, a computer might try to analyze every pixel of that person's face, comparing it to a database of billions of images before attempting to say hello. That precision, which made sense when computers were primarily calculators, is massively inefficient for AI, burning huge quantities of energy to process all the relevant data.

When Knowles and the more business-minded Toon founded Graphcore in 2016, they put "less precise" computing at the heart of their chips, which they call intelligence processing units, or IPUs. "The concepts in your brain are quite vague. It's really the aggregation of very approximate data points that causes you to have precise thoughts," says Knowles, whose English accent and frequent chuckle invite comparisons to a Hogwarts headmaster. (Given his constant whiteboard pontificating, Toon jokingly addresses him as "Professor Knowles.") There are various theories on why human intelligence forms this way, but for machine learning systems, which need to process huge and amorphous information structures known as "graphs," building a chip that specializes in connecting nodelike data points may prove key in the evolution of AI. "We wanted to build a very high-performance computer that manipulates numbers very imprecisely," Knowles says.

Put another way, Graphcore is developing a brain for computers that, if its co-founders are right, will be able to process information more like a human instead of faking it through massive feats of number crunching. "For decades, we've been telling machines what to do, step by step, but we're not doing that anymore," Toon says, describing how Graphcore's chips instead teach machines how to learn. "This is like going back to the 1970s—we need to break out our wide lapels—when microprocessors were first coming out. We're reinventing Intel."

Investor Hermann Hauser, co-founder of Arm Holdings Plc, which controls the most widely used chip designs, is betting that Knowles and Toon's IPUs will unleash the next wave of computing. "This has only happened three times in the history of computers," Hauser says—CPUs in the 1970s, GPUs in the 1990s. "Graphcore is the third. Their chip is one of the great new architectures of the world."

Graphcore's origins lie in a series of symposiums Hauser organized in 2011 and 2012 at the University of Cambridge for the Royal Society, the scientific fellowship that counts Isaac Newton and Charles Darwin as alums. Around a posh dining room at King's College, AI experts, neuroscientists, statisticians, and zoologists debated the impact advanced computing would have on society.

Knowles, whom Hauser says "has a brain the size of a globe," felt out of place in this ivory tower, even though he got his start at Cambridge. After graduating in the 1980s, he studied early neural networks at a U.K. government research lab. He went on to co-create Element 14, a wireless processor startup that sold to Broadcom Inc. in 2000 for $640 million. Soon after, he and Toon, who also had experience building semiconductor startups, teamed up for the first time. In 2002 they created Icera, a mobile chipmaker, which they sold to Nvidia Corp. for $436 million a little less than a decade later. (Nvidia has since shuttered it.) The two weren't ready to retire at that point. "We're both crap at golf," Toon says.

They were batting around other ideas when Knowles went to the Cambridge lecture series. "I was the scruffy chap in the room with a stovepipe hat who just wanted to build stuff—you know, 'Never mind thermodynamics, I want to build a steam engine!'" he recalls. When Steve Young, a Cambridge professor of information engineering who later sold a speech-processing service to Apple Inc. now used in Siri, gave a presentation on the limits of computational dialogue systems, Knowles peppered him with questions about energy efficiency. "I asked what numerical precision he was using for his arithmetic, which to Steve seemed out of left field," says Knowles, who stresses that "the precision of numbers are very critical as determinants of energy" in silicon.

Days later, Young emailed Knowles to say his students investigated the matter and discovered they were using 64 bits of data per calculation. They realized they could perform the same function, as Knowles had suggested, with less precise arithmetic, using 8 bits. When the computer had less math to do, ▶

it could use the energy savings to crunch more numbers; it's sort of the equivalent of a human brain shifting from calculating the exact GPS coordinates of a restaurant to just remembering its name and neighborhood. "If we built a processor more attuned to this sort of work, we could increase the performance by a factor of a thousand," Knowles says. Young and others were so impressed that Knowles and Toon decided they had to start Graphcore. They began raising capital to develop the idea as early as 2013 and revealed the company to the world in 2016.

The semiconductor industry is currently debating the sustainability of Moore's law, an observation dating back to the 1960s that says the number of transistors on a chip—and thus, its price performance—will double about every two years. Graphcore's leaders are instead concerned with a related concept, called Dennard scaling, which stated that as transistor density improved, power demands would stay constant. But the principle no longer applies, and adding more transistors to chips now means the chips tend to get hotter and more energy-hungry. To mitigate this issue, some chipmakers design their products so they don't use all their processing power at once—unused areas of the chip are called "dark silicon"—and instead run only the parts necessary to support an application.

Knowles and Toon say the heat problem especially will stop phones and laptops from getting much faster in the years ahead unless circuits can be radically redesigned for efficiency. "I was given a blank sheet of paper to start, which never happens in chip design," says Daniel Wilkinson, who works on Graphcore's chip architecture. They challenged the team of a few dozen engineers, mostly castoffs from their past startups, to design a chip that could harness all its processing horsepower at once while using less energy than a state-of-the-art GPU. One of the bigger energy stresses in silicon involves moving and retrieving data, but historically processors are kept separate from memory. Transporting that data back and forth between these components is "very energy expensive," Knowles says. Graphcore set out to design what he calls a more "homogeneous structure" that "intermingles" a chip's logic with memory, so it doesn't have to expend as much power to transport data to another piece of hardware.

