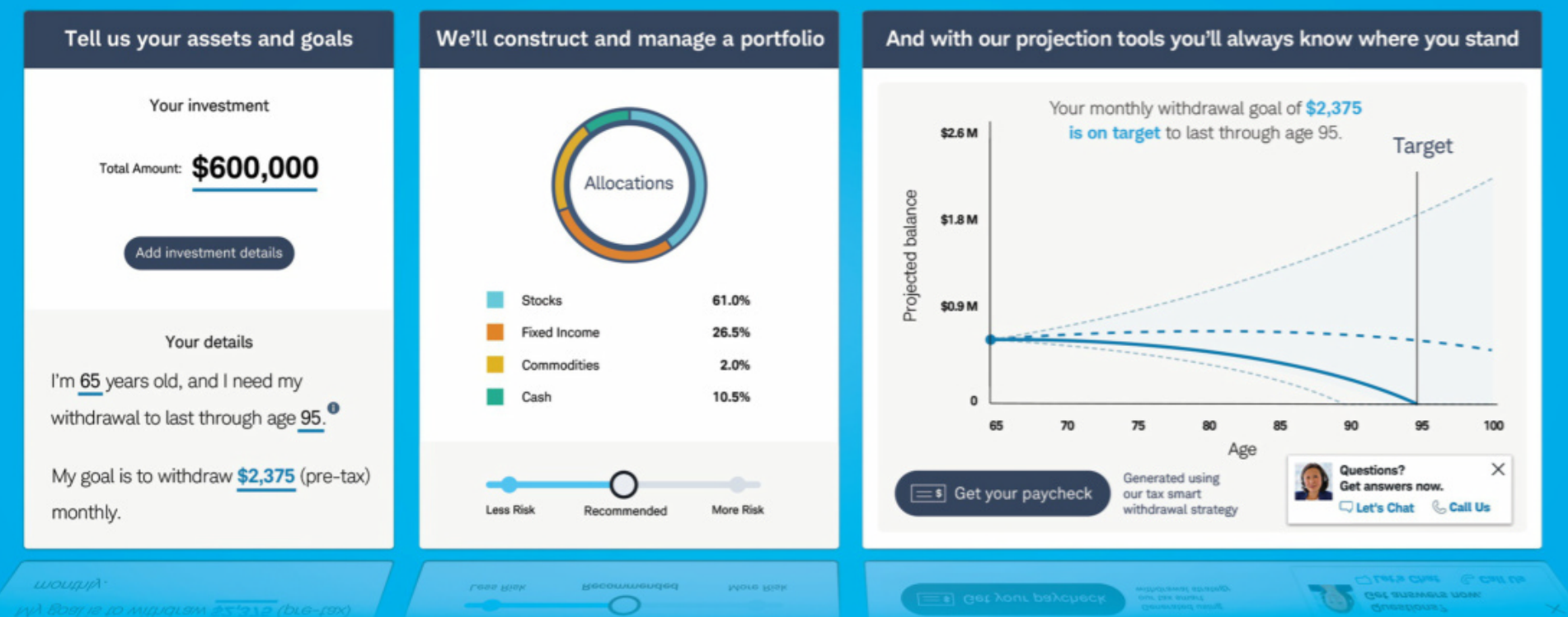


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FORTUNE



A Planet in Crisis

OUR WARMING EARTH IS AN EXISTENTIAL THREAT. THE CORONAVIRUS OUTBREAK—OR THE NEXT ONE—COULD BE TOO. HOW BUSINESS IS COPING WITH THE CHALLENGES OF AN INTERCONNECTED WORLD.

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Lisa McFadin
CEO, EXOGames

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Features April 2020



Burying CO₂ under fields like this one, in West Texas, could allow Big Oil to sell “carbon neutral” petroleum.

VOLUME 181 • NUMBER 4

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HEAR U, NEXT

Our own Alan Murray talks with top executives about the new rules of business in *Leadership Next*. fortune.com/radio

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Game Theory



ON SEPT. 17, the U.S. Naval War College and the National Center for Disaster Medicine & Public Health began a war-game simulation they called Urban Outbreak. Benjamin Davies, a researcher and game designer at the college, gathered 50 experts in disaster response from the government, military, academia, and the private and nonprofit sectors for two days of exercises at Johns Hopkins University's Applied Physics Lab in Laurel, Md.

The aim, Davies told me, was to see how people would respond in real time to “a profoundly dangerous and complex problem set”—the sudden arrival of a deadly pathogen in a dense metropolis. The question, in short: Would we be ready?

Within three months of that exercise, the first cases of illness from a novel strain of coronavirus were being identified in Wuhan, China, a city of 11 million people. In the three months since then, the virus has spread to more than 100 countries, overwhelmed governments and health care systems in cities as far-flung as Seoul and Seattle, and forced the quarantine of an entire European nation more than 5,000 miles away from the disease's epicenter.

Just as with Davies's simulated outbreak in the fictional city of “Olympia,” the real-life coronavirus outbreak has revealed a striking, if not unexpected lesson: We weren't—and still aren't—ready.

As Davies explained, that takeaway from the September simulation was a mark of success. The exercise, after all, was *designed* to reveal the resource gaps and communication failures among the players—the biases and confusions, the inevitable confrontations and areas where leadership and revised strategies are badly needed. The goal was to learn from all that and be ready the next time.

“Games have a wonderful tendency to raise hidden critical issues that remain just under the surface of a problem or interaction,” said Davies, who is also the operations specialist for the Naval War College's humanitarian response program. “When you get all those people in the same

room, and they lay out their plans in front of each other, suddenly all new issues arise: What time of day will the shipment arrive? By truck or helicopter? Where will the helicopter land? What will the military do if desperate people approach them?”

Each question can spiral into confusion or uncertainty, he says, and confound players as they chart the best course of action.

Which brings me to this issue of *Fortune*. Consider the pages that follow as our version of a war game for a crisis that may pose an even greater threat to civilization than the current spread of the coronavirus: the warming of the planet. (Please see our package of stories that begin on page 46.)

The platform here may be two-dimensional, but the goal is the same: to raise critical questions about our readiness to respond; and to shine a light on the gaps and ineffectiveness of the business community's current efforts on these fronts so that, perhaps, we can mount a more robust response moving forward.

To be sure, global industry—and yes, those of us who rabidly consume the products and services these businesses provide—caused many of the climate and environmental problems we face today. But then, as deputy editor Brian O'Keefe writes in his introduction to the package, business is also in a position to try to fix them. There's even a \$26 trillion market opportunity for those who do, according to one estimate.

The alternative to acting boldly, it should be emphasized, isn't “business as usual.” It's “game over.”

CLIFTON LEAF
Editor-in-Chief, Fortune
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The Conversation

JULIE SWEET

At age 42, Julie Sweet jumped from being a partner at an elite New York City law firm to becoming general counsel at Accenture. Now, a decade later, she's running the place. We sat down with the new CEO of the \$43-billion-in-revenue professional services firm **1** to learn what she's seeing—and hearing—about the global economy today. **INTERVIEW BY CLIFTON LEAF**

THIS EDITED Q&A HAS BEEN CONDENSED FOR SPACE AND CLARITY.

“Large companies are looking at this as the decade of delivery on the promise of technology.”

THE DIGITAL DECADE

Prior to being named CEO of Accenture in September, you were CEO of the firm's North American business.

2 How have your daily conversations changed?

SWEET I've spent the last six months traveling the globe, meeting with over 70 CEOs and 100 other C-suite leaders and our clients in Europe, Asia, and North America. It's been an incredibly intense time but exciting because when you do that in such a compressed time period, you hear consistent themes around the globe and across industry. One theme is that we are at an inflection point. For large companies, they are looking at 2020 as the decade of delivery on the promise of digital and technology. We spent the last five to six years experimenting, doing business cases, and now it's about going quickly from vision to execution to material value.

It's a very different mindset. CEOs are saying, “We're not questioning more digital business. We're not

questioning that technology can transform us. But we need to get return on our investment.”

CEOs and business journalists talk endlessly about “digital disruption.” How do you define the term?

I'll first talk about what “digital” means because a lot of people equate “digital” with “technology.” Digital is really two things. It refers to a set of technologies, everything from artificial intelligence to the use of e-commerce. But digital is really about a different way of working, of making decisions, of partnering and reaching your clients, and so it's also about how you do things. And the most successful companies really understand that going digital means changing how they work, how they engage, and how they make decisions.

But it's the other half of the term—“disruption”—that frightens many: It may well mean they'll be out of a job in five years. What do you say to clients to help them have that



Julie Sweet, who is six months into her tenure as chief of Accenture, is one of just 14 female CEOs leading a Fortune Global 500 company.

conversation with their workers?

What we say to our clients, what we do internally, and what we should all be doing with our communities is speak in terms of shared success. So when we have the conversation with the CEO that says, “Here’s how you need to use technology. It’s going to take away jobs,” **3** we advise them to talk upfront with their employees about how many can be reskilled—and for those who likely can’t be reskilled, we need to ask, How can we help them get their new job? We believe that part of our responsibility is to have that conversation from day one. In client conversations, I’ve had over the last two weeks, it has been on the agenda with probably five of them.

Accenture has, of course, disrupted itself over the past decade. Over 65% of your business is now in digital, cloud computing, and security services. **4 What did you learn from that renaissance?**

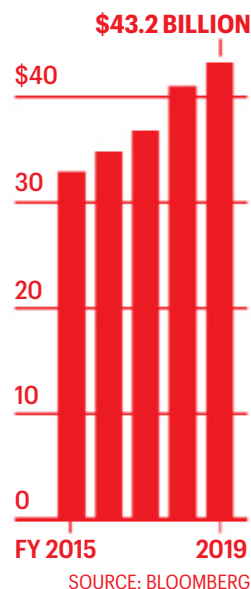
Well, I think first of all, our renaiss-

What has the coronavirus outbreak taught us about global business?

It highlights the integration of the supply chain around the world and the dependencies. We’re spending a lot of time with clients thinking about their supply-chain strategy and helping them become more resilient. One of the big aha moments is how many large companies still don’t use collaboration tools and aren’t using digital technologies internally. They’re engaging with their customers, but they haven’t invested in the infrastructure that allows their employees to telecommute. That’s going to be a big area of opportunity to help clients.

BETWEEN THE LINES

(1) ANNUAL REVENUES



Prior to the market’s dramatic March slide, surging revenues pushed Accenture’s market cap to a high of \$137 billion on Feb. 19, up from around \$56 billion in February 2014.

(2) First among equals: North America is Accenture’s largest market, accounting for 46% of the company’s 2019 revenues.

(3) Robot revolution? The Brookings Institution estimates that 36 million U.S. jobs will face “exposure to automation” by 2030, with about 70% of those at risk of being replaced by technology.

(4) The rise of digital: The share is up from around a third in 2015.

sance, as you call it, is really two things: It’s shifting the services we offer clients, but it’s also how we operate ourselves. So 99% of what we do is now done in the cloud; we’re using the same platforms that we’re implementing with clients. We digitized ourselves.

INSIDE THE M&A PLAYBOOK

You’ve also been on a buying spree. **5 How much of your growth is coming from that?**

We will always focus most on organic growth, and we’ve been very consistent in terms of our capital allocation. If you look back over the last few years, around two percentage points of our revenue growth every year is from acquisitions. So we’re growing at a 9% compound annual growth rate. Seven of those percentage points are from organic growth; two from inorganic.

We acquire companies for one of three reasons, though sometimes all three are relevant. The first is to scale hot areas of the market. So a couple of months ago, we bought a fast-growing Chicago company specializing in data science and analytics, a very hot area. The second reason is to build our deep industry and functional skills. So we’ve made acquisitions focused on financial services and health care. And the third reason is to acquire complementary skills. So last year we bought Droga5 **6**, which was just named the ad agency of the decade.

Talk about that for a moment. Why are so many consultancies gobbling up ad, marketing, and design firms?

We’ve been doing it for 10 years, building the capability that’s behind Accenture Interactive. It’s about creating customer experiences, which require deep technology skills and design skills. How do you actually reach customers, how do you segment them? To answer those questions in a holistic manner requires

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both data science and creativity.

We were hired recently by Kimberly-Clark to change the relationship they have with moms around their baby-care products. Their chief growth officer said that she wouldn't have hired Droga5 on its own or Accenture on its own. The combination is why they hired us.

The hard part is not just having those capabilities but also the scale behind them in terms of technology to serve major enterprises.

THE PEOPLE BUSINESS

Speaking of scale, you've got more than half-a-million employees across the world. 7 Will your workforce a decade from now be anywhere near as big, particularly as you continue to digitize operations?

We actually have constant change in our workforce because we build automation into everything we're doing. We're growing because we're serving more clients, doing higher-value things. So it isn't, like, "Oh, wait a minute, now we need to automate."

So I don't focus too much on how many people I have. I focus on, What are those people doing? And we do what we tell our clients to do: focus relentlessly on making sure that we're using the most advanced technologies and reskill our people to use them. When we automated 40,000 jobs in our business-process outsourcing business, we reinvested 60% of the upfront savings to upskill those who had those roles. We invest \$1 billion a year in training, reskilling, and leadership development—training over 300,000 people in the last three years alone.

And we have a growing business, which is why we're able to do it.

Most important is that we're transparent from the start. In this case, we said to our people, Help us automate what you're doing now, and then we're going to invest to upskill you. That's why we have no change in our average 10-year attrition.

(5) Getting acquisitive: Accenture spent more than \$6 billion on 129 acquisitions in its past six fiscal years.

(6) An ad, ad, ad, ad world: Accenture Interactive, the firm's digital "experience" agency, paid a reported \$475 million for the Madison Avenue shop last spring. In the past two years, Accenture has purchased similar firms in Brazil, China, Denmark, France, Germany, Mexico, the Netherlands, Spain, Sweden, the U.K., and the U.S.

(7) GLOBAL WORKFORCE



Accenture passed half-a-million employees in late 2019, after its fiscal year ended.

(8) Doubling down on diversity: Accenture was ranked No. 1 on Refinitiv's Global Diversity & Inclusion Index in both 2018 and 2019.

You're one of just 14 women CEOs at a Fortune Global 500 company. There was a moment, when you were in your early thirties, that became a turning point for you in your mission to help other women navigate their careers. You were about to make partner at white-shoe law firm Cravath, Swaine & Moore—and there was a meeting at the firm about unconscious bias.

It was in 1999, and I can still see myself walking up to our conference-room floor. We had an old-fashioned conference room, big table. I know exactly where I sat. It was literally two weeks before they were going to make the partnership decision. Everything was fine. I go in, I sit down, and they have this facilitator who turns to me at one point and says, "Julie, you're a senior woman in the world. Have you ever experienced any of these things, unconscious biases?"

I opened my mouth to speak ... and I started sobbing. Big loud sobs, and I could not get myself under control. I got up, went back to my office, and shut the door. Maybe half an hour later, the first woman corporate partner, a good friend of mine, came in.

And she said, "Okay, the men have met. They asked me to come see if you're okay."

And she looked at me, and she knew. She knew there wasn't some big scandal. Because at that very moment, when that woman asked me that, it was like everything kind of came crashing down: All the things that I had endured at that time to get to where I was.

And I do talk about it now because it was a turning point for me. And I thought, "Now that I'm going to be a partner, I have to make it so it's not the same for other women."

And it was something that I worked hard on as a partner, and it shaped who I am today. And as I've grown and learned, it became not just around gender 8 but around all kinds of diversity. 8



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How Data Visualization Propels Business Forward

Artificial intelligence and data analysis can bring your business into sharper focus—and reveal its untapped potential.



AN ABILITY TO SEE THE BIG PICTURE IS A VITAL SKILL

for every business. Enter data visualization, which is experiencing a surge in popularity across industries. But despite this proliferation and reports noting that 99% of organizations admit that being data-driven conveys competitive advantage, nearly nine in ten businesses admit that managing raw data remains a challenge.

“We’re asking more people to work with data than ever before, but not providing them with the working knowledge they need to effectively utilize it,” says James Fisher, chief product officer of end-to-end data integration and analytics platform Qlik. “Complete data and analytics solutions such as ours help take

raw data and, by applying analytics and artificial intelligence [A.I.], uncover new business insights. They also provide data that business leaders can consistently count on, and perspective that can help them ask better questions.”

According to a recent report, only half of organizations today say that they trust their own data. A whopping 95% suffer from detrimental effects on customer experience and organizational productivity due to the poor quality of data that they use to make decisions. And that’s before factoring human error into the mix, Fisher cautions, reminding that key data points and metrics can often differ from one department to the next. So even when organizations are equipped with the most powerful data visualization tools today, misunderstandings can still occur when making strategic decisions—leading to missed chances for business growth.