Over three years, they simulated computer tests on hundreds of chip layouts, eventually settling on a design with 1,216 processor cores, which Knowles refers to as "lots of tiny islands of processors that split up energy resources." The resulting IPU, first manufactured in 2018, is a sleek chip the size of a Wheat Thin that has almost 24 billion transistors and is able to access data for a fraction of the power of a GPU. "Each of these chips runs at 120 watts"—about the same as a bright incandescent lightbulb—"so about 0.8 of a volt and about 150 amps," Toon says, standing in a messy electronics lab at the Bristol headquarters, sliding his thumb over an IPU's mirrorlike finish.

> "It doesn't actually have to be supervised. The machines are finding out what to do for themselves"

To test out its prototype, the team fed it a standard data-training model of millions of labeled images of common objects (fruits, animals, cars). An engineer then queried the IPU with a photo of his own cat, Zeus, and within an hour the computer not only identified it correctly but correctly described Zeus' coat. "The IPU was able to recognize it as a tabby," Knowles says. Since that first test, the IPU has sped up and can now recognize more than 10,000 images per second. The goal is for the chip to be able to digest and ascertain far more complex data models, to the point the system would understand what a cat is on some more fundamental level. "We don't tell the machine what to do; we just describe how it should learn and give it lots of examples and data—it doesn't actually have to be supervised," he says. "The machines are finding out what to do for themselves."

On the fifth floor of Graphcore's offices, hulking industrial air conditioners blast cool air into the company's data server room and flap window shades to and fro, letting in some of Bristol's unusual mid-May sunlight. As energy-efficient as the chips are, planted in servers stacked together in fridge-size casings, the machines still generate a hellish amount of heat. These IPU server racks are potent enough to perform 64 petaflops of computing, the processing equivalent of 183,000 iPhone Xs working simultaneously at max speed. Knowles and Toon nicknamed their IPU "Colossus," after the world's first electronic programmable computer, which the British government developed to crack encrypted messages from Germany during World War II.

Graphcore has raised $328 million from investors, including BMW, Microsoft, and Samsung, and was last valued in December at $1.7 billion. It declined to comment on specific applications for its chips, citing nondisclosure agreements, but given its investors, some seem obvious—self-driving cars, Siri-like voice assistants, and cloud server farms. But Knowles is most excited about humanity-altering applications, such as the impact IPUs could have on the complex analysis that scientists need for research in climate change and medicine.

To help big corporate customers figure out how to build the next-gen computers required to use the chips properly, Graphcore offers server blueprints and packages its products with free software tools. “We’ll give you the recipe for the computer design and then sell you the ingredients,” Toon says. IPUs rely on a concept known as parallel computing. The basic idea is that programs need to be written for each processor for it to function, but as processors built into chips proliferate—a large Graphcore installation includes about 5 million processor cores and is capable of running almost 30 million programs at once—this coding task has superseded human authorship, meaning programing has to be automated for the processors to execute independently. In layman’s terms, Graphcore has sliced up mammoth computing undertakings into mini data problems, which are each handled separately on those “tiny islands of processors,” before they sync up like a Marine marching band to share what they learn at the most efficient moment.

Tobias Jahn, principal investor at BMW’s venture capital arm, envisions Graphcore chips in the automaker’s data centers and perhaps its cars. “BMW has an interest in Graphcore becoming a large-scale, worldwide silicon supplier,” Jahn says. The immediacy with which autonomous vehicles must execute so many critical tasks makes them a key market for something like an IPU, given the lag time that so often accompanies work in the cloud. Arm Holdings co-founder Hauser, now a partner at Amadeus Capital, estimates that each driverless car may need two IPUs. Graphcore says it’s on track to reach $50 million in revenue in 2019.

Graphcore’s first chip, the Colossus

Big-name rivals are crowding into the field, too. Tesla Inc. recently applied for patents on its own AI chips. Google last year unveiled a class of microprocessors designed for machine learning. And Nvidia has been modifying its dominant GPU chip designs so they’re less precise and more efficient—more like Graphcore’s. “Everyone else is sort of knocking at Nvidia’s door,” says Alan Priestley, an analyst at researcher Gartner Inc. “Graphcore has a good position, but it’s still a very small competitor compared to Nvidia’s market presence. So although their IPUs may be better than Nvidia’s GPUs for these workloads, the risk they face is customers choosing ‘good enough’ over ‘brilliant.’”

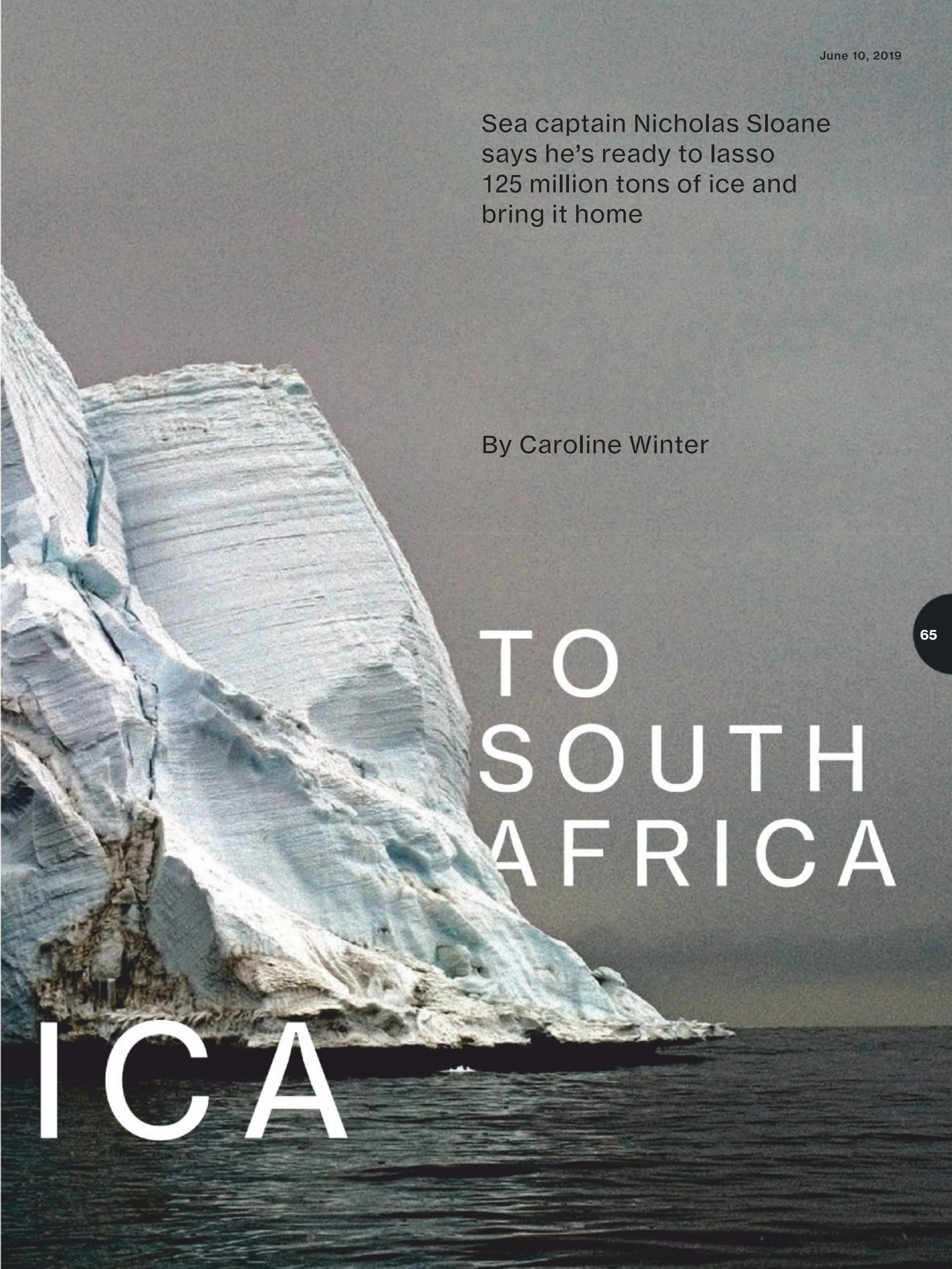
Another significant challenge is the ethical dilemma IPUs present if, as promised, they enable machines to operate 100 times more powerfully than today’s computers. Toon and Knowles are wary of the dangers, particularly how such technology could be misused for weapons and authoritarian surveillance. Ultimately, though, they say governments will need to be the ones to set limits. “Machine power gave us airlines and cars,” Knowles says. “But it also gave us tanks. Society will have to determine the balance of good and evil over time.”

For now, Graphcore is focused on developing more software that will open customers’ eyes to the power of IPUs, while expanding its business toward what the co-founders see as an eventual public offering. The company pops a bottle of Champagne for each major milestone, such as a $50 million funding round in late 2017 and a $10 million sales order in 2018. Signs of this growth are all around Graphcore’s office in the form of larger and larger empty bottles of bubbly. Knowles and Toon always start with Winston Churchill’s favorite brand of Pol Roger, which they say represents their pride that they might give Britain its first tech giant on the order of Apple or Alibaba Group Holding Ltd. “Start with Pol and end with Pol,” Knowles says, chuckling again while doting over a recently consumed 9-liter Salmanazar of Champagne. “By the time you IPO, you pop the biggest bottle.” Ⓑ

TOWING ICEBERGS FROM ANTARCT

Sea captain Nicholas Sloane says he's ready to lasso 125 million tons of ice and bring it home

By Caroline Winter



Nicholas Sloane doesn't mind discomfort. The 56-year-old South African marine-salvage master has survived two helicopter crashes and spent thousands of hours aboard ships that are burning, sinking, breaking apart, or leaking oil, chemicals, or cargo into the ocean. Often, he gets calls in the middle of the night asking him to pack his bags and fly immediately to a disaster zone across the world, anywhere from Yemen to Papua New Guinea. Twice, he's fought off armed pirates using water cannons, sound cannons, and strobe lights.

Usually, Sloane rooms on location, bunking in makeshift beds aboard singed or waterlogged ships he's working to rescue. He once lived for three months with a family on Tristan da Cunha, the world's most remote inhabited archipelago, orchestrating the logistics of catching and washing thousands of rockhopper penguins drenched in bunker fuel from a shipwreck. More recently, he spent 2½ years overseeing the almost $1 billion refloating of the *Costa Concordia*, the infamous Italian cruise ship that capsized inside a marine sanctuary off the coast of Tuscany, killing 32 passengers.

But at some point early last year, Sloane really wanted to take a bath and couldn't. He was home with his family in Cape Town, which had recently declared an emergency: After three years of severe drought, the city of 4 million was at risk of becoming one of the first in the world to run out of municipal water. To forestall a shutoff, each household was permitted only 50 liters—about 13 gallons—per day per person to cover drinking, cooking, washing, and showers. "That's enough to fill less than half a tub," says Sloane, a soft-spoken man with graying hair, ruddy skin, and a deep crease between his green eyes. "My wife used to take a bath every night and a shower every morning. She told me, 'You'd better do something.'"