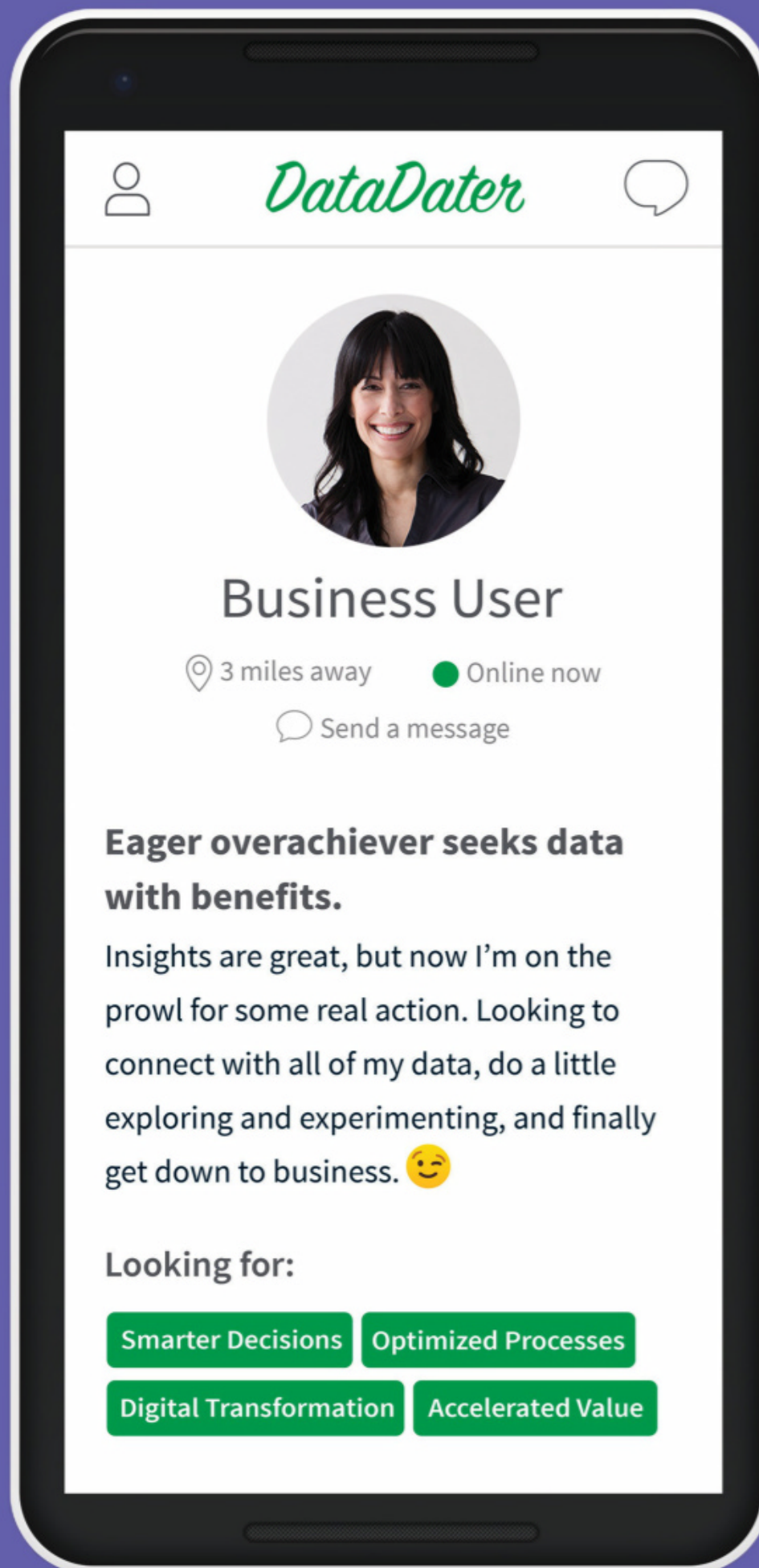
Solutions such as Qlik, which use A.I.-powered insights to provide greater peripheral vision into what’s happening in an organization by sniffing out helpful insights contained in all kinds of data, can help provide a competitive edge. They can help predict market patterns and customer buying habits, streamline internal processes, identify new growth opportunities, reduce risk, and make strategic decisions. And they can translate these learnings into easily understood data visualizations that convey key messages at a glance.

Businesses of every size are using tools like these to recognize significant operational gains. For example: Global retailers are using them to predict which products will fly off shelves; health care providers are leveraging them to more cost-effectively manage care pathways; and manufacturers use them to keep supply chains running smoothly in the face of unforeseen disruptions.

“Traditional data visualization tools won’t get you far enough,” notes Fisher. “You also need to couple them with data integration, analytics, and A.I. capabilities if you want to empower your people to spot opportunities to create value and effect positive, meaningful change.” ■


Nearly nine in ten businesses admit that managing raw data remains a challenge.

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BUSINESS. DISTILLED.

GLOBAL TRADE

Distrust Is Contagious

The devastating economic impact of the coronavirus crisis is leading some American businesses to consider the previously unthinkable—“decoupling” their operations from China.

BY CLAY CHANDLER



FROM THE MOMENT it erupted in Wuhan, China, the COVID-19 virus has proved particularly lethal to patients with the prior, chronic illnesses often described as “underlying health conditions.” Now the contagion is having a similarly grim effect on the U.S.-China economic relationship—where accumulated mistrust and resentment have created unhealthy conditions of a different kind.

As the virus shakes the world’s business community, sending global stocks into or close to bear-market territory, it’s easy to forget that many of the first economic warning signs came from U.S. companies with significant China exposure. Apple and Nike reported supply-line disruptions. Ford, General Motors, and Tesla shuttered factories in China and fretted over shortages everywhere else. Starbucks and Walmart closed Chinese stores, while Disney suspended operations at parks in Shanghai and Hong Kong.

At minimum, the chaos has prompted U.S. investors and executives to rethink the wisdom of concentrating supply lines in China and relying heavily on Chinese

consumers. More broadly, the epidemic has added kindling to a smoldering debate about “decoupling”—the idea that after four decades of stitching the U.S. economy ever more closely to China’s, the time may have come to pry them apart again.

Decoupling implies a full split, and few business leaders are willing to use the “D” word on the record. But proponents of a more distant relationship, including some of President Trump’s top economic advisers, have seized on the contagion as proof of the dangers of doing business in a secretive, Communist-controlled economy. Over the past few weeks, White House trade adviser Peter Navarro has called the outbreak a “wake-up call,” while Commerce Secretary Wilbur Ross predicted it would help bring manu-

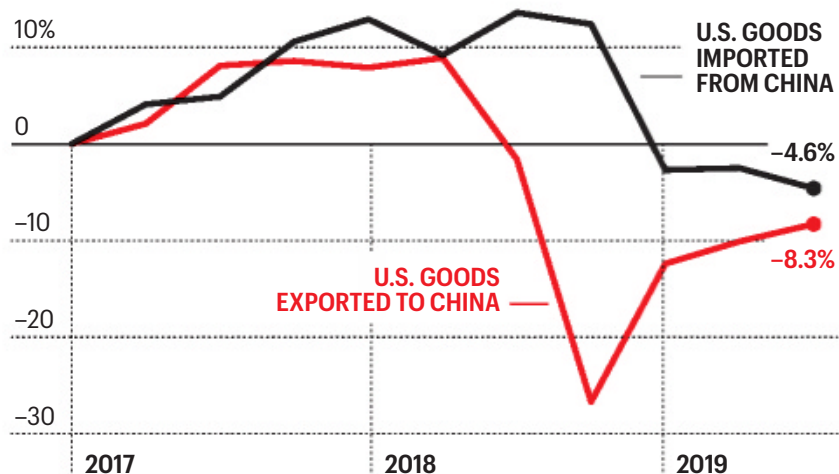
facturing jobs back to the U.S. Even those who favor continued engagement warn that the virus may hasten a decisive fracture in relations already frayed by three years of hostile rhetoric over matters of trade, technology, national security, and human rights.

Trump and China’s Xi Jinping in December reached a “phase 1” deal that puts trade hostilities on hold. But escalating conflict had already led U.S. businesses to reroute orders worth hundreds of billions of dollars to other countries, in industries from textiles to toys. Huge electronics retailer Best Buy has suggested that it will reduce products made in China to 40% of the cost of goods it sells, down from 60% in 2019. In a recent earnings call, CEO Corie Barry called the coronavirus “one more piece of evidence that will continue

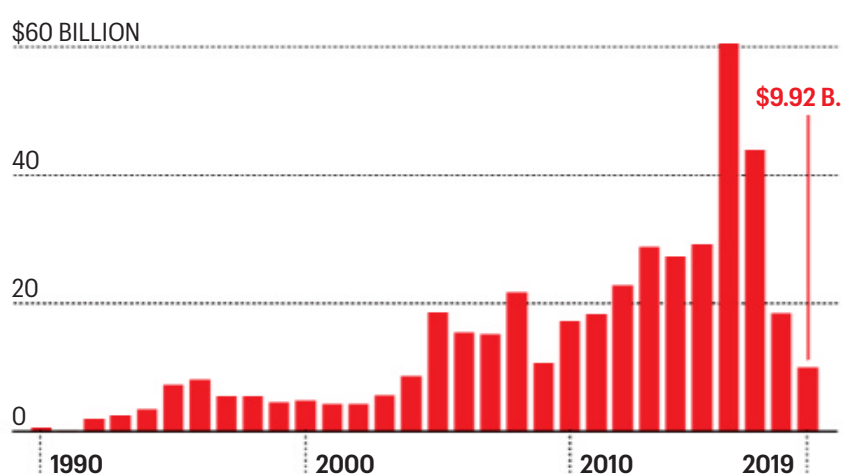
CONSCIOUS DECOUPLING

The U.S.-China economic relationship had begun to lag well before the coronavirus outbreak, amid tensions over trade.

CUMULATIVE CHANGE IN TRADE BETWEEN THE U.S. AND CHINA SINCE 2017



COMBINED U.S. AND CHINA FOREIGN DIRECT INVESTMENTS



SOURCES: U.S. DEPARTMENT OF COMMERCE; RHODIUM GROUP

to put pressure on diversifying supply lines.”

The superpowers’ diverging paths are painfully apparent in technology. Google, Facebook, and Twitter are banned in China, and first-time foreign visitors marvel that it is almost impossible to get around, communicate, or dine there without relying on Chinese tech giants Tencent or Alibaba. In hardware, the U.S. has cited security and human-rights concerns in cutting Chinese tech companies out of its supply chains. It has also placed telecommunications giant Huawei and dozens of other Chinese firms on a blacklist that prevents them from buying key components from U.S. firms without a waiver. Beijing has responded by turning its technological back on America, accelerating its drive for autonomy in areas such as semiconductors and artificial intelligence.

Another symptom of the diseased relationship is the constricted flow of talent. The 370,000 Chinese students enrolled in U.S. colleges and universities account for 34% of all international students in the U.S., and many U.S. schools rely on Chinese tuition to balance their budgets. But travel restrictions designed to contain the virus have prevented thousands of Chinese students from returning to the U.S. for this spring’s semester. Even before the outbreak, Chinese students were finding it harder to obtain U.S. visas,

and many in the applied sciences complain of a “red scare,” in which they are increasingly viewed as government spies.

The rift creates difficult choices for economies that trade heavily with the superpowers. Taiwan’s biggest chipmaker, the \$36-billion-in-revenue Taiwan Semiconductor Manufacturing Co. (TSMC), supplies U.S. companies including Apple and Chinese firms including Huawei. In recent weeks, the Trump administration has pressured it to shift production of its military-use chips to the U.S. TSMC says that it hasn’t ruled out the possibility but that there is “no concrete plan.”

The prospect of a split is especially troubling in Australia, a staunch U.S. ally that is also the developed world’s most China-reliant economy, with trade worth around \$200 billion annually. Australia ships a third of its exports to China, and Chinese nationals account for 15% of its tourists. Former Australian Prime Minister Kevin Rudd, now president of the New York-based Asia Society Policy Institute, has been beating the drum to warn against separation. “A fully decoupled world would be a deeply destabilizing place, undermining the global economic growth assumptions of the last 40 years,” he lamented in a recent speech.

By mid-March, China’s government was declaring that the slowdown caused by the coronavirus was reversing, report-

Even those who favor continued engagement warn that the virus may hasten a decisive fracture in relations already frayed by three years of hostile rhetoric.

ing that more than 90% of the state-owned firms it oversees had resumed operation (though many are far from full strength). In theory, trade and investment between the U.S. and China could stage a “V-shaped” recovery, as happened after the SARS epidemic in 2003.

But COVID-19’s economic toll, far greater than that of SARS, is also affecting an American public that’s less sympathetic than ever to China. In 2019, the percentage of Americans with an unfavorable attitude toward China jumped to a record high of 60%, according to the Pew Research Center. In the upcoming presidential election, hostility toward China may be the rare issue on which Trump and his Democratic opponent agree.

Both nations have too much to lose from completely severing their myriad commercial connections. And COVID-19 has shown how much damage the economic equivalent of a quarantine can do. For now, like the rest of us in this age of contagion, they’ll opt for fewer contacts and less prosperity in exchange for less entanglement. Call it the economic version of social distancing. —*With reporting by Phil Wahba*

BY THE NUMBERS

-\$109
BILLION

Decline in China-U.S. trade from 2018 to 2019

SOURCE: U.S. COMMERCE DEPARTMENT

370,000

Chinese students enrolled in U.S. colleges and universities

SOURCE: INSTITUTE OF INTERNATIONAL EDUCATION

60%

Share of Americans with an unfavorable attitude toward China—a record high

SOURCE: PEW RESEARCH CENTER

FINANCE

Riding a Roller-Coaster Stock Market

With each new lurch, investors are trying to make sense of the big question: How low will this market go?

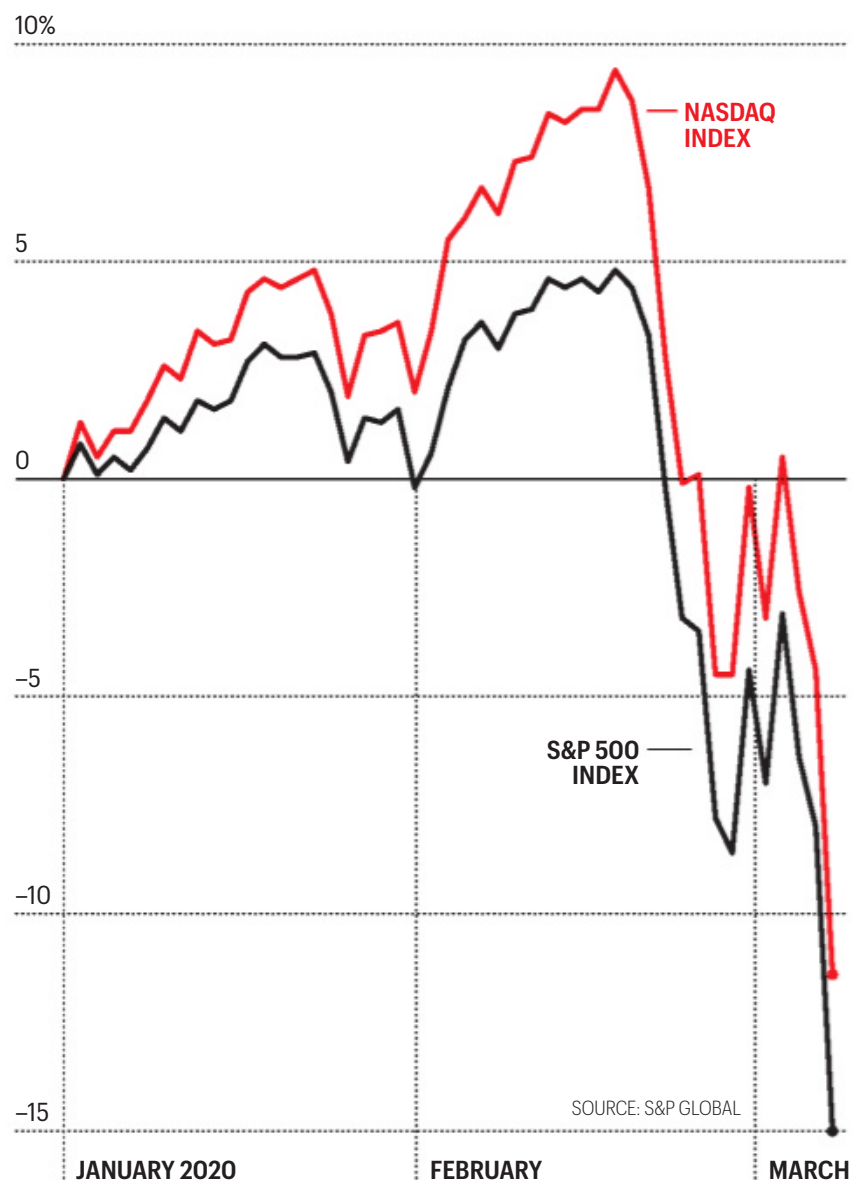
BY SHAWN TULLY

▶ **THINK BACK TO** a simpler time. For instance, January and February. Though it seems distant now, the S&P 500 hit its all-time high of 3394 on Feb. 19. “The stock markets previously had priced in a Goldilocks scenario and entered the year with an elevated price-to-earnings multiple, providing little cushion,” says Jared Franz, an economist at investment giant Capital Group. Then came the coronavirus.

As the effects of the coronavirus continued to spread throughout late February and March, the stock market sustained a series of blows. Investors were not only plagued by uncertainty, they also began to reassess the rich premiums they had been paying for all sorts of assets. And once they started asking “How much is this market really worth?” the answer was bleak indeed. “In the past cycle, the elixir was that when the Fed eases, the price of risk assets goes up,” says Liz Ann Sonders, chief investment strategist at Charles Schwab. “That narrative is now undergoing an epic shift. Credit is tightening even though rates are falling, and that’s hitting valuations.”

The bedrock metrics show one thing for sure: Even after the repeated drops, stocks have simply gone from outrageously overpriced to overpriced. The coronavirus was the catalyst that

THE CORONAVIRUS SENT STOCKS PLUMMETING FROM THEIR HIGHS IN FEBRUARY ...

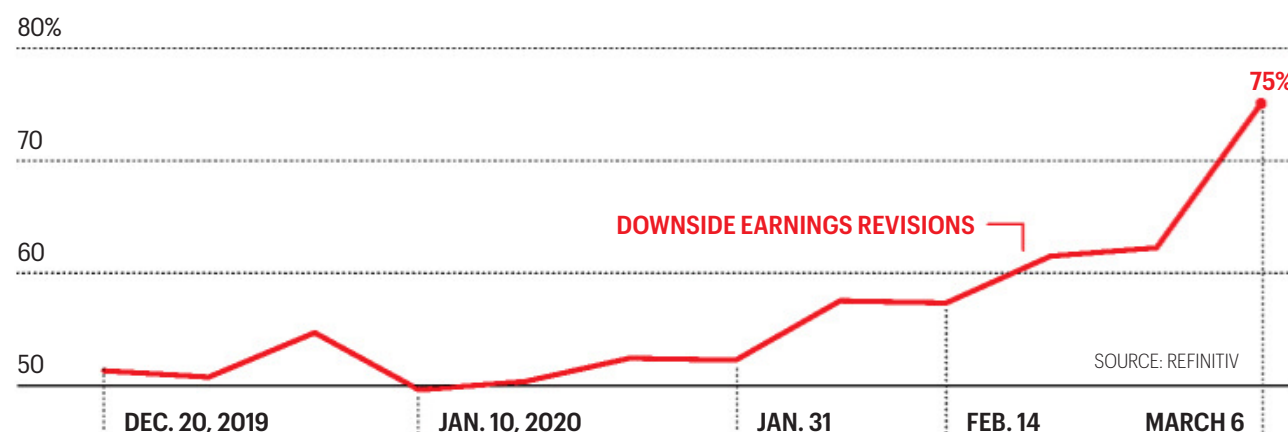


kicked off the current cycle of doubt, but there’s another factor at play too: For most of 2019, stock prices roared ahead while earnings stalled, creating a mismatch between inflated valuations dependent on rising profits and profits that hit a wall. And, says Franz, that wall has only grown higher: “Earnings expectations for the S&P 500 were already muted and have come down further given potential supply disruptions”

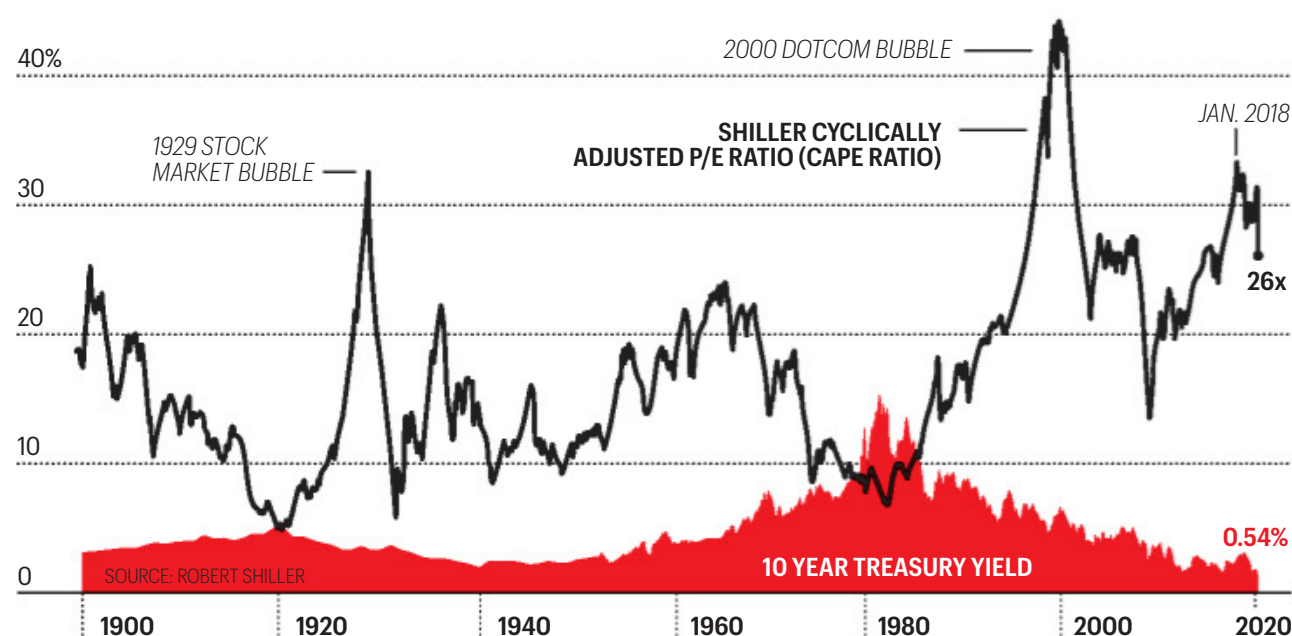
caused by the coronavirus outbreak.