More than a year later, disaster has been averted, thanks to badly needed rainfall and drastic reduction in water use. But conditions in Cape Town remain far from normal. The daily-use limit has been raised, but only to 70 liters, and people still take speed showers, collecting the runoff to use for toilet flushing. Some hotels have removed stoppers from bathtubs to keep profligate tourists in line. And farmers throughout the country are reeling. More than 30,000 seasonal jobs have been lost in the Western Cape, and crop production has declined by about 20%. During the height of the drought, hundreds of farmers in the Northern Cape killed off most of their livestock rather than truck in costly feed. "Everyone has cut back their flocks of sheep to the bare minimum needed to start again when it rains," one farmer told Bloomberg News in 2017.

Sloane still hasn't taken that bath at home, and he isn't optimistic about Cape Town's future. "We'll never get back to the days where water is flowing all over the Cape," he says, pointing out that the city's population has grown almost 40% in the last 20 years. "If the taps run dry, the first day people will be standing in lines at watering points throughout the city. The second day, if you don't get your water, well, people are killed for that."

That's why Sloane is working on a solution that might sound absurd. Making use of his unusual skill set, he plans to harness and tow an enormous Antarctic iceberg to South Africa and convert it into municipal water. "To make it economically feasible, the iceberg will have to be big," Sloane says. Ideally, it would measure about 1,000 meters (3,281 feet) long, 500 meters wide, and 250 meters deep, and weigh 125 million tons. "That would supply about 20% of Cape Town's water needs for a year."

Sloane has already assembled a team of glaciologists, oceanographers, and engineers. He's also secured a group of financiers to fund the pioneer tow, which he calls the Southern Ice Project. The expected cost is more than $200 million, much of it to be put up by two South African banks and Water Vision AG, a Swiss water technology and infrastructure company.

Now Sloane's team needs an agreement with South Africa to buy the Antarctic water, if the plan succeeds. His team could charter the necessary ships and prepare all required materials within six months, though the mission will need to take place in November or December, when the Antarctic climate is somewhat less ferocious. "We're taking on all the risk," he says. "We're ready to go."

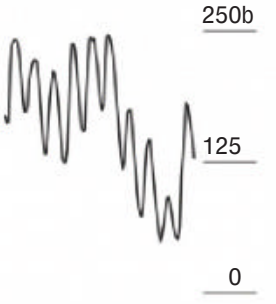
Harvesting icebergs isn't a new idea. In the mid-1800s, breweries in Chile towed small ones, sometimes outfitted with

PREVIOUS SPREAD: CAMILLE SEAMAN

sails, from Laguna San Rafael to Valparaiso, where they were used for refrigeration. In the late 1940s, John Isaacs of the Scripps Institution of Oceanography began exploring more fantastical plans, such as transporting an 8 billion-ton iceberg to San Diego to mitigate California droughts. (Icebergs of the size Isaacs had in mind—20 miles long, 3,000 feet wide, and 1,000 feet deep—are extremely rare.) In the ’60s oil companies began using thick ropes to wrangle and redirect much smaller Arctic icebergs before they collided with rigs, a practice that’s now common. If conditions are too rough, or a berg too big, the rigs sometimes need to be moved instead.

In the ’70s, the U.S. Army and the Rand Corp. both looked into using Antarctic ice as a source of fresh water. At about the same time, Prince Mohammed al-Faisal began pouring funds into polar research, in hopes that his assembled team of international glaciologists and engineers would find a way to alter the drift of icebergs, potentially bringing them as far as Western Australia. Prince Mohammed even sponsored the First International Conference on Iceberg Utilization for Fresh Water Production, Weather Modification and Other Applications in, of all places, Ames, Iowa, in 1977 and had a miniberg weighing 4,800 pounds trucked in from Alaska. “The people of Ames have seen princes before, but it has been many millenniums since an iceberg has visited these parts,” wrote the *New York Times*, delighting in the spectacle. The paper also described some of the more outlandish suggestions floated by speakers, such as outfitting icebergs with nuclear-powered paddle wheels that would allow them to “be propelled as self-contained units.” One skeptical delegate lamented: “There isn’t much money around these days for Arctic and Antarctic research, so they’ve flocked around ▶

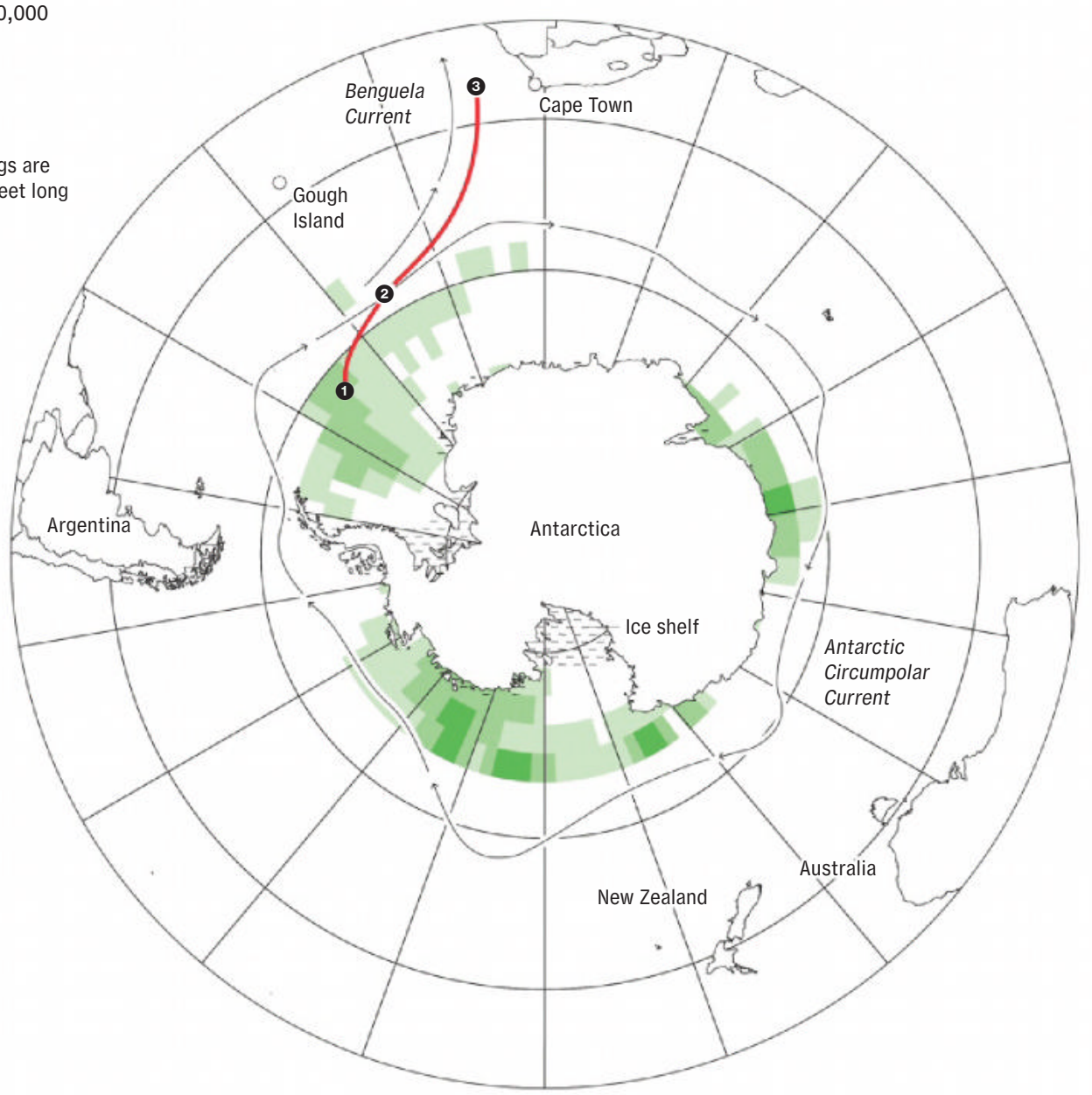
Gallons of stored water at Cape Town’s six major dams

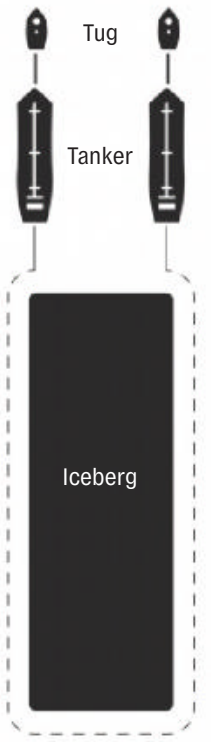


Bound for Cape Town

Iceberg density per 20,000 square miles in 2017
- 25 to 100
- 100 to 300
- 300+

Most Antarctic icebergs are 1,300 feet to 4,000 feet long





1. Encircle an iceberg in a giant plastic net.
2. Use tankers and tugboats to maneuver the skyscraper-size berg into a helpful current…
3. …and park it off the coast of South Africa three months later. Container ships take the water ashore.

DATA: CLIMATE SYSTEMS ANALYSIS GROUP, COLLECTE LOCALISATION SATELLITES, NATURAL EARTH, OLAV ORHEIM

◀ like flies to the honey pot. It's embarrassing."

Eventually, Prince Mohammed stopped funding polar research, but attempts to access iceberg water continued. Today, in Newfoundland, a handful of small Canadian companies, including one called Iceberg Vodka, hire so-called iceberg cowboys, who use chainsaws, articulated claws, and even rifles to take off chunks of passing Arctic bergs, so they can be netted, melted, and used to distill premium alcohol. (Icebergs form from compacted snow, and their water is uncommonly pure.) This spring thieves made off with 8,000 gallons of Iceberg Vodka's water, siphoning it from a large tank. "Our suspicion is that whoever took it thought it was vodka," said Chief Executive Officer David Meyers. Berg Water, another Newfoundland company, sells 12-packs of "15,000-year-old" water for as much as $180.

More urgently, interest is being fueled by the world's increasingly dire shortages of fresh water. Today, as many as 2.1 billion people worldwide lack access to safe drinking water, according to the World Health Organization, and the United Nations says global water demand will outstrip supply by 40% as soon as 2030. The problem is the result of poor government oversight, fracking, pollution, and failing infrastructure. Even in the U.S., leaks and theft account for an estimated loss of 16% of fresh water, writes David Wallace-Wells in *The Uninhabitable Earth: Life After Warming*. In Brazil and other places, the loss is as high as 40%.

There's no magic fix. Desalination is a poor solution—it's expensive and energy-intensive and produces more chemical-laced brine than potable water. Much of that brine, which is extra-salty and contains potentially harmful substances necessary for the desalination process, including copper and chlorine, is pumped back into the ocean. There, its density causes it to sink to the ocean floor, where it depletes oxygen and destroys marine life. According to a 2019 UN report, global desalination plants already produce 51.8 billion cubic meters of brine annually, enough to cover the entire state of Florida a foot deep. Last year a study of almost 180,000 people in Israel linked desalinated water to a 6% to 10% increase in heart disease. Plus, it tastes terrible.