At the S&P 500’s mid-February summit, the price-to-earnings ratio stood at 24.2, based on S&P projected 12-month trailing earnings, through Q1 2020, of \$140. That’s 21% above its 20-year average of roughly 20, and almost 40% over the 70-year norm of 17.5. The steep drop of 19% through March 9 lowered the multiple to 19.6—near the average of the past two de-

... AND EARNINGS ESTIMATES REVEAL A GRIM OUTLOOK FOR PROFITS ...



... YET VALUATIONS REMAIN HIGH BY HISTORICAL STANDARDS.



decades, an era in which they have been richly priced.

As always, equities deliver returns in two packages: dividends and capital gains. Let's start with dividends. At the recent peak, rising prices had driven the yield to just 1.87%. The selloff has lifted yields to almost 2.2%, better but still below the average of over 3% since 1951. This year, companies spent an amount equal to 42% of their earnings on those dividends. So, on the

dividend front, investors are being poorly rewarded for their risk.

On the capital gains side, there are three driving factors: share buybacks, growth in profits, and "multiple expansion," or a rising price-to-earnings ratio. Today, S&P 500 companies are spending the equivalent of all earnings that don't go to dividends on buybacks. (They are able to fund internal investment through added borrowing.)

If the S&P continues to steer the cash equivalent of more than half its profits to repurchases, share counts will fall by 3.0%. That would lift earnings per share by a like amount, so if the P/E—the figure by which you multiply those earnings to get the share price—stays at 19.6, the S&P index will advance by the same 3%. Hence, if the current P/E of 19.6 holds, you'll get a combined 5.2% return from dividends and buybacks alone.

But these improvements when it comes to dividends and capital gains are minor when compared with the abyss below.

Quarterly earnings went flat starting in Q2 of 2018 and have barely budged since then. With the coronavirus likely to hammer earnings a lot harder than analysts are positing, even no growth now sounds rosy.

And profits are still 40% above where they were three years ago. So today's 19-plus P/E is putting a high valuation on what looks like an earnings bubble. For confirmation that values are out of whack, look at the CAPE, or cyclically adjusted price/earnings ratio, a measure developed by Robert Shiller, a Yale professor and Nobel laureate. Shiller adjusts the multiple by using a 10-year average of inflation-adjusted profits, a methodology that smooths the lurching swings that make equities look cheap when profits spike and pricey when earnings drop.

Even after the big drop, the Shiller P/E registers 26. It has never stayed at a level that high for long, and the only times it's been higher were the run-up to the market crash in 1929 and the tech bubble of 2000. If valuations, measured by the Shiller benchmark, return to normal by 2021, the S&P would fall an additional 22%, to 2150.

One thing we can be sure of? Reversion to the mean is a powerful force in the markets—and it usually prevails. ■



Biden at a Democratic Party fundraiser in November 2019.

POLITICS

In the Money

After fumbling fundraising in the early months of the campaign, Joe Biden finally has donors' attention. But is it too little, too late?

BY NICOLE GOODKIND

BIG NUMBER

\$22 MILLION

Biden's five-day fundraising total after Super Tuesday; last year he raised the same amount over three months

SOURCES: BIDEN CAMPAIGN; FEC

▶ **JOE BIDEN'S SURPRISE** Super Tuesday win jabbed his floundering campaign with a shot of adrenaline, vaulting him ahead in the polls and the delegate count. But as dramatic as those gains may be, they pale in comparison to what the triumph is poised to do to his campaign coffers.

At the end of 2019, it took the Biden campaign a full three months to drum up about \$22 million, a figure that put him squarely behind Sen. Bernie Sanders and former Mayor Pete Buttigieg. In the week following his 10-state victory, Biden brought in the same sum in just five days.

"It's an avalanche now," says John Morgan, an attorney and top bundler for Biden, of the incoming interest in backing the former Veep. The question has gone from, "Will there be enough cash to get through the month?" to "Will there enough time in the day to go to all of these fundraising events?" says Morgan. "Everyone is clamoring to hold them." (The Biden campaign did not respond to requests for an interview.)

Biden has long had the backing of some deep-pocketed execs, such as former U.S. Commerce Secretary Penny Pritzker and Avenue Capital Group's Marc Lasry. But in the days since Super Tuesday he's attracted new ones. Gilbert Andrew Garcia, managing partner of bond firm Garcia Hamilton & Associates and former supporter of Mike Bloomberg, says he's now "100% behind Joe"—as is the ex New York City mayor himself. Bloomberg has pledged to throw his financial might behind his old rival and reportedly plans to create a new organization to help Biden win in six primary battleground states—and eventually take on President Donald Trump.

Biden, who had just \$3.4 million to spend on ads in Super Tuesday states—as compared with Sanders' \$18.5 million—is expected to use his newfound cash to boost staffing in key states and up his ad profile. Indeed, since his surge Biden has invested an additional \$10.3 million in TV spots in states like Ohio, Florida, and Michigan, outspending the Sanders campaign, according to data from Advertising Analytics.

Another likely budget line: aiding down-ballot congressional races, says Lawrence Norden, director of the Brennan Center's electoral reform program. Part of Biden's appeal is his promise to hold the House and turn the Senate blue, so backing those races is essential to buttressing his support.

Team Sanders, meanwhile, says it's not cowed by Biden's growing war chest. "Bernie doesn't spend his time holding fancy fundraising events to ask billionaires for money," says digital fundraising director Robin Curran.

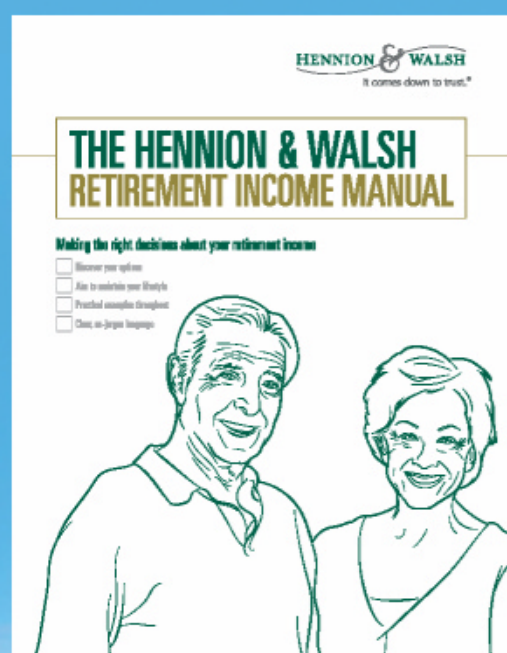
Of course, if Biden's bid to land the nomination is successful, he'll face the President—and the roughly \$93 million the Trump campaign had on hand at the beginning of the year. Time will tell if Biden's bankrollers are ready to go dollar-for-dollar with the power of the presidential purse. ■

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DIGITAL HEALTH

Bringing A.I. to the Coronavirus Fight

Artificial intelligence is helping predict the spread of infectious diseases, giving health officials a new tool to reduce the threat.

BY AARON PRESSMAN

▶ **ON THE LAST DAY** of 2019, an artificial intelligence warning system run by Toronto startup BlueDot flagged a news report from China about a mysterious pneumonia strain in the city of Wuhan. The system, which sifts through 100,000 articles and online posts daily in 65 languages, alerted BlueDot's human employees, who immediately saw parallels to the deadly SARS outbreak in 2003.

After switching to a system based

on data from billions of airline passenger itineraries, BlueDot was able to determine almost instantaneously which cities worldwide were most at risk if the mystery illness spread. The company quickly sent out warnings to health authorities and other clients about what would come to be called the coronavirus outbreak, which has so far infected almost 100,000 people and killed more than 3,000 as of early March.

“Outbreaks don't care whether it's New Year's Eve or not,” says Dr. Kamran Khan, CEO at BlueDot and a medical professor at the University of Toronto. “In order to get in front of these diseases and threats, we have to move even faster than they do.”

It's a far cry from when Khan started BlueDot about seven years ago. Back then, mapping the potential spread of a virus and alerting authorities could take several weeks. And reluctant governments would sometimes sit on the data for weeks or months after that.

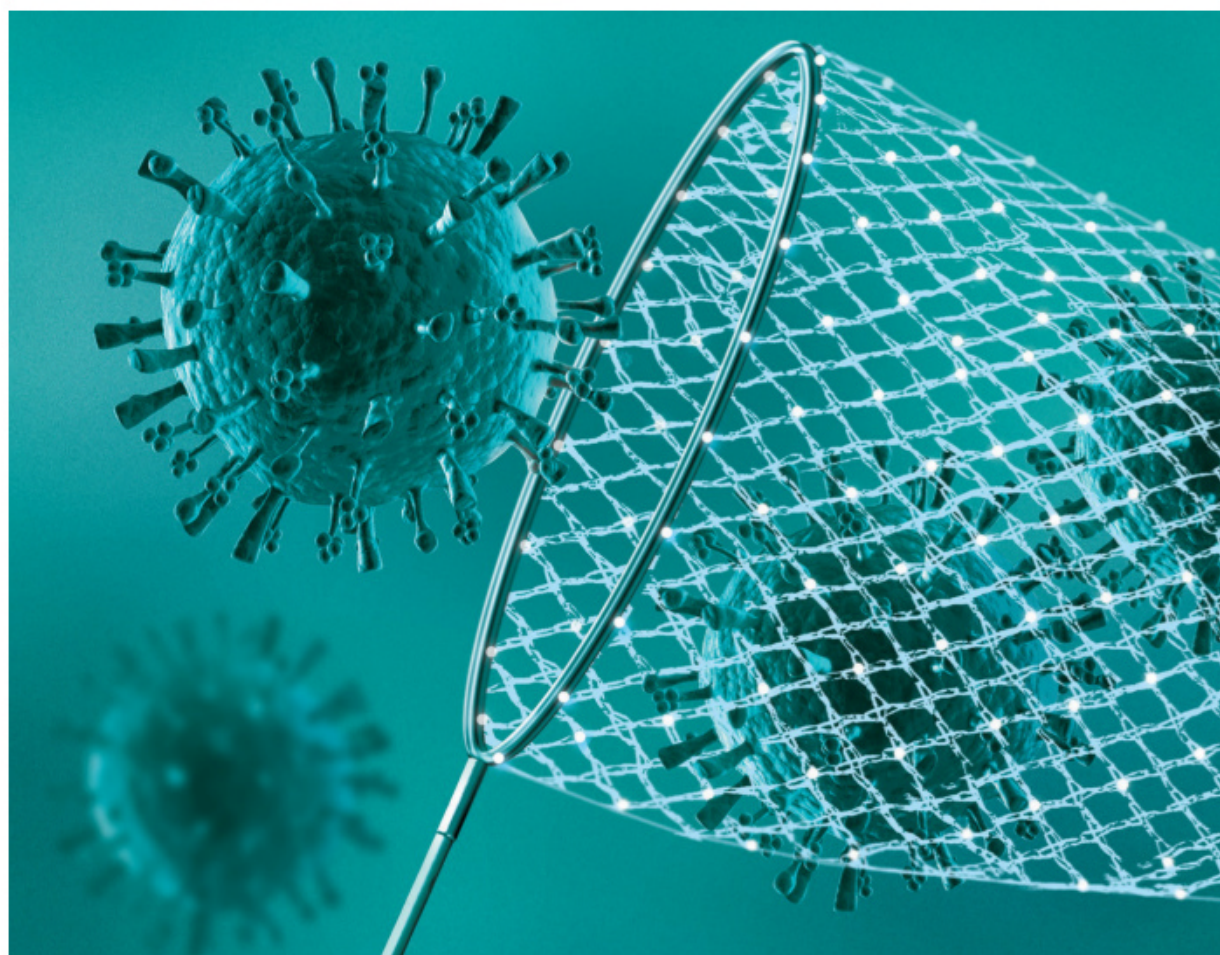
But the era of A.I. and big data has revolutionized tracking and forecasting the path of infectious disease outbreaks like that of the coronavirus. Fueled by algorithms that can translate languages and distinguish between different meanings—Anthrax, the heavy metal band, versus anthrax, the infectious disease—BlueDot and its rivals suck up all the data they can to uncover potential epidemics.

The earlier and more detailed their warnings are, the better health authorities can tell where to screen for infected people and allocate resources. A brief head start can save thousands of lives.

With the coronavirus, A.I.-based alerts helped the World Health Organization and China's officials react more quickly than they did during previous outbreaks like that of SARS. Still, early warnings can do only so much: China's government has been criticized for moving too slowly, while the U.S. stumbled over a lack of test kits.

The systems created by the startups feed off information generated by an ever more interconnected and mobile world, using everything from

ILLUSTRATION BY
DOUG CHAYKA



search keyword data to the location of people clicking on Wikipedia pages.

Much of the data comes from the world's largest Internet companies, including Google, which supplies search keyword and location data to some pandemic-detection startups. Meanwhile, Facebook has shared aggregated data about users' movements as well as posts mentioning the coronavirus from Facebook Groups and Instagram. Anonymized data from Twitter, China's Tencent, and others also fuels the algorithms, which typically run not on the monitoring firms' own computers but on servers managed by Amazon, Microsoft, and Google that use chips specifically designed for A.I.

To be sure, pumping huge amounts of information into A.I. and machine-learning systems is no guarantee of success. For example, Google shuttered a project that forecast the severity of seasonal flu outbreaks after it wildly overestimated the 2013 cycle. One problem was that Google's own efforts to help people search for health care information fooled the system into forecasting that more people were getting sick.

The challenge for companies developing pandemic-detection systems is to ensure that they focus only on relevant bits of information, without getting misled by hysteria that's unrelated to actual illnesses. That's why all of the systems still rely on

humans to look deeper into each case and why they frequently adjust the sources of information that their technology relies on. "You have to recognize that data is constantly changing based on what people are doing online and always have to retune your algorithms for that," says John Brownstein, chief innovation officer at Boston Children's Hospital and cocreator of another A.I. alert system, HealthMap, which warned about the coronavirus a day before BlueDot.

HealthMap's A.I.-generated warning about the coronavirus was backed up by intel from local physicians in Wuhan who were sharing their concerns in an online forum called ProMed. Such posts are the "early canaries in a coal mine that can provide data pointing to do a deeper dive," Brownstein says.

Using fresh data is also important. Initial simulations of how the coronavirus may spread relied on past air travel itineraries. But once the outbreak became known and governments began banning movement in certain regions of China, travel patterns changed, notes Mark Gallivan, director of data science at Metabiota, another startup using A.I. to detect pandemics. As a result, the San Francisco company updated its library of historical passenger information with real-time location data from millions of mobile phones. "The first four countries that showed the highest

importation risk on Jan. 14 were actually the first four that ended up receiving cases," he says.

Another approach is to eschew all the online chatter and news reports and instead use actual medical data. San Francisco startup Kinsa sells smart thermometers that work with an app to help people decide when to see a doctor. With about 1 million households and more than 1,000 schools using Kinsa gear, those thermometers provide clues about the spread of the seasonal flu in the U.S. The eight-year-old company claims to have exceeded the accuracy of the Centers for Disease Control's flu forecast for some years and hopes to develop a system that could predict flu outbreaks in local areas up to three months in advance.

"The difference is the quality of the data," Kinsa CEO Inder Singh explains.

Of course, the Kinsa method works only where people use its devices. In the U.S., that means most cities but not so much in rural areas. And the company has yet to expand to other countries, where even a \$20 smart thermometer may be too pricey for most people.

Ultimately, though, more medical devices reporting directly to A.I. systems could make for the quickest and most accurate early-warning system, says Metabiota's Gallivan: "For earlier detection, it's about creating a much smarter public health and medical system." ■

THE DATA FUELING A.I. PANDEMIC PREDICTIONS

Smart, connected medical devices

Millions of patients are treated with thermometers and other devices that send data to an app. The aggregate information can provide early warning of a cluster of patients with fever, for example.

Search keywords and locations

The questions people want answered at a particular time and place can signal an outbreak. But the data must be filtered carefully, as search queries can reflect hysteria as much as a real epidemic.

Local news articles

Reporters on the ground often write stories about unusual medical problems or virus outbreaks. The articles can be translated and analyzed using natural-language processing.

Air travel patterns

Airlines generate about 4 billion travel itineraries annually. That historical data can be used to predict how an outbreak may spread to other cities based on the most popular destinations from the source city.