Meanwhile, more than 100,000 Antarctic icebergs melt into the ocean each year. They range from merely large to country-size (the biggest seen recently was the size of Jamaica), and by some calculations they contain more than the annual global consumption of fresh water. Rather than let that water slip away, several groups are vying for berg-towing funds and know-how. The European Union in 2010 received a proposal to pull icebergs from Newfoundland to the Canary Islands, which have long been short on fresh water; and the United Arab Emirates plans to test its prospects of importing icebergs by bringing one from the Antarctic to Australia or Cape Town by late 2020. In Germany, a company called Polewater Gmbh says it's spent $2.8 million over the past six years hiring experts to complete a strategy for getting Antarctic iceberg water to drought-stricken areas, with an emphasis on minimizing environmental impact. Having won the blessing of some Greenpeace officials, Polewater says it

Sloane, master marine salvager and would-be iceberg transporter

PHOTOGRAPH BY BRYAN SCHUTMAAT FOR BLOOMBERG BUSINESSWEEK

"If we hit the wrong current, that's it. Then we'll have to call up the Aussies and say, 'Do you want to buy an iceberg?'"

needs $67 million to build the company over the next three years.

But when it comes to towing a 100 million-ton iceberg through the notoriously rough Antarctic Ocean, where swells regularly reach 15 meters, investors are betting on Sloane. "I was the greatest skeptic around," says Bert Mulder, chief operating officer of Water Vision, Sloane's Swiss backer. "Then I started to listen to Nick Sloane. If anybody can do it, it's him. I truly believe that."

Sloane was born in Northern Rhodesia, now Zambia, and grew up exploring rivers and lakes. "There was no TV, only basic radio, so the outdoors was your life," he says. At about 10 he moved with his family to a town outside Durban, South Africa, where he began sailing and found he loved ocean racing in stormy weather, particularly because daring counted for more than tactics alone. After high school, he completed his national service with the merchant marine, then spent 10 years becoming a master mariner, running tankers and cargo ships and towing oil rigs. From there, he stumbled into the high-intensity work of marine salvage, where successful teams are rewarded with payouts of 7.5% to 10% of the distressed ship's assessed value, a fee that often reaches millions of dollars.

Today, Sloane spends roughly six months of the year in Cape Town with his wife and three kids. But he's always on call for his employer, Resolve Marine Group, a global salvage company based in Florida. From one day to the next, he might find himself rappelling from a helicopter onto a burning supertanker or using his connections and organizational skills to oversee the complicated logistics of cleaning up a toxic spill in remote waters.

The iceberg is Sloane's side project, and he's enlisted perhaps the biggest names in the game. The first is Georges Mougin, the French engineer whom Prince Mohammed tapped as CEO of his company, Iceberg Towing International. Now 91 years old with bushy eyebrows—but still sharp and a dapper dresser—Mougin has spent much of the past four decades exploring the technologies and materials to be used for iceberg transport. The second is Olav Orheim, trim and energetic at 77, who served as director of the Norwegian Polar Institute from 1993 to 2005. Orheim has probably landed atop more icebergs than anyone in the world and once was stranded overnight on one with David Attenborough, the English broadcaster and voice of the nature series *Planet Earth*.

Together with oceanographers and engineers from Norwegian and South African universities and from government-affiliated institutes such as the Pretoria-based Council for Scientific and Industrial Research, Sloane's team began forging a plan and soon attracted press coverage. "Unfortunately, the first article came out on April 1," Sloane says. "People still think it's an April Fools' joke."

The team is focused only on Antarctic icebergs, which break off from the giant sea shelf that extends from the southern continent's landmass. These are often hundreds of times bigger than Arctic icebergs, and the biggest are almost always tabular and therefore more stable. By contrast, Arctic icebergs, most of which descend from Greenland's steep glaciers, are typically irregular and contain weak spots that make them liable to split or flip.

Using satellite data, the team will identify an iceberg that's the right size and shape and on a course for Gough Island, a tiny landmass halfway between Antarctica and Cape Town—about 1,600 miles from Sloane's final destination. (There are typically three or four desirable bergs available on any given day.) Next, they'll inspect the iceberg on location, using sonar and radar scans to determine its precise dimensions and check for structural flaws. If everything looks good, the team will employ two tugboats to encircle the berg in a gigantic net of 5-inch-diameter ropes fashioned from Dyneema, a supermaterial that, unlike metal cables, is neutrally buoyant and also stronger and better suited for low temperatures, friction, and tension. Costing about $25 million, the net will extend about 2 miles across and 60 feet high. It will act as a kind of belt around the belly of the iceberg, which could reach more than 70 stories below the surface of the ocean. ▶

All this will be done amid high waves and winds reaching 80 mph. “It’s the worst part of the ocean worldwide,” Sloane says. “People don’t go there unless they have to.” With the net in place, the iceberg will be attached to two supertankers at a distance of about a mile. The tankers, which will remain about 1,000 feet from one another, will move at about 1 mph. Because they’ll have little ability to steer at such low speeds, each tanker will be led by tugboat. The operation will need to be insured by Lloyd’s of London in case the iceberg breaks apart en route, leaving dangerous debris in the path of other ships.