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LEADING FROM THE HEART

Q&A with Lujain Al Ubaid, co-founder and CEO, Tasamy for Social Entrepreneurship

For a sensitive and privileged Saudi child, it was a life-changing routine. At regular times throughout the year, the mother of 6-year-old girl Lujain Al Ubaid would take her on a journey far from the luxury condominiums of Riyadh's most well-to-do neighborhoods and into some of the poorest and most deprived districts of the country's capital.

There the family would distribute food, toiletries, and other essentials to the needy and the despairing, while little Lujain watched from the back seat of the car.

"To this day, I can remember those scenes vividly," Lujain says. "The poor people would crowd around the car, desperate to receive anything that we could give them.

"When we drove away, the car windows were covered in their handprints. It is an image I will never forget—those handprints have remained in my heart forever." Some 30 years later, inspired by those searing childhood experiences, Lujain has become one of the most prominent drivers of the social and economic transformation of her country. As the CEO of Tasamy for Social Entrepreneurship, she is helping socially



Lujain Al Ubaid, Co-founder and CEO, **Tasamy for Social Entrepreneurship**

Born and raised in Riyadh, **Lujain Al Ubaid** is one of Saudi Arabia's most prominent social entrepreneurs and best-known businesswomen. As the co-founder of **Tasamy**, she is supporting the growth of enterprises that are tackling some of the country's most pressing social and economic challenges.

“

I HAVE LEARNED THAT DOING THE RIGHT THING IS BETTER THAN SAYING THE RIGHT THING. IT IS CRUCIAL TO TRANSFORM WORDS INTO ACTIONS.

—

LUJAIN AL UBAID,
CO-FOUNDER AND CEO,
TASAMY FOR SOCIAL
ENTREPRENEURSHIP

”

►► minded entrepreneurs across Saudi Arabia grow the businesses that the country needs to tackle poverty and other urgent social challenges. Tasamy provides a full portfolio of services to social entrepreneurs, including training sessions, impact investment workshops, and incubators and accelerators, and it develops social innovations in response to specific issues.

The businesses that Tasamy has helped nurture include a women-run furniture factory in southern Saudi Arabia that has trained over 800 underprivileged women and just won a major contract for a governmental residential construction project. “It is incredible to see the investment that we have made in these women transform into action,” Lujain says.

With the success of Tasamy, that young girl gazing in pity and frustration at the misery around her has grown into one of Saudi Arabia’s most

effective social entrepreneurs. “Those journeys with my mother represent the foundations of my business,” she says. “They taught me that only by being inclusive can we overcome the challenges that we face as a nation.”

What motivated you to launch Tasamy for Social Entrepreneurship?

A social enterprise is a business that delivers solutions for societal change. When I was growing up in Saudi Arabia, I saw that there was a huge need to empower young people who wanted to build solutions for the social challenges in our country. I reached a point where I felt that if nobody else was going to do anything about it, I would have to do it myself. As a result, in 2011 my business partner and I launched Tasamy.

What are Tasamy’s goals?

Our general mission is to grow sustainable and innovative solutions to different challenges by empowering social entrepreneurs and by partnering with private— and public —sector entities. The Tasamy office is full of



One of Tasamy’s success stories **ThreadsN**. This social enterprise focuses on developing and sharing STEM experiences for the next generation

CULTURE OF
COMPASSION

entrepreneurs who are developing business models to meet these challenges. Seeing Tasamy’s space being used by entrepreneurs is the best reward I can imagine.

What has been the impact of Tasamy so far?

Tasamy helped introduce the concept of social entrepreneurship to Saudi Arabia. In the first two years, we incubated 16 projects. To see people supported by Tasamy go through their journeys and flourish and blossom is so exciting. Some of them are established and in the growth phase, some are pivoting, some have failed and come back with new projects. It is incredible to see the investment that we made in these individuals be transformed into action.

What support have you received from official sources?

Vision 2030 has given Tasamy a huge boost. The concept of social entrepreneurialism has been fully embraced by the current leadership. We have won important contracts with the small-to-medium-size business authorities, with the support of the government.

How does Tasamy support women entrepreneurs?

I am part of the female empowerment movement in Saudi Arabia. If we do not work on initiatives to push women forward, we will not be able to progress. At Tasamy, for example, we have run training sessions on how to say no, which is something that women often struggle with when talking to investors. And of the 11 employees at Tasamy, nine are women. It is inspiring and empowering to see women at work in Saudi Arabia today.

BAGS WITH A MISSION FOR WOMEN ON A MISSION

FEED Founder, Lauren Bush Lauren, carrying the **Leather FEED 1 Bag**, which provides **185 school meals**.

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INVEST

OK Boomerang

When former leaders return to their old companies for “boomerang” stints as CEOs, the rust often shows—and shareholders suffer. **BY RYAN DEROUSSEAU**

▶ **EDWARD BREEN'S** four-year tenure heading DuPont was one for the corporate history books. He reshaped the centuries-old industrial giant through a series of acquisitions, including a merger with Dow Chemical. Then he engineered the slicing of \$86 billion DowDuPont into three separate public entities.

In June 2019, after the splits were finalized, Breen relinquished the CEO role, becoming chairman of DuPont de Nemours, the newly formed specialty chemical company. But shares in the new DuPont soon tanked, as weak demand for auto parts and U.S.-China trade tensions ate into earnings. The board's solution? Bring back Breen. He's CEO again, as of Feb. 18.

It's a common tactic among companies in dire straits: rehiring an old friend. CEOs who return for a second stint don't have a learning curve, the thinking goes, and maybe they can spark magic. The iconic example is Steve Jobs, who famously came back to Apple, the company he founded, after 12 years away and transformed the computer maker into the world's most valuable company.

But Jobs was an exceptional leader—and for second-time-around CEOs, success is more the exception than the rule. That's the conclusion of researchers at the University of North Carolina who tracked “boomerang CEOs.” In a recent study, the authors reviewed 6,429 CEOs who led S&P 1500 companies between 1992 and 2017, and found 167 cases when a former CEO ricocheted back to the head role. Executives who went from CEO to co-CEO and back at the same

company were counted as boomerang leaders.

In general, investors would have been better off if the boomerang hadn't come back. Companies with such CEOs garnered annualized stock returns (including dividends) that were, on average, 10% lower than those of non-boomerang companies. Their shares also lagged their industries.

What accounts for the disappointing reunions? Some boomerang CEOs returned under unusually tough conditions. A.G. Lafley of Procter & Gamble and Steve Ells of Chipotle each enjoyed great runs in the 2000s, then were overmatched by new crises (e-commerce and *E. coli*, respectively) in second stints in the 2010s.

But rehiring a familiar face is often a sign of broader management dysfunction. “It's a failure of CEO succession planning,” says Travis Howell, a researcher on the study. Companies bring in ex-chiefs in part because they have no one else to turn to. (The numbers also show yet another sign of gender imbalance in the C-suite: Only two of the 167 boomerang CEOs were women.)

Boomerang CEOs are also unusually likely to be founders. Founders made



ROUND 1

Shares in Michael Dell's eponymous company soared during his first stint as CEO ...


ROUND 2

... but they have lost value and trailed the market during his “boomerang” stint.

up 44% of the UNC study’s boomerang CEOs (compared with only 4% of all CEOs in the sample). And on average, they performed even worse than non-founders. Often a founder’s entrepreneurial vision no longer meshes with the mature company’s needs, Howell notes; the skills involved in growing a new business don’t necessarily translate well to managing a behemoth. (Here again, Jobs is a rare exception.)

Michael Dell’s tenure at his eponymous company illustrates the phenomenon. The stock was a world-beater in its early years. But its shares languished (along with Dell’s personal-computer business) after Dell the man returned as CEO in 2007, falling 43% before Dell took the company private in 2013. (Dell shares have also trailed the market since the company went public again in 2018.) Indeed, boomerang CEOs are particularly unlikely to replicate their past success in tech: The UNC study found that in industries in which the rate of change is rapid, such as technology, returning CEOs perform far worse than in relatively stable sectors, like industrials.

CEOs who aggressively innovate seem more likely to buck the downward trend. Ron Shaich led Panera Bread in the 2000s, then returned as CEO in 2012 after a two-year break. He tore down the organization, investing heavily to reorient the chain around fast-casual service. By 2017, when Panera was sold to private equity firm JAB Holding, its stock had soared. Starbucks’ Howard Schultz was similarly bold when he reoccupied the corner office in 2008, closing stores, retraining staff, and introducing mobile ordering across the company.

The bad aggregate track record notwithstanding, there are a few boomerang CEOs on the current scene who have earned investors’ confidence. Since founder W. Kent Taylor returned in 2011 as CEO of the **Texas Roadhouse (TXRH, \$52)** restaurant chain, the stock has returned 264%,

compared with 159% for the broader market. Taylor has earned kudos for keeping price increases modest, allowing the \$2.8 billion chain to underprice competitors. Texas Roadhouse’s recent willingness to more efficiently deploy labor at its 611 locations is a positive development for the stock, says KeyBanc analyst Eric Gonzalez.

Then there’s **DuPont (DD, \$40)**. Breen’s knack for restructuring remains acute: In early 2021, DuPont will spin off its struggling biosciences and nutrition unit, enabling it to focus on stronger industrial businesses. Its shares trade at valuations far below those of its industrial peers and have been driven even lower by the coronavirus crisis. But many investors believe DuPont’s woes are cyclical and will recede in the long term. “Valuation should be higher,” says Jonas Oxgaard, an analyst at Bernstein. Put another way: Breen could deliver the boomerang effect investors like, where fallen share prices return to normal. **F**

BY THE NUMBERS
167

Companies in the S&P 1500 that rehired one of their former CEOs, 1992-2017

-10%

Average annual amount by which their stocks trailed companies run by first-stint CEOs

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Pounding the pavement with pooches could prove a better career than senior care.

SERVICES

Are We Caring for Carers?

Thanks to caps on reimbursement for senior care, dog walkers are leading the home-care pack. BY ERIKA FRY

HOW THEY COMPARE

MEDIAN ANNUAL PAY

Dog walker
\$31,300

Senior caregiver
\$26,200

Childcare provider
\$23,300

▶ **A CAPITALIST SOCIETY** measures value by what it's prepared to pay for people's time. So, what to make of the fact that when it comes to the hard work of care, Americans pay the most—\$14.80 an hour—to the people who walk their dogs? Those who tend to children and the elderly make considerably less, according to PayScale, a compensation data and software company.

But don't blame free-market forces, says Sudarshan Sampath, PayScale's director of research. Dog walking is a competitive business, while roughly 70% of home health workers are paid by Medicare and Medicaid. The government caps reimbursement for the service at a rate that—given operating costs and margins—makes for paltry wages, says Jeounghee Kim, an associate professor at Rutgers who studies the care economy. Parents, meanwhile, tend to pay for childcare and often rely on family members or unlicensed providers; for regulated services to compete, they have to keep wages low.

With a senior population that is expected to double in the coming decades—not to mention a shortage of professional caregivers already—Sampath sees the artificially low wages as a real issue: “The economic case doesn't make sense anymore.” Kim calls it a crisis that has so far proved “too expensive to fix.” ■

REVIEW

PICTURE NOT SO PERFECT

BY RACHEL KING

BEFORE THERE were influencers and algorithms, there was just a baker's dozen of employees huddled in a small office space outfitted with Ikea furniture in San Francisco determining what was “Instagrammable.” In *No Filter* (Simon & Schuster), Bloomberg reporter Sarah Frier chronicles the rise of the photo-sharing social network from scrappy startup through its \$715 million acquisition by Facebook (cobbled together over a weekend barbecue at Mark Zuckerberg's house) to the ad-driven juggernaut it is today. Interviews with key executives, venture capitalists, and most-followed celebrities get to the heart of what has made Instagram a cultural phenomenon, as well as the tensions between its founders and corporate owners. *No Filter* might be the most engrossing book about Silicon Valley drama since Nick Bilton's *Hatching Twitter*. But instead of cofounder infighting, the focus here is on the battle for Instagram's soul, which has far-reaching consequences for society and its relationship with technology.





*I wish to train
with astronauts*

Addison, 8
Wilms tumor

WHERE THERE'S A **wish** THERE'S A WAY.


For children battling a critical illness, a wish is more than a dream. It can be a turning point that can give them the emotional and physical strength to keep going.

.....
WISHES NEED YOU ★ WORLDWISH.ORG/DONATE
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Make-A-Wish.
INTERNATIONAL




*You Can
Help
Turn Things
Around*



You might think ending extinction means going to the ends of the Earth. But sometimes, saving the world is as easy as showing up. Your support is vital to the San Diego Zoo's mission of protecting animals all over the world. Join us in making a difference—together, we can be heroes for wildlife.

ENDextinction.org



San Diego Zoo Global is involved in conservation projects in more than 70 countries, including for gelada monkeys, African penguins, and lemurs, species you can see in the San Diego Zoo's Conrad Prebys Africa Rocks.

SAN DIEGO ZOO



VENTURE

Prime Sub

When the sandwich shop where Peter Cancro worked came up for sale, he bought it—even though he was only 17. Here's how he turned that shop into a major franchise, fought off bankruptcy, and built Jersey Mike's into a billion-dollar business. **AS TOLD TO DINAH ENG**

▶ MY FIRST JOB was at Mike's Subs in Point Pleasant, N.J., a small beach town on the Jersey Shore. My older brother worked there the summer before I did and got me the job. I was 14, and I would sprinkle the subs as they came down the line, wrap them, and work the cash register. I did everything, except I wasn't old enough to work the slicer.

The owner was great. He ran the business like a tight-knit fam-

ily. Even though I was a teenager, he gave me the feeling that my voice mattered. I made \$1.75 an hour, which was big money in 1971. I worked full-time in the summers and part-time through the school year.

Back then, there were no McDonald's or Burger Kings in town. Mike's was

"I learned by doing," says Jersey Mike's CEO, Peter Cancro.

a 1,000-square-foot store with 17 seats, and most of the business was takeout. It did what would be \$40,000 a week in today's dollars.

In 1975, when I was a senior in high school, the store came up for sale. I was president of my class and going to college to study law. One night my mother said, "Mike's is for sale. Why don't you buy it?" I laughed, went up one flight of stairs, and by the time I reached the top, I decided to do it.

I talked to the owner, who had a couple of potential buyers but could hold off the sale for a week or so. I started knocking on people's doors, trying to raise \$125,000 to buy it. On Friday, a gentleman said he would put up all the money but wanted to be 50/50 partners. I knew the amount of work involved in running the store and wanted to [own it outright], so I said no.

On that Sunday, I called Rod Smith, my Pop Warner football coach, who was also a banker. I told him what I wanted to do, and he helped finance the real estate and business loan. He knew me, and he said I always get the ball across the goal line. Back then, you shook hands, trusted people, and did business that way.

So my senior year I went to homeroom, history, English, skipped gym, and went to work. I had

PETER CANCRO'S BEST ADVICE

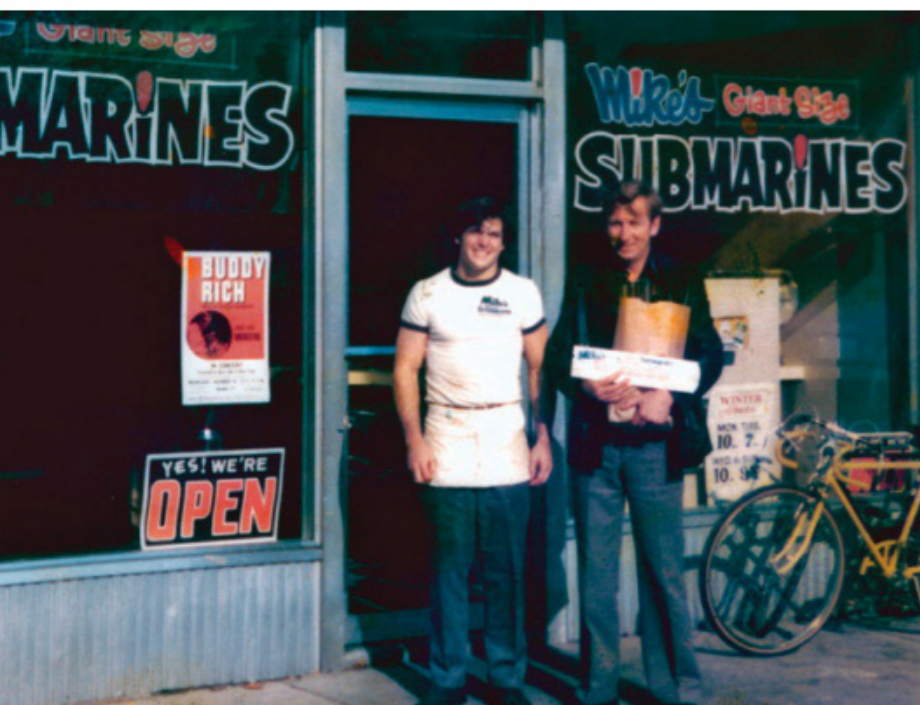
Rise up together. With each customer transaction, don't just say, "How are you? This is how much you owe." Make human contact. Share something about yourself with your customer. If someone's down, try to help turn that around.

to come up with a medical excuse on why I missed gym so much, so I said I had a bad back.

There were 12 people working in the store in the off-season, and we had worked together for years, so they were happy for me. When you're 17, you feel invincible, and most times you are because you think that way. Paperwork and taxes were a challenge, but I learned by doing.

People came from all over the country to vacation at the beach, and at the end of the summer, they would order our subs to take home with them. In 1986 we opened a second store in town and changed our name from Mike's to Jersey Mike's, so that people would know where the product was from. People were asking us to franchise, so in 1987 we started doing that.

Cancro (left) with a customer outside the original Mike's location in Point Pleasant, N.J., circa 1977.



We got to 35 stores when the recession hit in 1991. No one would lend money in the Northeast, which really hurt us. Everything we had made was spent on growth, advertising, and more people, and we overspent. We were negative a million and a half dollars and were counseled to declare bankruptcy, but I said no way.

I had to lay off all six people in the office, including my brother. It's amazing how many bills you can pay when you have no payroll.

It was tough times. I was married with three young children. I owed money to equipment companies, construction companies. I'd float one bill and pay another to keep from going into collection.

I persevered by showing up morning to night, seven days a week. I liquidated my 401(k), sold the Mercedes-Benz and any extra things we had, bringing it down to one used car.

I went out and did the store visits myself for more than a year, then gradually started hiring people back.

In recessions, we do better because people give up the tablecloth restaurants for our shops, so the business was still great. I got lucky breaks, and things turned around. I learned to slow down and not overspend. By 1998 we hit 100 stores.

In the beginning, I went charging up the hill. Now I look around the hill and plan first before expanding.

When we meet new

people who want to buy a franchise, I want to see if they understand our culture. We're big on community involvement, which I learned from the town merchants in Point Pleasant when I was 14.

All our marketing is local. In March we do a Day of Giving, when the owners give all their sales to a local charity. Last year we raised \$7.5 million for good causes. Cause-related marketing benefits charities and makes you a part of the community.

We pay people higher than minimum wage. It's up to the owners, but we recommend a percentage for payroll out of the gross. In California, for example, minimum wage is \$12 an hour, but with 10 to 12 people in each store, those who work the slicer can make \$20 to \$22 an hour.

In '08 and '09 a recession happened again, but there was still some money to be lent. Everyone was hit, but our company grew through it because we had enough stores open and had planned better for capital and growth.

We're in 47 states, Canada, and Australia and have about 1,700 stores now. In 2019 we did \$1.4 billion in sales. It's still owned just by me.

What I love about being CEO is making a difference in people's lives. Mostly I'm proudest of having coached all my kids' sports teams. No matter how busy I was, I made it back for their practices. And they all got their first job at age 14. ■



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TECHNOLOGY

INSIDE XEROX'S AUDACIOUS BID TO BUY HP

Two 20th-century tech giants are duking it out in a hostile-takeover battle, with the future of a \$200 billion industry at stake—and rabble-rousing investor Carl Icahn watching from the wings.

BY SHAWN TULLY

JOHN VISENTIN is speaking with the simmering impatience of someone who's 100% sure his opponents are 100% wrong. "They want to block us with a poison pill, telling their investors they aren't bright enough to make up their own minds," he fumes. "That really annoys me!"

The "they" here is HP Inc. And Visentin, CEO of venerable printer-maker Xerox Holdings, is building a case for one of the most audacious takeover quests in recent memory.

In November, Xerox made a guppy-devours-the-whale bid to buy HP, an offer now set at \$35 billion. Today, with a cliffhanger proxy battle looming, HP's countermoves are irking the takeover architect.

Visentin, a plainspoken 57-year-old from a blue-collar Canadian family, is the antithesis of a swashbuckler. He's a career tech guy whose résumé includes a few stellar years in private equity and a stint as an executive vice president at the old Hewlett-Packard. But he's capable of waxing passionate about his plans. "Printing is long overdue for consolidation," he says, during an interview at Xerox's anonymous glass-cube headquarters in Connecticut. "The potential for cutting costs, for investing for the future, is tremendous." HP, he says, is thwarting Xerox by promising huge share buybacks: "How is that investing for the future?"

Thirty years ago, a Xerox-HP takeover battle might have dominated the headlines. Today, these aging giants operate far from the

spotlight. But they still run richly profitable printing businesses, generating cash that could finance the kinds of transformation that Visentin envisions. What makes his bid particularly bold is that it has been decades since a company Xerox's size has succeeded in buying a rival that's so much bigger. In 2019, Xerox posted sales of \$9.1 billion—less than one-sixth of the \$58.8 billion HP tallied in its most recent fiscal year.

One person's "bold," of course, is another person's crazy. To finance the merger, Xerox would take on \$24 billion in new debt. "It makes no sense because all that debt would make the combined company much riskier," says Bill George, former CEO of Medtronic and a professor at Harvard Business School. HP brass, who oppose the merger, argue that the leverage would threaten the companies' survival. "You can't work through economic cycles with that level of debt," says CFO Steve Fielser, who calls Visentin's \$2 billion in planned annual savings "unachievable."

Xerox's offer—now \$24 a share, a premium of about 20% over HP's mid-March stock price—will face a vote at HP's annual shareholder meeting, expected in May. Rooting for a deal is activist titan Carl Icahn. He's Xerox's largest investor, with an

PAPER CUTTER
Xerox's Visentin argues that steep expense reductions and bets on big digital printers like the Iridesse (shown here) would make an HP-Xerox merger pay off.

PHOTOGRAPH BY
REED YOUNG



REAL MONEY

15%

COMBINED SHARE OF XEROX STOCK CONTROLLED BY CARL ICAHN, 84, AND DARWIN DEASON, 80

\$20.1 BILLION

ANNUAL REVENUE OF HP'S PRINTER DIVISION (FOR FISCAL YEAR ENDING 10/31/19)

\$24 BILLION

DEBT THAT XEROX WOULD INCUR TO ACQUIRE HP

SOURCE: COMPANY FILINGS

11% stake, worth about \$750 million; he also owns 4.4% of HP, worth some \$1.3 billion. Icahn led a campaign in 2018 that blocked Japan's Fujifilm Holdings from purchasing Xerox. He then backed a new management team headed by Visentin, who became Xerox CEO that May. Icahn claims that a combination promises huge gains for both sides. "I want to own the stock of the merged companies," he tells *Fortune*, "and Visentin is a tough guy and the right guy to run it."

If Xerox wins the proxy battle, a new HP board will likely approve the deal. But HP may persuade its shareholders to rebuff Xerox, or even turn around and buy Xerox—a deal proposed by, among others, Carl Icahn. Whatever the outcome, Visentin's bid could shake up a backwater of the tech world by highlighting a strategy that has revived mature industries from autos to airlines: consolidation.

P RINTERS MAY BE unglamorous, but they're also a \$206-billion-a-year industry. Though revenues are shrinking as clients turn to digital documents, those boxy appliances produce enormous cash flow, as customers keep paying for years for paper, maintenance, and pricey toner cartridges.

The field encompasses 12 major players, including HP, Xerox, and eight Japanese companies. Mergers could offer this gaggle some advantages: Combined, companies could slash costs by reducing headcount and winning lower prices on outsourced parts and services. They would then have more cash to invest in faster-growing arenas, including 3D printing and customized digital printing.

If such a strategy succeeded, it could pay off disproportionately for investors. HP and Xerox trade at a

dirt-cheap 7.5 and 5.4 times free cash flow, respectively, reflecting investors' belief that they'll keep shrinking. The average multiple for the S&P 500, by contrast, is 19, and a growth surge could help their shares close that gap.

Boosters of an HP-Xerox merger point out that each focuses on different parts of the market. HP's \$20.1 billion printing business specializes in desktop printers, a category called A4s. Xerox relies mostly on A3s, the huge multipurpose models used by businesses. In most cases, it leases them on contracts through which it provides supplies and maintenance.

Last year, Xerox produced free cash flow of \$1.3 billion and HP of almost \$4 billion. Visentin argues that he can produce \$2 billion in new yearly savings—and the healthier margins and investment opportunities that come with them—by combining Xerox and HP. At Xerox,

Visentin has delivered on the cost cutting: The company has sharply reduced what it spends on outsourcing such functions as IT management and payroll and medical claims management, lowering total expenses by almost 10% in 2019. The question now is whether HP's investors will let him take his shears to their company.

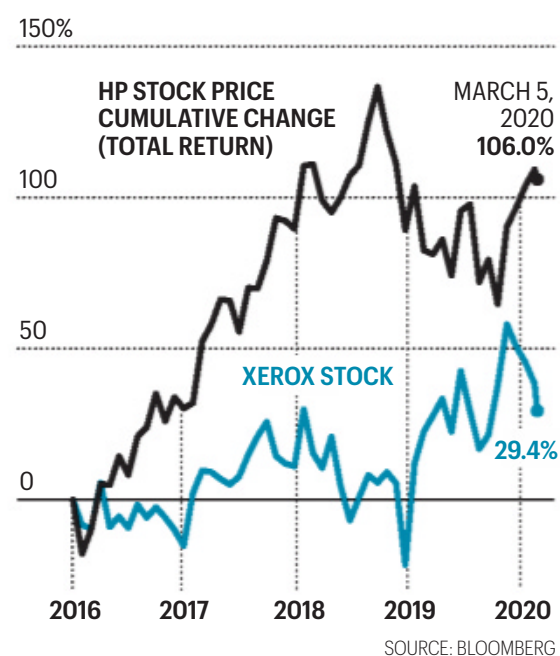
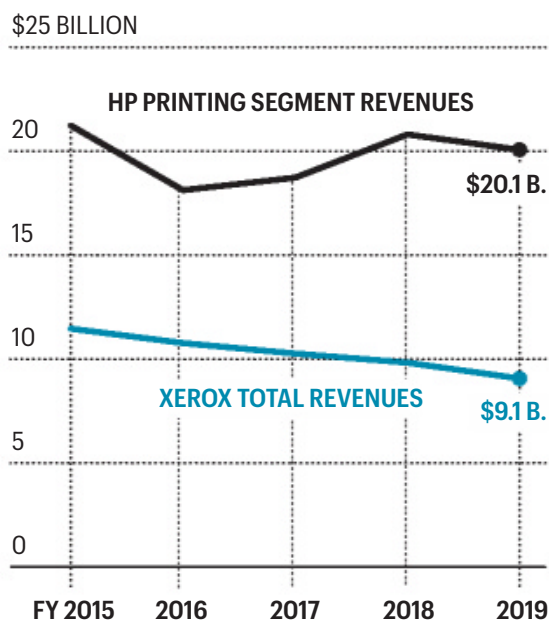
TWO WOOL INVESTORS, HP is taking a cash-is-king approach. On Feb. 24 it unveiled a plan to buy back \$15 billion in stock over three years and pledged to return 100% of free cash flow to shareholders. CEO Enrique Lores tells *Fortune* that Visentin's bid both undervalues HP and would leave it overleveraged. HP is open to acquisitions, he says, but can expand sales and profits without them, by shifting the product mix to faster-growing business lines—including, yes, 3D and digital printing.

While Wall Street analysts are skeptical of that claim, HP's counter-moves have won some converts. "The cash return program probably moved HP from a disadvantage to a slight advantage," one institutional shareholder says. This investor believes Xerox could regain its edge by raising its offer price by \$2 to \$3 a share. But that could mean taking on even more debt, a precarious proposition.

If Xerox looks like the winner as the vote approaches, it's possible HP will bid for Xerox. Indeed, in a Feb. 27 proxy filing, HP gave a detailed narrative of negotiations on just that topic. According to the filing, Icahn and Visentin proposed selling Xerox to HP at around \$45 a share—a huge premium over Xerox's early March

WHEN THE INK RUNS LOW

Xerox's executives and biggest shareholders argue that consolidation with HP could revive both companies' flagging revenues. Other investors have their doubts.



SOURCE: BLOOMBERG

price of \$32. But even at that price, it's a move that HP, with its much larger revenue stream, could afford.

If HP becomes the buyer, the boardroom maneuvering will undergo some fascinating twists. HP would need to convince institutional investors that it isn't overpaying, lest they flip their support to Xerox. It would also likely need to propose a friendly merger to the same Xerox management that it has been trashing as irresponsible. The deadline for HP to unseat Xerox's board in a hostile takeover at its annual meeting has passed for 2020, a scenario that Jim Woolery of King & Spalding, Xerox's lawyer, says gives his client an advantage.

The best long-term outcome for

shareholders may involve HP buying Xerox. The combined company would carry much less debt, probably less than \$10 billion net of cash holdings, leaving more cash to invest in R&D and acquisitions, even as it reaches more customers. The problem, in some shareholders' eyes: If HP is the buyer, Visentin and his "Let's not copy, let's reinvent" mindset might be sidelined. And the benefits of consolidation may mean that a Xerox acquisition is better than none.

Darwin Deason knows who he's cheering for. The 80-year-old Texan sold an outsourcing services company to Xerox in 2010 and still owns 4% of its stock; it was Deason who teamed with Icahn, 84, to block the Fuji takeover. Deason says he's amused to be "at my last rodeo, fighting for the little guy to buy the big guy, when it almost always goes the other way around. But here I am riding the bull!" If that bull breaks some dishes in the sleepy china shop of the printer industry, the two octogenarians won't be the only ones who profit. ■

The best outcome may well involve HP buying Xerox because the combined company would carry much less debt.



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Google Cloud

PERSONAL TECHNOLOGY

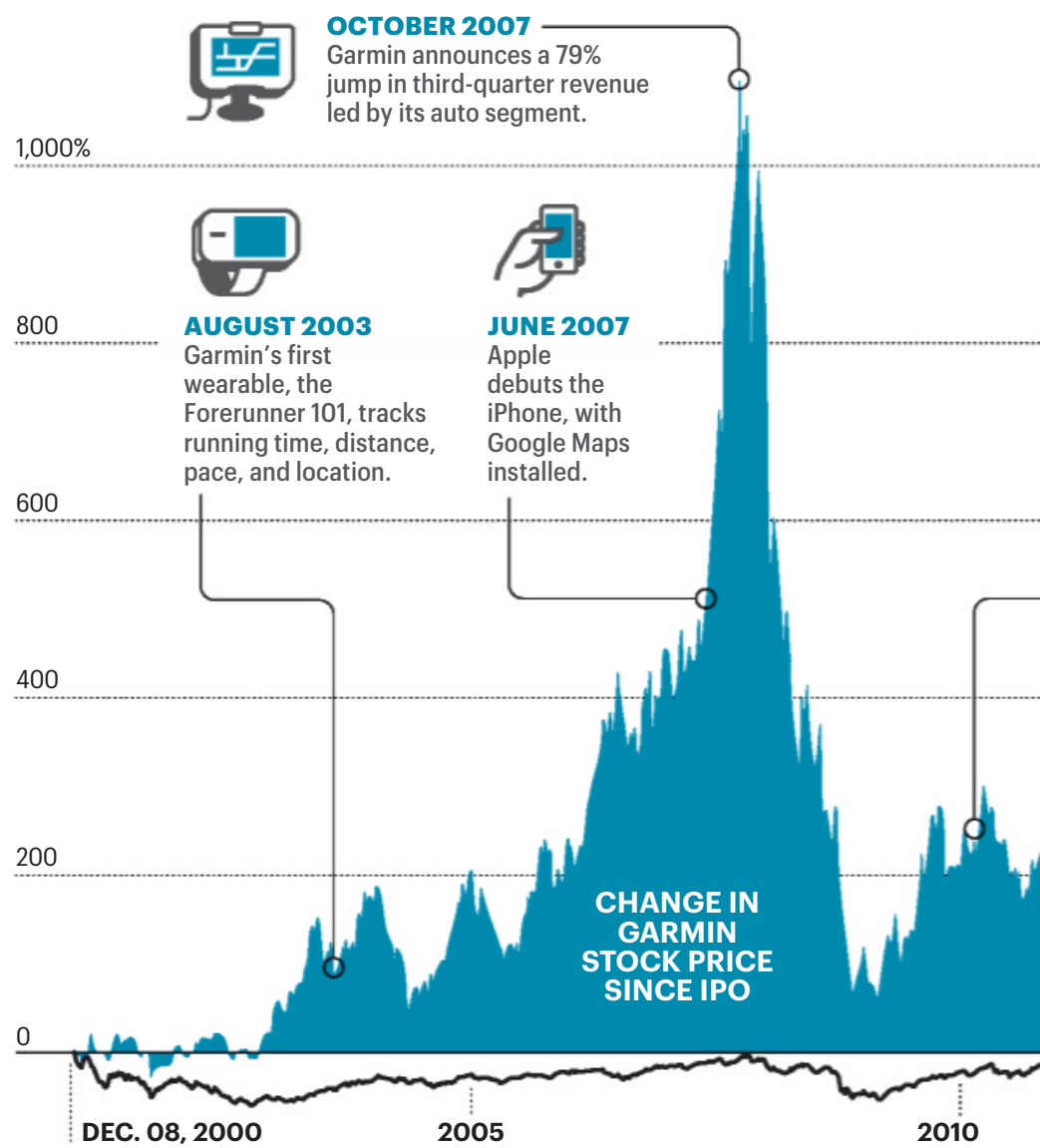
GARMIN GOES THE DISTANCE

Far from Silicon Valley, the gadget maker focused on its expertise in GPS technology—and reversed an onslaught from the likes of Apple and Google. For now.

BY DANIELLE ABRIL

FOR ALL THE TIME, effort, and money companies plow into the endless hunt for innovation, many of their best ideas come from within. A Procter & Gamble chemist in the 19th century figured a bar of soap that floated in the tub would enliven the bathing experience, and Ivory Soap was born. In the 1970s, a 3M employee, craving a better way to mark pages in his hymnal, modified an uncommercialized adhesive invented a few years earlier by a colleague; Post-it Notes became an iconic 3M success story. And at Garmin, a suburban Kansas City maker of navigational devices for boats, planes, and cars, a group of running-obsessed employees applied their know-how to their hobby—a move that revitalized the company when it badly needed a win.

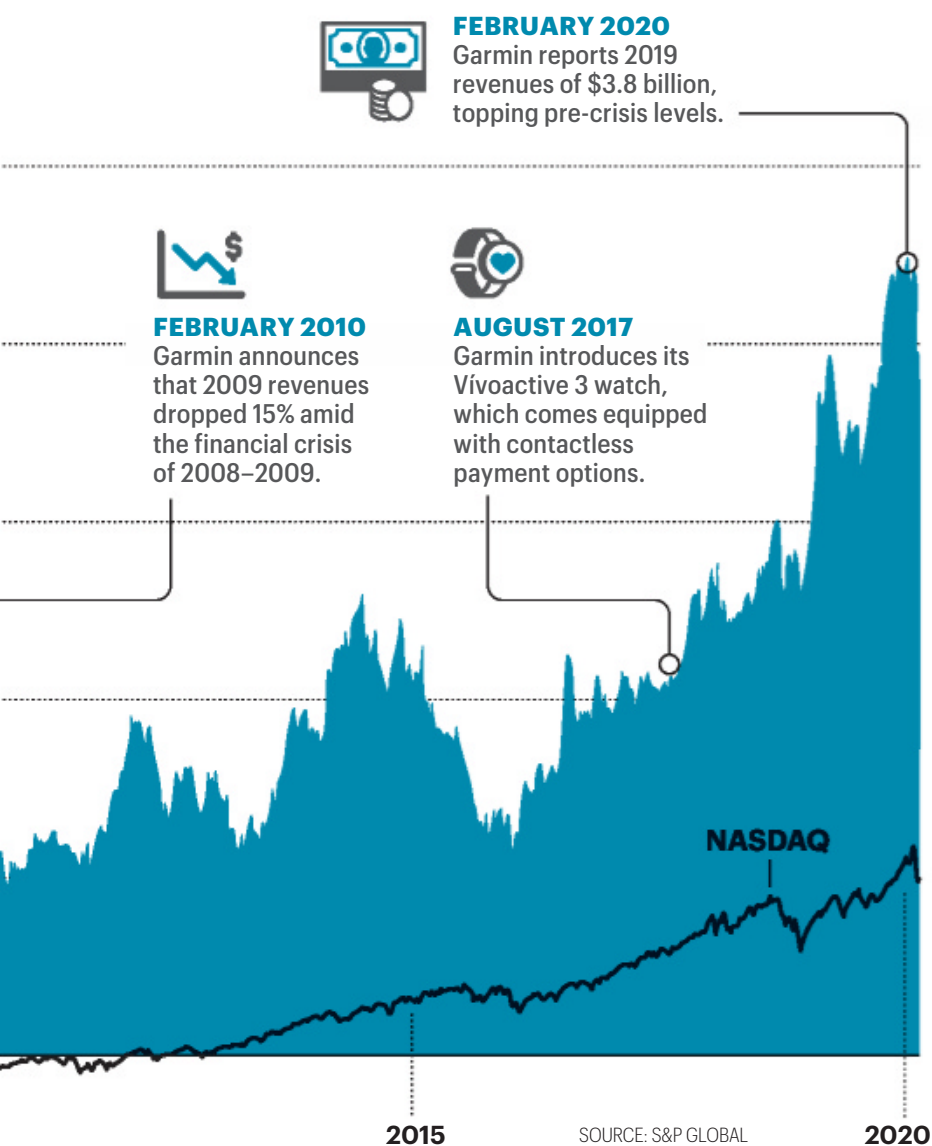
It was the early 2000s, and Garmin had grown from its niche of making consumer devices utilizing the government's global positioning system, or GPS, technology. Together with rival TomTom, Garmin dominated the market for in-car navigational devices, game-changing gadgets that marked



ROLLER COASTER
Garmin's stock price soared on the strength of its in-car navigational device. Apple's iPhone and Google Maps erased those gains. GPS-enabled fitness watches sent shares soaring again.

the beginning of the end for foldable maps. GPS for personal fitness wasn't popular before the Garmin jogging klatch began noodling. "They said, 'We do all these GPS things. Why don't we have a GPS product for runners?'" recalls Cliff Pemble, Garmin's CEO and a 31-year company veteran.