The goal will be to follow the Antarctic Circumpolar Current eastward and then, at the right moment near Gough Island, deploy full force to switch over to the Benguela Current, which will bring the iceberg upward toward South Africa’s western coast. “If we hit the wrong current, that’s it,” Sloane says. “Then we’ll have to call up the Aussies and say, ‘Do you want to buy an iceberg?’ ”

Traveling “slower than the slowest thing on Earth,” as Sloane puts it, the journey will take an estimated 80 to 90 days. The anticipated melt rate is about 0.05 meters to 0.1 meters per day from each side and the base, which would result in a reduction in size of about 8% by arrival—but certain factors, most notably storms, could increase erosion at the water line. The final destination will be northwest of Cape Town, where the iceberg will run aground and sit amid the fairly cold, slow-moving Benguela Current, about 25 miles from land. There, Sloane’s team will hold the berg in place with a 1,000-ton mooring system, and, like the French artist Christo, wrap the entire underwater portion in a giant, 800-ton geotextile skirt designed to reduce wave impact and inhibit further melting. The skirt, expected to cost roughly $22 million, will let fresh water pass through, creating a buffer of cold water, while keeping salt water out. As the iceberg gets smaller, it will be moved closer to shore.

To harvest the water, the team will ship earthmoving equipment, including grading and milling machines, to the iceberg via barge. The machines will be used to excavate a shallow saucer, which will help speed melt to anywhere from 60 million to 150 million liters a day of an icy slurry. The slush will be pumped into a rotating fleet of grocery-grade container ships.

Back on land, the slurry will be fed into a temporary pipe system and mixed with water from municipal reservoirs. Sloane believes the iceberg could supply Cape Town for a year before it becomes unstable and breaks apart. This, he says, will likely happen once the berg is reduced to about 30% of its original size—though it’s impossible to know for sure. “Nobody’s tried this, so there are going to be unexpected discoveries,” he says.

Before even attempting the tow, the team will need a few months to perform a reduced environmental assessment for the government—reduced because Cape Town is still in crisis. One problem may be the effect of parking a giant ice cube off Africa’s coast. “We have no idea what such a thing would do to all the atmospheric, oceanic ecosystem dynamics in the area,” says Marcello Vichi, a professor of oceanography at the University of Cape Town who’s collaborating with Sloane’s team but has some reservations. “We’d need to do a lot more research, but that’s where money comes in, and time.” Alan Condron, who works at the Massachusetts-based Woods Hole Oceanographic Institution and joined the project in May, will begin modeling impacts within the next months. He also plans to model melt rates and various towing routes, as well as the carbon footprint of hauling icebergs vs. desalination. But there’s a limit to what these projections can achieve, he says. “At some point, you can throw all the modeling you have at it, but you just need someone to go out and do it.”

The price of delivering Antarctic water will be perhaps the biggest obstacle—Sloane says it would cost Cape Town about three times what it now pays for delivery of surface water. Critics within the Cape Town government say it would cost substantially more. “This proposal was not considered suitable for Cape Town,” says Xanthea Limberg, a member of the mayoral committee for water and waste services. “Such a project is both complex and risky with an anticipated very high water cost. The greatest challenges pertained to containment and transportation of the melt water as well as its injection into the water supply system.”

Other officials say the world’s worsening water crisis, along with South Africa’s booming population and the local impact of climate change, require looking beyond traditional

A Brief History of Towing Ice

1949
John Isaacs of the Scripps Institution of Oceanography suggests towing icebergs to California.

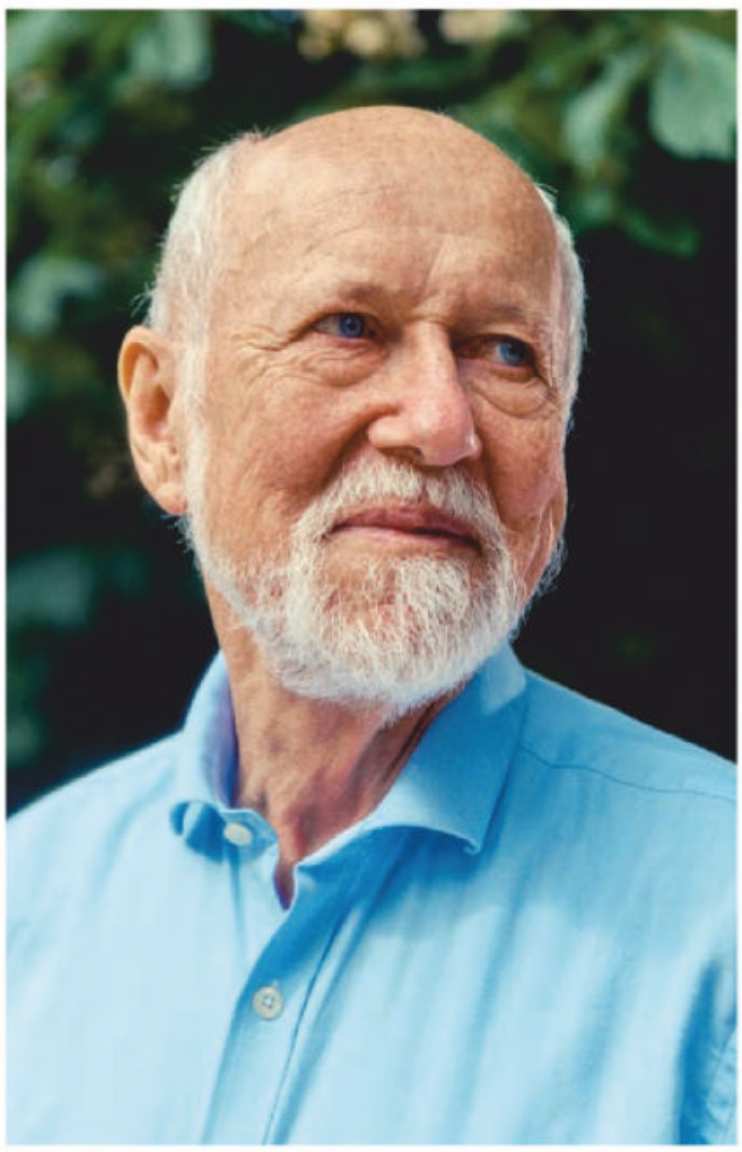
1960-Present
Oil companies redirect bergs to keep them from crashing into rigs.