In 2003, Garmin offered its first fitness wearable, the Forerunner 101. What began as an employee side project has come to define the company nearly two decades on—especially after a lethal technology combination of the iPhone and Google Maps laid waste to Garmin's core automotive business. Today, Garmin is a rare example of a company far from Silicon Valley that not only took a punch from the tech behemoths but



REAL MONEY

15,000

THE NUMBER OF GLOBAL EMPLOYEES AT GARMIN, WITH OFFICES IN MORE THAN 30 COUNTRIES, INCLUDING AT ITS HEADQUARTERS, IN OLATHE, KANS., AS WELL AS IN TAIWAN, THE U.K., AND OREGON. HEAD-COUNT GREW 15% IN THE PAST YEAR.

\$1.05 BILLION

REVENUE GENERATED IN 2019 BY GARMIN'S LARGEST AND FASTEST-GROWING CATEGORY, FITNESS, WHICH INCLUDES MULTI-SPORT WATCHES AND SMARTWATCHES.

SOURCE: GARMIN

“There aren’t a lot of instances where companies have been able or even tried to make those kinds of leaps.”

GARMIN DIDN'T set out to conquer mass markets, focusing instead from the beginning on niche products for enthusiasts like boaters, pilots, and off-roaders. Its founders, Gary Burrell and Min Kao, were engineers at Allied Signal who started the company in 1989, shortly after GPS became available for civilian use. (The muscular-sounding Garmin is simply a mashup of the duo's given names.) Affordable navigation systems were a revelation for hobbyists, giving them access to the same technology previously reserved for users of sophisticated military equipment.

The company released its first product, the unglamorously named GPS 100, in 1991. It targeted small boats and planes, and it was so popular that by the end of the year, Garmin was profitable. Seven years later it would introduce the product that didn't just put Garmin on the map, it put digital maps in people's cars. In-car navigation “was a category that we pioneered,” says Pemble, who is 54 and was Garmin's sixth employee. “That gave us rocket fuel. It made Garmin a consumer brand.”

Along the way, Garmin played to its Midwestern strengths of stressing a corporate culture based on hard work and humility. “They knew how to get the best out of people,” says Josef Reed, a former systems engineer often tasked with briefing senior management. “They'd give praise and critiques at the same time.” Says Stephanie Mountain, a former Garmin marketing analyst: “They were constantly pushing people to their limits.”

The company had permission to push, in part, because it was so tight-knit. Burrell, a devout Christian who died last year at age 81, referred to himself as a “servant leader,” and his presence was felt throughout the

has thrived in competition with them. Watches and other wearables made up about a third of Garmin's \$3.8 billion in revenue last year. It sports a \$15 billion valuation, making it a minnow compared with rivals Apple, Alphabet, and Samsung—but a substantial player in its own right.

How Garmin withstood the onslaught is a case study of a company sticking to what it knows best—in its case, products pegged to one key technology, GPS devices—and proof that not all innovation comes from a sun-kissed strip of land in Northern California. Indeed, Garmin's aw-shucks Midwestern nature and its stick-to-itiveness in the face of adversity go a long way in explaining its staying power. It's hard to imagine the

company's mega-cap rivals acknowledging, for example, that they more or less lucked into what would become a killer app. “What we probably underestimated was the importance of the wearables,” says Pemble. “We were dabbling with it way back when. But nobody could foresee that it would become the category that it is today.”

The big tech companies remain an existential threat for Garmin, of course. Apple and Samsung are the two biggest players in smartwatches, and Alphabet's Google is in the process of buying rival Fitbit. “Selling the watch to the masses requires a different product and a whole different mindset than what [Garmin is] doing today,” says Stephen Baker, an analyst with market researcher NPD Group.

“The biggest challenge is getting that mass market to understand

company. “He literally knew my wife and kids’ names,” says Rick Evans, who worked for Garmin from 2000 to 2016. “And he knew that about everybody.”

Such tightness would come in handy when times got tough in the late 2000s. The company was soaring in 2007, when it had some 40 different in-car GPS models for cars, trucks, and motorcycles. The automotive segment had become a \$2.3 billion business, more than doubling its revenue from the previous year and representing nearly 74% of overall sales. Then came the iPhone, which Apple released in the middle of that year with Google Maps loaded on all phones. The first version of the iPhone lacked a GPS chip, relying

instead on more rudimentary technology to pinpoint locations. But within a year, Apple incorporated GPS, making its phone a multifaceted replacement for Garmin’s stand-alone devices.

Garmin’s business took an almost immediate hit, and its problems were exacerbated by the financial crisis. In 2008, the stock price collapsed, falling below \$16 a share from highs of more than \$120 in 2007. As Wall Street had feared, revenue declined by \$500 million in 2009, to \$3 billion. Though Garmin remained solidly profitable—it earned \$704 million that year—investors were rattled. “Back then, [investors] would come in and say, ‘They’re going to get put out of business,’” says Ron Epstein, a Bank of America analyst who has

covered Garmin for 15 years.

Kao, who remains Garmin’s executive chairman and was CEO at the time, kept calm and focused investments on the nonautomotive parts of the company’s business. Over the next decade, for example, Garmin bought more than 25 companies around the world, mostly distributors of navigation equipment that broadened its geographic reach. It also bought access to weather information as well as contactless payments technology it would embed in its wearable devices. Pemble, the CEO, says Garmin never lost sight of the need to grow. “The most efficient thing to try is to double down on growth and opportunity,” he says. “Saving money and cutting expenses never really works.”

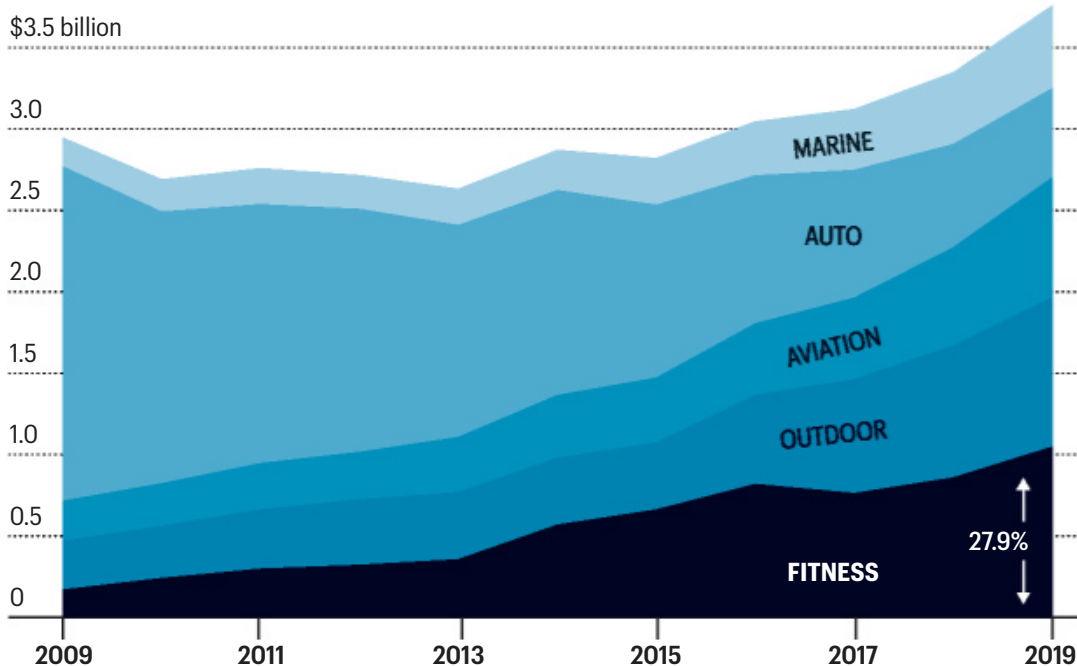
Garmin’s product innovation was hardly flawless. In 2008 it debuted the Nüvifone, its own GPS-enabled smartphone that eventually used Google’s Android mobile operating system. Expensive for its day at \$300 retail, the phone had a touch screen that wasn’t very responsive and often confused swiping and tapping. Its camera was low-quality and didn’t include video. And Garmin charged users \$6 to check the weather, traffic, and local events—things Apple and other phonemakers offered for free. The company exited the smartphone business after two and a half years.

GARMIN PROVED TO BE at its best when it plodded along at product development, the antithesis of Silicon Valley’s mantra of moving fast and breaking things. It helped that the company made products for regulated industries, particularly aviation, where precision is more important than time-to-market. “I had worked for Apple and seen how quickly they could move,” says Matt Ronge, a for-

TRADING PLACES

As Garmin’s automotive business, the in-car navigation gadgets that made the company a household name, has dwindled, fitness watches and trackers have picked up the slack.

GARMIN ANNUAL REVENUES



SOURCES: S&P GLOBAL, BLOOMBERG

we have the perfect watch for them.” —SUSAN LYMAN, GARMIN'S MARKETING CHIEF

mer Garmin software engineer. “Seeing the pace at which things moved at Garmin was very different.”

Nowhere was the company's slow progress more apparent than in fitness watches, which gradually became favorites of hard-core athletes eager to use GPS to pinpoint the accuracy of their events. “Having the GPS is so important,” says Ray Maker, a runner and fitness gadget blogger, who was an early convert to Garmin's Forerunner line. “Your heart and legs don't really know what pace you're doing.” He says Garmin's strength is its multiple features, which may also be intimidating for casual athletes.

Garmin's fitness segment, which extends beyond watches and into devices like a baseball bat-swing sensor and indoor smart bike trainers, was the company's top revenue generator last year. That helped the company surpass its 2008 revenue mark of \$3.5 billion for the first time, sending its shares soaring as well. While the automotive segment has shriveled relative to its fitness offerings, its aviation line has become one of its fastest growers.

Will Power, an analyst with brokerage Robert W. Baird, credits Garmin's “blocking and tackling” for its staying power. “They build really strong defensive positions in areas that, by and large, have less competition.”

In a way, Garmin never stopped being a niche player, albeit a multibillion-dollar one. “What we like about Garmin is the way they position deep expertise around the customer group they're serving,” says Edzard Overbeek, CEO of HERE Technologies, a mapping company that provides location data to Garmin. “The team that is responsible for their cycling watch are professional cyclists. The aviation team are pilots. The secret sauce is understanding what the expert user wants.”



PERSONAL NAVIGATION

Clockwise from top left: the Forerunner, Impact bat-swing sensor, Vivosport, and Striker 7.



A COMPANY CAN go only so far catering to enthusiasts, of course, and at the CES gadgets show in January, Garmin showed off its mass-market aspirations around fitness products—displaying more than 30 watches and wearables ranging from a \$70 kids' fitness tracker to a \$2,500 Marq Driver watch that boasts a stylish look and multiple motor-sport functions. In all, Garmin offers about 90 wearable products made for runners, swimmers, boaters, pilots, and people who just want to track their steps.

“The biggest challenge is getting that mass market to understand we have the perfect watch for them,” says Susan Lyman, the company's top marketing executive. “It kills me when I see people walking their first 5K or running with nothing on their wrist.”

Going after every segment inevita-

bly means challenging the beasts of Silicon Valley, the same companies that knocked Garmin off its perch a decade ago. The Apple Watch, mocked as a less-than-innovative offering when it debuted in 2014, now commands 38% of the smart-watch market. Fitbit, soon to be part of Google, has 7.5% share. All of Garmin's watches combined add up to just under 6%.

Garmin, ever the good Midwesterner, plays down the necessity of beating the unbeatable competitor. “We're not trying to out-Apple Apple,” says Pemble. “We're trying to be Garmin. We only focus on what we can control. So we prepare our business and structure our business in a way that best suits it for the next crisis.” After all, you don't need a fancy navigational device to know that crisis eventually will arrive. ■

BUSINESS FACES THE CLIMATE CRISIS

At its core, business is about meeting needs. Your local deli is a neighborhood fixture because people crave delicious sandwiches. The tax prep industry exists because people hate to fill out 1040s. Big Oil was built to serve a modern world hungry for energy to power our cars and trucks. Before Netflix, we didn't grasp how essential streaming movies could be. Whether big or small, timeless or newly imagined, these urgent demands are what drive businesses to innovate and grow.

Today, the world is confronting a colossal unmet need unlike anything we've grappled with in the past. The warming of our planet thanks to human activity is causing dramatic changes to the climate. According to the

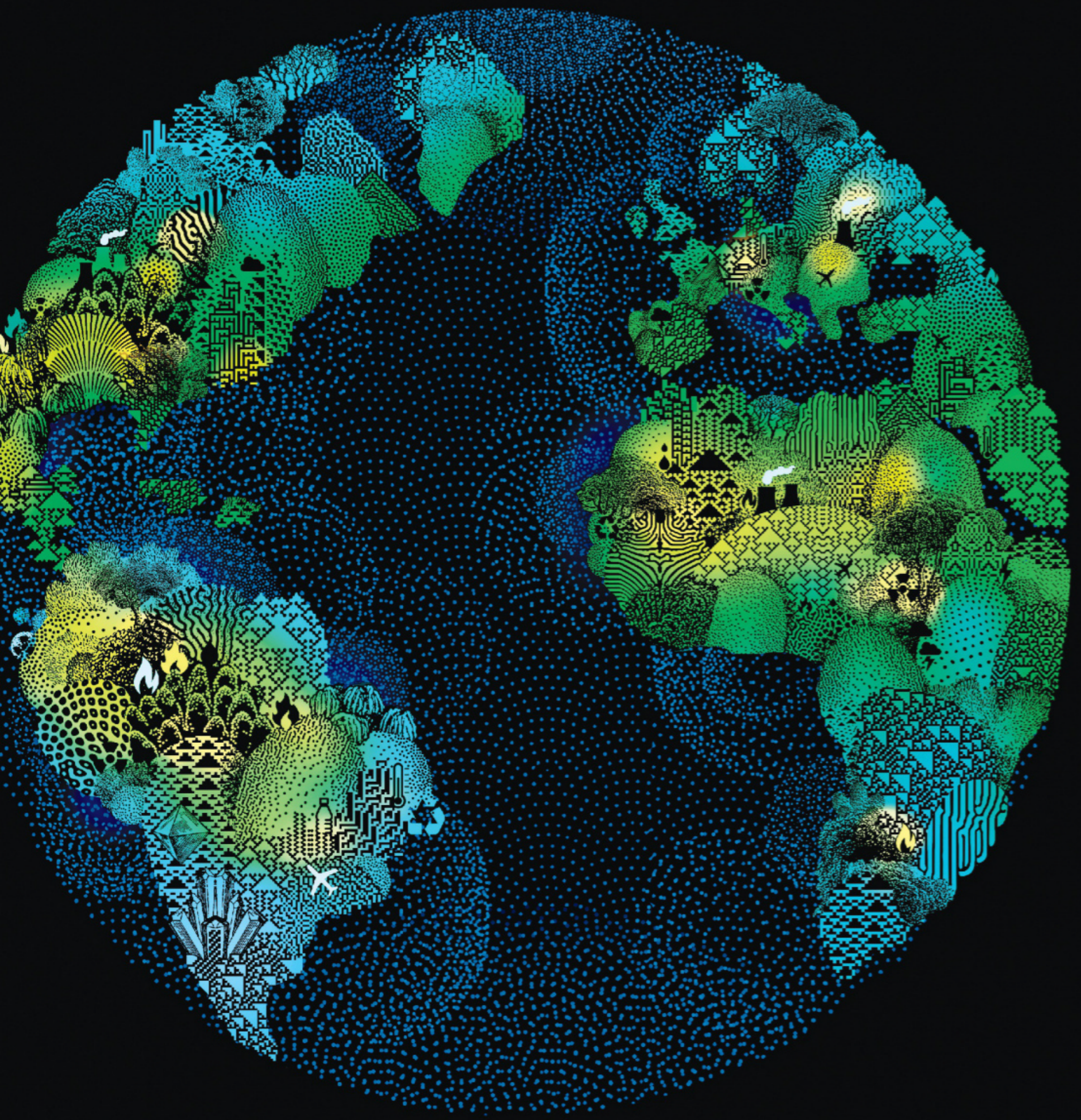
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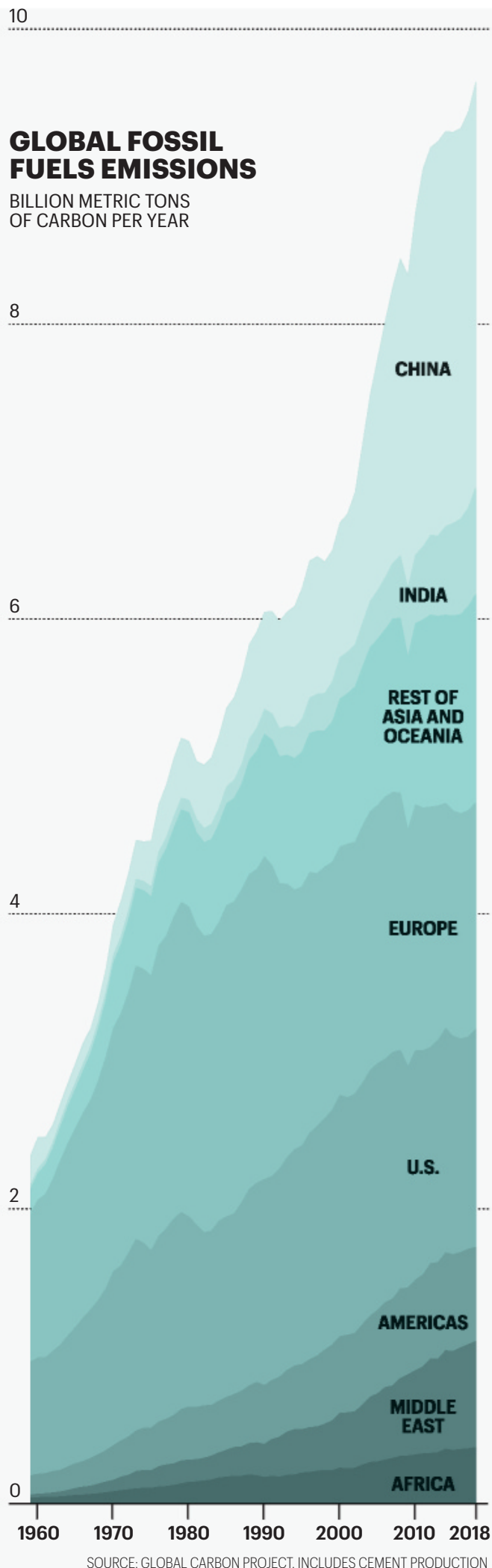
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Global Carbon Project, emissions hit a new record of 43.1 billion metric tons in 2019—the third straight year of increases. If unaddressed, CO₂-driven warming is likely to alter life on earth in dramatic ways over the coming decades, and to come with a price tag of trillions of dollars in lost economic output. Finding solutions to this potentially existential threat is imperative.

There's no getting around the fact that business, up to this point, has been a big part of the problem. Companies have flooded the planet with refrigerators, SUVs, and plastic soda bottles for decades, with little thought to the consequences beyond the bottom line. They've feasted on cheap energy from burning fossil fuels, and their lobbyists have battled legislation to incentivize change.

But there are signs that we may be reaching a turning point. The business world—far later than it should have, and still not as aggressively as it needs to—is finally beginning to face up to the climate crisis.

"I do think we're seeing some exciting momentum," says Helen Mountford, vice president for climate and economics at the World Resources Institute (WRI), a global research organization focused on sustainability. "Nowhere near enough, but there is meaningful change."

As an example, Mountford points to the statement in December from 631 institutional investors managing more than \$37 trillion in assets, urging governments to phase out coal power, put a price on carbon, and end subsidies for fossil fuels. Then there is the growing number of large companies around the world—826 at last count—that have taken on increased accountability for their own actions by signing up for "science-based targets" to reduce their carbon emissions under strict monitoring by NGOs.

Companies are responding to a new set of vital needs. Increasingly, consumers want to know they're spending money with businesses that are on the right side of sustainability. And talented recruits are demanding that employers demonstrate their commitment to mitigating climate change. Not to mention that there are huge amounts of money to be made. As part of a project called the New Climate Economy, Mountford and her team calculated that there's a \$26 trillion economic opportunity in moving to a low-carbon economy. "Now is the moment to start to reboot," she says.

In the pages ahead, we explore the complexity of this crucial juncture for business and the planet. To get an inside perspective on how advocacy is shaping corporate behavior, we turned to author and activist Bill McKibben. In partnership with the Pulitzer Center on Crisis Reporting, we sent reporter Vivienne Walt and photographer Sebastian Meyer to Malaysia to investigate the struggling plastic recycling industry. And we asked veteran energy writer Jeffrey Ball to explore Big Oil's high-stakes bet on carbon capture.

There are no guarantees when it comes to tackling climate change. But if business takes it one unmet need at a time, the possibilities are endless. —*Brian O'Keefe*

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SD-WAN TAKES NETWORKING TO THE NEXT LEVEL

The network of the future will be virtual, cloud-delivered, and self-healing.



THE POTENTIAL FOR DEPLOYING AND MANAGING NETWORKS

as software has long been a dream for IT leaders. Traditionally, networks have been hardware-based, saddling enterprises with equipment that's both resource-intensive and expensive to manage. Deploying and managing networks as a service via the cloud represents a visionary approach that's gaining momentum in today's digital environments. And as mission-critical enterprise applications move to the cloud, wide area networks (WAN) must be able to provide agility, flexibility, and the ability to scale rapidly.

Luckily, today's cloud-delivered software-defined WAN (SD-WAN) offers the potential for networks to extend from the data center and the cloud all the way to the edge, leveraging the speeds and programmability of technologies such as 5G. Innovative SD-WAN approaches are possible in every business sector, from convenience stores to manufacturing and energy.

"Software-defined WAN purchased as a service from the cloud is a long-term trend that will occur

over the next several decades. It's the network of the future," says Sanjay Uppal, senior vice president and general manager of the VeloCloud Business Unit at VMware. "And VMware has been saying 'The cloud is the network' right from the start. It's a phrase that captures it all."

As on-demand networking via the cloud becomes widespread, companies will gain new business potential, with opportunities to identify and upsell to customers who want network analytics that reduce IT deployment costs. The challenge for IT and business managers will be to provide high-quality WAN services to remote locations, such as branch offices or retail chain stores.

A NEW HORIZON FOR NETWORKING

As connectivity options expand, workers in every industry can access corporate applications and data at any time, from anywhere. A key IT goal is ensuring that remote employees experience the same levels of network access and application performance as colleagues located at headquarters.

Through centralized, cloud-based SD-WAN management, IT leaders can eliminate network challenges such as poor reliability and unpredictable performance. Moreover, greater network automation ensures that security policies are in place and that networks seamlessly adjust to evolving application and end-user demands.

"Networks are now becoming fully automated so that a human doesn't have to intervene to ensure functionality, remove bottlenecks, and confirm security protocols are in place. These analytics and server decisions are being made across cloud and telecom networks that are connected and orchestrated with zero-touch open-source software," says Arpit Joshipura, general manager of networking, edge, and IoT at the Linux Foundation.

Increased automation sets the stage for self-healing networks that will fix anomalies on the fly and strengthen overall network security. By creating SD-WAN innovations such as these, VMware allows business executives to focus on business growth instead of spending time and resources managing their networks. ■



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PUTTING THE MONEY SQUEEZE ON FOSSIL FUELS

Banks, asset managers, and insurance companies around the world are waking up to the challenge of global warming. Here's how they can drive change—and why they need to move much faster.

BY BILL MCKIBBEN

THE FOSSIL FUEL INDUSTRY faces a classic business problem: Someone else has come up with a better technology. Over the past decade, engineering advances have helped drive down the price of solar panels and wind turbines by some 90%. Clean energy is now the cheapest way to generate power in most of the world. And today, storage batteries are on the same plummeting price curve—so that, increasingly, the sun's habit of going down at night is no big deal. Even the car, which has helped define our culture and consumes vast quantities of fossil fuel, is changing fast. No honest person who has driven a Tesla will dispute that it's a superior machine: fast, with few moving parts, and a quiet elegance that makes a rumbling muscle car seem more than a little old-fashioned.

Faced with that kind of challenge, incumbent industries usually play for time, trying to eke out another decade or two of profits before wandering off to a well-appointed re-

tirement home. For the energy industry—at the heart of our economy for so long—transition periods have been particularly slow. Fixed investments and established supply lines mean that, in the past, converting from wood to coal or coal to oil has played out over 40 or 50 years or more. Plenty of time for a nice wind-down.

But the fossil fuel industry also faces a decidedly novel business problem: It turns out that its product is destroying the world.

Does that sound like hyperbole? This winter, a team of economists at that radical outpost known as JPMorgan Chase prepared a report for high-end clients that eventually leaked to the British press. It explained the current science in great detail and concluded: “We cannot rule out catastrophic outcomes where human life as we know it is threatened.” Quoting many groups from the International Monetary Fund to the UN’s Intergovernmental Panel on Climate Change, the report said policymakers have

“SOMETHING WILL HAVE TO CHANGE ... IF THE HUMAN RACE IS GOING TO SURVIVE.”

DAVID MACKIE AND JESSICA MURRAY, JPMORGAN CHASE ECONOMISTS IN A FEBRUARY 2020 REPORT TITLED “RISKY BUSINESS: CLIMATE AND THE MACROECONOMY”

no choice but to force the transition off coal, oil, and gas because a business-as-usual climate policy “would likely push the earth to a place that we haven’t seen for many millions of years,” sweeping the planet past irrevocable tipping points as the poles melt and oceans acidify. “It is clear that the Earth is on an unsustainable trajectory,” it said. “Something will have to change at some point if the human race is going to survive.”

How the world deals with the fossil fuel industry’s

PRESSURE CAMPAIGN Activists from the Stop the Money Pipeline coalition near JPMorgan Chase’s New York headquarters in February.



two existential problems, in other words, will define humankind's future. And it has become increasingly clear that while government plays a key role in the race to solve these problems, so too do banks, insurance companies, and asset managers: Wall Street as well as Washington, if you like shorthand. There's an emerging agreement among all parties, activists and financiers alike, that if the transition to clean energy goes at the pace that the oil and coal lobbyists would like, the planet will break.

If that transition instead goes unnaturally fast—well, we can't stop global warming. Not anymore. But we might limit it to the point at which civilizations endure. I wrote the first book for a general audience on this topic back in 1989, and I can tell you we are at a point we have never seen before. The demand for urgent action is today crashing up against a climate denial script that has been carefully nurtured by the oil industry since the 1990s and is now the reigning wisdom at the White House. Which narrative emerges victorious will not only determine the financial landscape of the planet, but it will also determine the literal landscape—how high the seas rise, how many forests burn, how many people must leave their homes. Changing the climate is the biggest thing humans have ever done, and now we'll see how effectively we can respond to a mess of our own making. One thing is for certain: The chances of success are very low unless the business world embraces the challenge.

A

BOUT A DECADE AGO, analysts at a small London think tank, the Carbon Tracker Initiative, published a report laying out the es-

sential underlying facts of the climate crisis. The fossil fuel industry had in its inventory of reserves a vast quantity of carbon: that is, the coal and gas and oil deposits it had identified and told shareholders and regulators it would burn—enough to produce almost 3,000 gigatons of carbon in the form of carbon dioxide. The world's scientists, however, had concluded that we could really only burn about 600 gigatons more and have any hope of meeting the climate targets that the world's governments had set. The numbers have fluctuated some over the decade as

those targets have shifted, but the ratios remain unchanged: In essence, the industry has far, far more supply than the atmosphere can deal with.

And that's a problem not just for life on earth but also for balance sheets. You could call that excess supply a carbon bubble if you'd like—at current prices it may represent something like \$20 trillion worth of fossil fuel that is already reflected in the value of these firms but that scientists say we must keep in the ground. (The dramatic decline in crude prices that has helped rock the stock market of late, meanwhile, has put a profit squeeze on Big Oil.) Mark Carney, who just stepped down as governor of the Bank of England in March to become the UN's climate finance envoy, was far ahead of other regulators in recognizing the danger, telling the world's insurers at Lloyds of London in 2014 that they were dangerously overexposed to the risk of these potentially stranded assets.

\$20 TRILLION

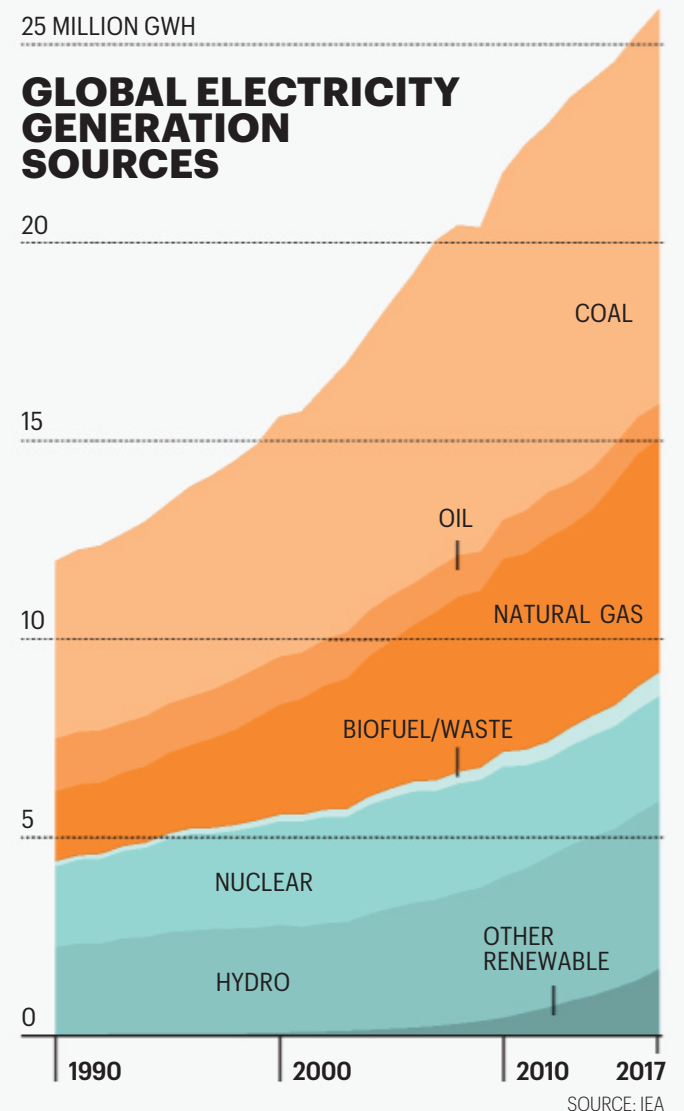
Estimated market value of fossil fuels reflected in energy companies that scientists say we can't afford to burn

SOURCE: CARBON TRACKER INSTITUTE

\$12 TRILLION

Total value of asset managers and endowments that had divested from fossil fuels as of December 2019

SOURCE: GOFOSILFUELFREE.ORG



Beginning in 2012, environmental activists around the world, myself included, began calling for institutions to divest their holdings in fossil fuels. At first, we campaigned mostly on moral grounds, and the early respondents were small colleges and religious denominations. But the push quickly gained steam, becoming the biggest anticorporate campaign in history. As of December 2019, some \$12 trillion worth of endowments and portfolios had divested, according to Gofossilfree.org, in part because the smart money had come to realize that the fossil fuel sector was lagging everything else in the market.

The institutions that have begun to divest include New York City's pension fund, half of the colleges and universities in the U.K., the Norwegian sovereign wealth fund (at more than \$1 trillion, the biggest pool of investment capital on the planet), the Rockefeller charities (which descend from the planet's first oil fortune), and the vast University of California system. Not a day goes by without some new announcement: As I was writing this piece, Twitter flashed the news that KiwiSavers, the primary retirement fund in New Zealand, had joined the ranks. Together, divestment has changed the dialogue, not to mention the cost of capital: Coal executives complain it's nearly impossible to raise money because so many funds have divested, and in last year's annual report, Shell Oil called divestment a material risk to its business. As America's favorite stock picker, Jim Cramer, put it in a typically manic diatribe on CNBC this winter, there's no money to be made anymore in fossil fuel stocks because "we're starting to see divestment all over the world." As a result, he said, fossil fuels were "in the death knell phase."

But that phase-out still isn't coming fast enough to meet the scientific targets necessary to mitigate the climate crisis. As Carney explained in one of his last appearances as BofE governor in December, big institutional

*Bill McKibben is an author, environmentalist, and activist whose books include *The End of Nature* (1989) and *Falter* (2019). He is a cofounder and senior adviser at 350.org, an international climate campaign organization.*



LEADING VOICES Departing Bank of England chief Mark Carney (left) has been vocal about the financial risk of climate change. BlackRock CEO Larry Fink said in January that sustainability would now be at the center of the asset management giant's investment strategy.

investors tended to have horizons of two to 10 years. "In those horizons, there will be more extreme weather events, but by the time that the extreme events become so prevalent and so obvious, it's too late to do anything about it."

As a result, campaigners have expanded the divestment drive one ring out, this time pressuring the financial institutions themselves instead of just the fossil fuel companies. We have mounted a fast-growing crusade to get the BlackRocks and the State Streets, the JPMorgan Chases and BofAs, the Liberty Mutuals and the Chubbs to end what they call a "money pipeline" that has funneled at least \$2 trillion in loans to the fossil fuel industry since the end of the Paris climate talks in 2015.

On the one hand, it may seem like an unlikely crusade: These are, after all, the richest institutions on planet Earth; even after the global financial crisis of 2008 they mostly emerged unscathed and, in some cases, bigger than ever. Do they have anything much to fear from scruffy protesters?

But the anger of the general public over climate change is reaching a crescendo, especially as people have come to understand the degree to which the fossil fuel industry covered up its early knowledge of global warming. This winter, a poll conducted by Yale researchers found that fully a fifth of Americans were ready to "personally engage in nonviolent civil disobedience" against "corporate or government activities that make global warming worse," if a person they liked and respected asked them to. One guesses that such sentiment is highly concentrated in precisely the urban and suburban precincts where American money is highly concentrated—Trump may own the bright-red electoral map of the U.S., but the money map tilts in the other direction. And financial institutions need

to be a little wary of their customers: There are a lot of Chase credit cards in the hands of people who have come to care about global warming.

In fact, the speed with which these institutions have begun to bend is instructive. Early on in this new Stop the Money Pipeline campaign—which includes big NGOs like the Sierra Club and Greenpeace—protesters gathered outside Liberty Mutual’s Boston headquarters, pointing out that the insurance giant was continuing to invest heavily in fossil fuel projects, even as it was cutting off policyholders in California because climate-fueled wildfires were making their homes too risky to underwrite. And it was only a matter of weeks before Liberty Mutual began to buckle, announcing a policy in December that would restrict its investment in coal and in Canada’s dirty tar sands oil complex. Others like the Hartford soon followed, and that same month even Goldman Sachs proclaimed that it would restrict financing for fossil fuel projects in the Arctic.

A significant breakthrough came in January, when Wall Street behemoth BlackRock—the biggest financial player of all, with \$7.4 trillion in assets under management and a key target of the emerging campaign—announced that it was going to put sustainability at the center of its investment strategy. In a letter to investors, CEO Larry Fink said, “The evidence on climate risk is compelling investors to reassess core assumptions about modern finance.” Fink said that BlackRock would vote against management teams that weren’t working toward sustainability goals, and his firm would press companies to disclose plans “for operating under a scenario where the Paris Agreement’s goal of limiting global warming to less than two degrees is fully realized.” And since BlackRock is the biggest single stockholder for many public companies, the threat comes with real weight.