1977
Prince Mohammed al-Faisal sponsors an international conference on iceberg use in Iowa.

2010
Karl Lagerfeld features a berg in his Chanel runway show.

2019
Thieves steal 8,000 gallons of meltwater from Newfoundland company Iceberg Vodka.

Mougin began studying iceberg transport in the 1970s.



Orheim has been atop more bergs than perhaps anyone on Earth.

water sources. “We do not have the luxury to discard options,” says Dhesigen Naidoo, CEO of South Africa’s Water Research Commission, a nonprofit funded by the country’s water tax. “An iceberg is 99% pure water, and you have the prospect of that sitting on your doorstep in a giant chunk that you can tap into. It’s a terrific idea.”

Time is running out for South Africa to order an iceberg for delivery this year. Instead, politicians will likely pray for rain, which is frustrating for Sloane’s backers. “We silently sometimes think, A little more drought could bring the project closer,” says Mulder of Water Vision. “But at the same time, you wish the best for the people in Cape Town and that abundant rainfall comes.”

In early April, Sloane jets to Paris to visit Mougin and Orheim, who both live there. Dressed in a well-cut blue suit and brown leather dress boots, he looks like any other businessman, but for the Oakley sunglasses hanging from a cord around his neck and his Thule briefcase, which is worn to the point of shredding in one corner. Over the previous month, he’s been to England, Japan, and Mozambique for salvage work. “I thought I was going to have to attend to a shipwreck in Yemen, but it worked out that I could come here,” he says.

Sloane has put more than $100,000 of his own money into the Southern Ice Project. “If you’d asked me 10 years ago, I probably would have said this was crazy, but now the time is right,” he says, sitting in the lounge at the InterContinental Paris Le Grand Hotel, where he’s staying. Cape Town, he points out, is by far the most conveniently located city for a pioneer tow, given its relative proximity to Antarctica and the path of the Benguela Current, but he believes icebergs may eventually be pulled to Perth, Australia, and Santiago, Chile. “And if you can get it to Cape Town, you can get it to Namibia and maybe as far as Angola.”

For now, Sloane is focused entirely on his continent, where cities and towns across several nations are running dry. “I promise you, the water situation in some parts of Africa is getting worse all the time. It’s certainly not getting better,” he says. “Twenty or 30 years from now, I think towing icebergs will be a regular thing.” Ⓑ

ROBO TAXIS: *READY FOR TAKEOFF*

More than a half-dozen companies have flown autonomous or semiautonomous electric aircraft that can take off vertically from almost anywhere, and the first commercial models are scheduled to hit the market next year

By Richard Weiss and Stefan Nicola

EHang 216

EHang Air Mobility Group, China

First flight: 2014

Range: 22 miles, 25 minutes

Capacity: 2 passengers, 570 pounds

Poised to be the first to market, the vehicle is guided via a connection between a passenger's smartphone and the company's command center. EHang says it will start selling the $300,000 aircraft next year and anticipates strong demand from emergency responders, air taxi services, and operators of tourist flights.

Volocopter 2X

Volocopter GmbH, Germany

First flight: 2016

Range: 17 miles, 27 minutes

Capacity: 2 passengers, 350 pounds

Backed by automaker Daimler AG, the Volocopter features 18 rotors, nine batteries, and a parachute. With a top speed of 62 mph, it's intended for short journeys such as airport runs. The company this year will open a "Voloport" in Singapore for public test flights and expects commercial service as early as 2021.

Astro Elroy

Astro Aerospace Ltd., U.S.

First flight: 2017

Range: 19 miles, 25 minutes

Capacity: 1 passenger, 260 pounds

Small enough to squeeze into most garages, the single-seater has 16 independent rotors and a carbon-fiber body for short autonomous or self-piloted hops. The company aims to sell the Elroy to public and private customers for commuting, taxi service, deliveries, and even military missions.

Kitty Hawk Cora

Kitty Hawk Corp., U.S.

First flight: 2017

Range: 62 miles, 30 minutes

Capacity: 2 passengers, 570 pounds

The Cora has completed more than 700 test flights, mostly in New Zealand. Backed by Google co-founder Larry Page, the drone can fly as fast as 110 mph thanks to 12 independent lift fans on the wings. The company expects airlines and rideshare-like services to use the vehicle.

Workhorse SureFly

Workhorse Group Inc., U.S.

First flight: 2018

Range: 225 miles, 2.5 hours

Capacity: 2 passengers, 550 pounds

This hybrid can fly longer than rivals because its gasoline engine recharges the batteries. The SureFly, with folding arms for parking in a garage, will cost less than $200,000. Workhorse, a maker of electric trucks and delivery drones, says a remote-control model is in the works, but the current version requires a pilot.

Lilium Jet

Lilium GmbH, Germany

First flight: 2019

Range: 186 miles, 60 minutes

Capacity: 4-5 passengers

The electric air taxi, powered by 36 jet engines that swivel after takeoff so it flies like a fixed-wing plane, uses 90% less energy than helicopter-like drones, giving it enough range to fly from New York to Boston. Lilium says a ride from Manhattan to the city's airports would cost about $70 per passenger.

CLOCKWISE FROM TOP LEFT: COURTESY EHANG; COURTESY VOLOCOPTER; COURTESY FLY ASTRO; COURTESY LILIUM; COURTESY WORKHORSE; COURTESY KITTY HAWK

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JON RIMANELLI

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