OF COURSE, this is only half the equation for businesses thinking about the climate crisis. The other half is all upside: Someone is going to have to build—and finance—the most massive industrial transition in human history. “Achieving net zero emissions will require a whole-economy transition,” Carney said in his valedictory speech to the City of London in late February. “Every company, every bank, every insurer, and investor will have to adjust its business model. This could turn an existential risk into the greatest commercial opportunity of our time.”

Consider just one small example: Late last year, New York City decreed that all big buildings in the five boroughs needed to cut their carbon emissions 40% by 2030. That’s necessary because the 2% of buildings over 25,000 square feet contribute about half the city’s emissions. Meeting the target clearly won’t be easy. As the CEO of the Urban Green Council, John Mandyck, said, “This law could possibly be the largest disruption in our lifetime for the real

estate industry in New York City.” You’re a landlord who misses your target? The fines run up to \$268 a ton of carbon, which could mean a million dollars for some big property owners. But, on the other hand, think of the money to be made from those repairs: a whole new workforce trained in insulation or overhauling HVAC. It’s all technically achievable. As Vivian Loftness, a Carnegie Mellon professor, explained to reporters, “We’ve got [older] mechanical systems that are running at 50% efficiency, where there’s things on the market that will run at 95% efficiency. We’ve got a lot of room for upgrades for boilers and chillers, air-handling units, control systems—there’s so much room in just the hardware of buildings.”

Imagine the money to be made from financing that kind of overhaul. And then think of the money to be saved once you have completed the upgrades: If you’re using 40% less energy, year after year, you have suddenly found a remarkable boost to your P&L. Energy efficiency is one of those revolutions that can pay for itself.

But none of it is really worth doing unless it can be done fast. That’s the rub with climate change: Our period of leverage to affect the outcome seems to stretch only a few years into the future. The scientists of the Intergovernmental Panel on Climate Change issued their most recent update in October of 2018, cautioning that unless fundamental transformation of our energy system took place in the decade of the 2020s—and they defined that transformation as cutting carbon emissions in half—we could kiss goodbye any hope of meeting the necessary climate targets.

And that would be, in the long run, rather expensive. In the same month as that IPCC report, British economists attempted to calculate the damage that would come from global warming that reached about 3.7 degrees Celsius by century’s end, which is in line with our current trajectory. Their figure? \$551 trillion. Which is significantly more money than currently exists on planet Earth.

Our options are clear: Invest now with the opportunity to earn a nice return (and save humanity in the bargain), or take unfathomable losses down the line. The correct choice should be obvious to any smart financier. ■

BIG OIL'S

CO₂ CEMETERY
The West Seminole field in Texas, where Occidental Petroleum hopes to bury many tons of captured carbon dioxide.



HAIL MARY



Oil companies are betting big on “carbon capture” technology that sucks greenhouse gases out of smokestacks and the air. It could help a polluting industry remake itself. But is it too little, too late?

BY JEFFREY BALL



LIKE AN OLD RACEHORSE, the West Seminole oilfield, a 12-square-mile patch of dirt on Texas’s far western flank, has been trudging along for years, kept kicking by an elixir its jockey shoots into its rump.

On a recent afternoon, as storm clouds blanketed the field and a winter wind howled, dozens of rusty pump jacks rocked up and down, groaning with each revolution as they sucked out more black gold. The drug that the field’s operator, Occidental Petroleum, injects into West Seminole loosens the oil in the stone beneath the sagebrush—forcing from the rock ever more of the hydrocarbon treasure locked inside its geologic pores. The magic medicine is an old industrial gas with a new image problem: carbon dioxide.

For decades, Occidental has been pumping massive quantities of CO₂ into the ground, juicing the flow of oil in aging fields that have lost the oomph nature originally gave them. The CO₂ frees more oil to rise to the surface, where it can be sold and burned. The petroleum industry has used this turbocharging technique—called “enhanced oil recovery”—elsewhere. But Houston-based Occidental is a global expert. Across thousands of square miles of eastern New Mexico and western Texas, on the iconic swath of

land called the Permian Basin, the company nicknamed Oxy has built a multibillion-dollar web of infrastructure to manage vast quantities of the CO₂. The Permian rocks' structure makes them particularly giving of their oil when their spongelike holes are coaxed with the greenhouse gas in liquid-like form.

Oxy buys CO₂ drilled from natural formations in Colorado and New Mexico, then sends it through thousands of miles of pipelines, goaded by massive pump stations. At the end of the line, the company blasts it into thousands of wells that fan out like toy soldiers across the Permian, a booming chunk of the American West that now accounts, extraordinarily, for some 5% of global oil production. Oxy's setup amounts to a ruthlessly efficient assembly line for hydrocarbons.

Now, amid rising consumer anger about global warming and ballooning government subsidies for companies working to solve it, Oxy is attempting a stunning CO₂ pivot. It hopes to stop pumping into its fields CO₂ extracted from the earth, and instead deploy CO₂ sucked from man-made sources: from power plants, factories, and even thin air.

The company's ambition is to build into a core business a process that has long been little more than a science project: "carbon capture and storage," or CCS. It involves chemically snagging CO₂, typically as it's wafting out of smokestacks but also from ambient air itself, and then injecting it into subterranean rocks. The goal: Rather than continue to dump CO₂ into the atmosphere, where it's thickening a chemical blanket that's warming the earth, humanity can bury it underground, ostensibly forever.

Countless difficulties imperil the CCS dream. Influential environmentalists oppose it, arguing it diverts attention from renewable energy. Beyond principle, technical dilemmas loom. One, now fueling a technological race, is how to slash the cost of capturing CO₂, which remains too expensive to work without subsidy. Another, now evolving into a high-stakes lobbying fight, is how far regulators should go in forcing oil companies to prove that CO₂ they're sending into rock stays safely where it's put.

No member of Big Oil is gunning harder for CCS than Oxy. Even before concerns

about the coronavirus—and a global petroleum-price war—sent oil-company shares tumbling this March, Oxy was trading around a 15-year low, burdened by debt from a recent acquisition. And its CO₂-fueled position in the Permian is core to its viability. So from its Houston headquarters, whose walls are hung with glamour shots of oil rigs, Oxy is making a series of bold CCS bets. One is on a contraption of massive fans that would suck CO₂ from the air. Another is a bid to establish what amounts to a green-minded polluters' club: a network in which some of America's biggest industrial emitters would capture and sell CO₂ to Oxy, delivering it through an as-yet-unbuilt pipeline bankrolled with the help of American taxpayers.

If the plans work, Oxy contends, the company will be able to accurately say that much of its oil is "carbon negative"—actually good for the planet, because extracting it would involve the safe disposal of more CO₂ than burning it would emit. More immediately accretive to Oxy's bottom line, the move would boost its oil sales and also capture subsidies governments are rolling out to companies that can prove they're capturing man-made, or "anthropogenic," CO₂. For Oxy, such a masterstroke might repaint its brown corporate image green. It also could gird the company for a future in which, more oil executives are coming to believe, they will have to somehow neutralize emissions from their hydrocarbons in order to continue selling them.

Vicki Hollub, Oxy's CEO, tells me that she has concluded that her company's "social license to operate"—the consumer and political buy-in any firm needs to sell its product—depends on doing "all that we can do to address climate change." The trick will be to do so while satisfying shareholders. Hollub argues Oxy's CO₂ expertise is a competitive edge in an industry ever more concerned about a warming planet. "The world will transition out of fossil fuels, but it's going to take quite a long time," she says. Along the way, "the last barrel of oil produced in the world" should come not from a new well but from an aging field, helped by CO₂. "The carbon footprint is lower," she says, "and it's just more efficient for the planet." Like lemonade from lemons, her environmental argument leverages her corporate portfolio.

Anthony Cottone, senior director for strategic development at Oxy Low Carbon Ventures, a unit the company

**“OIL COMPANIES NEED
A REASON TO EXIST.
IT’S A SECOND CHANCE.”**

ANTHONY COTTONE, AN EXECUTIVE AT OXY LOW CARBON VENTURES, ON THE IMPORTANCE OF ACTING TO REDUCE ATMOSPHERIC CO₂



REJUVENATOR Pumping systems like this one at West Seminole could use recycled CO₂ to help old oil wells stay productive longer.

created to engineer this shift, is even more direct. Buffeted by today's push for lower-carbon energy, "oil companies need a reason to exist," says Cottone, who contends that reason should be to serve up CCS. "It's a second chance."

A **S CONSUMERS** eye a torrent of natural disasters indicative of a warming world, scientific experts say curbing carbon emissions enough to avert the worst consequences of climate change will require deploying CCS at grand scale. The existential task, according to the Intergovernmental Panel on Climate Change, or IPCC, a scientific body whose pronouncements frame conventional wisdom on global warming, is to slash emissions by 2050 to "net zero," meaning any remaining emissions would have to be offset by pulling CO₂ out of the air.

So far, emissions continue to rise. Although renewable energy use is growing fast, the International Energy Agency projects fossil fuels, which provided 81% of global energy in 2018, still will provide 74% in 2040. If there's any chance to meaningfully decarbonize the economy, it will require decoupling the emission of greenhouse gases from the burning of hydrocarbons. And that will mean grabbing as much as possible of the approximately 33 billion metric tons of CO₂ that fossil fuel combustion produces annually and siphoning it away.

That is why governments are racing to support CCS—from Sacramento to Washington, from Texas to North

Dakota, from Canada to the U.K. to Norway and beyond. Some of them view the technology as a way to sustain their own fossil-fueled economies. Others see it as a bridge to a future when renewable energy is cheap and robust enough to power the world largely on its own.

Carbon capture, in short, presents heavy industry and all who profit from it with the possibility of switching in the public eye from climate villains to climate saviors—without abandoning their reliance on fossil fuel, and largely at public expense. It's a potential new lease on life at a time when markets—far more than policymakers—are pushing polluters to clean up their acts. In January, BlackRock, the world's largest asset manager, announced it will reorient its investments to trim their climate risk, including reducing fossil fuel exposure. In February, BP, the British oil behemoth, said it would aim for net-zero carbon emissions by 2050, a plan that depends largely on CCS.

With real money suddenly on the line, the race to scale up CCS has entered a cutthroat, meaning very real, phase. The competition is

among the surest signs that global capitalism is undergoing a fundamental transformation to adapt to a warming world. Whether the metamorphosis will actually check climate change is, alas, another question.

T

HE PROMISE and the difficulty of large-scale CCS loom in cement and steel over the outskirts of southwest Houston.

The W.A. Parish Generating Station was the seventh-largest CO₂ emitter in the U.S. in 2018. It also houses one of the largest carbon-capture projects in the world.

As I approach Parish on a drizzly winter morning, I try to wrap my head around the notion that CCS might anchor a green future. My first glimpse, from several miles away on the highway, is of the plant's four dominant smokestacks. They tower some 500 feet, dwarfing anything else on the horizon. When I reach the entrance, where the red, white, and blue sign boasts "Pride & Power," I see a black pile of coal so massive that two yellow earth-moving machines crawling atop it, grunting as they spread the solid fuel, look from my vantage point like toy trucks. The coal arrives from Wyoming, typically twice daily, in trains about 120 cars long.

The carbon-capture project—dubbed Petra Nova, Latin for "new rock"—starts with a 15-foot-diameter pipe that sucks, from the smokestack of one of Parish's four coal-fired power-generating units, some of the waste gas it coughs out. CO₂ constitutes about 13% of that waste gas, which whooshes through the pipe and into a 300-foot-tall tower. That tower is a vertical maze of tubes, inside which the gas mixes with a chemical, amine, that grabs the CO₂. As the rest of the gas heads into the sky, the amine, in another chemical reaction, releases the CO₂, which flows into huge compressors. Pressurized, the CO₂ enters a pipeline, travels 81 miles to an oilfield near Vanderbilt, Texas, and is injected into the earth—with the aim of helping produce a lot of sellable oil.

The carbon-capture machinery is working as planned, says NRG, the power producer that helped launch the project and owns Parish. In 2017 and 2018, Petra Nova's first two full years of operation, it captured about 8%

BURYING CLIMATE CHANGE

Carbon capture and sequestration (CCS) shows promise as a weapon against climate change, but the technology has barely begun to be deployed. Here, some facts to keep the science in perspective.

1

A GROWING SLICE OF THE PIE

Curbing climate change in line with United Nations goals would require slashing global energy-related CO₂ emissions, now about 33 billion tons a year, to below 10 billion tons in 2050. CCS would have to shoulder about 9% of the carbon-cutting load between now and 2050, and 28% of cuts in 2050 itself, according to the International Energy Agency.

2

SO FAR, SLOW GOING

In the United States, total energy-related CO₂ emissions were 5.3 billion tons in 2018. But the U.S. has developed only about 25 million metric tons of CO₂-storage capacity, according to a December 2019 study by the National Petroleum Council, a government advisory group, enough to bury less than one-half of 1% of those emissions.

3

PLENTY OF ROOM

The U.S. has enough room in geologic formations to store hundreds of years' worth of emissions from "stationary" sources like power plants and factories, according to the National Petroleum Council's report. Aging oilfields account for most current capacity; the greater potential, scientists say, is in underground formations onshore and offshore that naturally hold salty water, not oil.

4

BIG, DOWN UNDER

CCS began in 2019 at Gorgon, an Australian project led by Chevron that's capturing CO₂ from an underwater natural-gas field and injecting it into a formation under an island. When ramped up, it will be one of the world's biggest CCS projects, injecting up to 4 million metric tons of CO₂ per year.

of the approximately 32 million tons of CO₂ that the Parish plant produced. The rest has risen into the atmosphere. But that small victory was the objective, Judith Lagano, NRG's senior vice president of asset management, tells me during a tour of the plant: "It's doing what it was supposed to do."

Financially, however, Petra Nova, whose \$1 billion price tag was defrayed by \$195 million in federal grants, has underperformed. Global oil prices and the quantity of oil the CO₂ has wrung from the field near Vanderbilt have fallen below expectations and triggered \$209 million in "impairment losses" for NRG in 2016 and 2017.

Today, Lagano says, NRG has new hopes for Petra Nova's profitability. One reason is Texas know-how: NRG and its partners expect, as they're getting more familiar with the oilfield, to boost production. A more immediate reason is Washington politicking: A newly generous carbon-capture tax break is about to start flowing.

THE TAX CREDIT, passed in 2018, succeeds a much-smaller prior version. It results from six years of oil-industry lobbying, in large part by Oxy. When I ask Oxy's Hollub whether that push was defensive, to ensure her industry didn't lose ground to renewables, or offensive, to win Oxy market share over oil rivals, she doesn't flinch. "It was, without a doubt, an offensive move," she says.

The subsidy gives operators of CCS projects, for 12 years, a tax credit ramping up to \$35 for every metric ton of man-made CO₂ they catch and deploy to boost oil production. It gives them a credit reaching \$50 for every metric ton they capture and shoot into a different sort of geology, filled not with oil but with salty water. Studies suggest underground "saline aquifers" could be stuffed with quantities of CO₂ that dwarf those in oilfields—indeed, that could entomb global emissions through the end of the century.

Once Oxy won the subsidy, it raced to take advantage of it. In 2018, it created Oxy Low Carbon Ventures, essentially a low-carbon skunkworks. Its marching orders were "to replace natural CO₂ with anthropogenic CO₂" in the Permian, says Robert Zeller III, a buttoned-down chemical engineer and Oxy lifer who was tapped as the unit's vice president for technology. Zeller and I are speaking at Oxy's headquarters, in a windowless and mirthless conference room. Oxy won't let me meet with Zeller in his office, in part for fear, the spokeswoman overseeing the discussion explains, that I'll see something on the walls that's too revealing.

In plain English, says Zeller, his unit's mandate was: "You have a blank palate. Go figure it out." The team figured it out—through some calculations that bowled them over. Burning a barrel of oil typically coughs out about 8,000 cubic feet of CO₂, Zeller says. The team realized that Oxy typically shoots about the same quantity of CO₂ into the Permian to produce each barrel of enhanced-recovery oil. That meant that if Oxy could capture enough CO₂ to replace the natural CO₂ it was using, it could call that oil "carbon-neutral." The equation would be even more compelling in certain regions where the geology requires more CO₂ to push out every barrel. CCS-produced oil from those formations could be not just carbon-neutral, but actually carbon-negative.

"That," Zeller says, "was the eureka."

To capture CO₂, Oxy is pursuing two parallel paths. The sexy one aspires to grab the gas from thin air. Studies have concluded that if enough CO₂ could be economically vacuumed out of the sky, the climate could benefit materially. A handful of "direct air capture" startups have since

become investor darlings. Bill Gates was an early backer of a Canadian firm called Carbon Engineering, which has built a pilot plant in British Columbia. Oxy invested in Carbon Engineering in January 2019, after concluding its technology is particularly scalable in oilfields. (U.S.-based oil major Chevron also invested in the firm. Neither oil giant will say how much it put in.)

The challenge is to slash the technology's cost. Zeller says Carbon Engineering's first commercial-scale plant will be up and running in the Permian by 2023. It will be sized to take from the sky 1 million metric tons of CO₂ yearly, roughly as much as is coughed out by 216,000 cars. The plant's likely cost: \$1 billion. "The first of a kind is going to cost too much," he says, but Oxy intends to position potentially dozens more such facilities in the region, at which point Zeller expects the cost for each to fall at least 30%.

Oxy's less-sexy strategy is to lock down a supply of anthropogenic CO₂ from smokestacks, Petra Nova-style. It has mapped the locations of America's biggest emitters: power plants, steel plants, petrochemical plants, and more. Oxy executives won't show me their map—it's presumably one of the things on their walls I'm not supposed to see. But emissions data is publicly available, and as CCS enthusiasm spreads, such maps line the walls of more and more offices in the oil patch. They show hotspots in Midwest coal-burning country and throughout the Texas and Louisiana oil colossus. Oxy is now scrambling to line up deals for the CO₂ these polluters are releasing into the atmosphere.

It's also now lobbying Washington for an-

**"THE FIRST
OF A KIND
IS GOING TO
COST TOO MUCH."**

ROBERT ZELLER, AN OCCIDENTAL EXECUTIVE, ON THE PROJECTED \$1 BILLION PRICE TAG OF THE COMPANY'S FIRST CARBON-CAPTURE PLANT

other subsidy, this one for a pipeline to ferry human-spewed CO₂ to the Permian. In case the government doesn't concur, Hollub tells me, Oxy is wooing infrastructure-investment funds. Her ultimate goal: Cheaper CO₂, because it and electricity are the biggest costs in Oxy's Permian operation. By "the mid to latter part of the 2020s," Hollub says, a shift to anthropogenic gas should cut Oxy's CO₂ costs by 20% to 30%.

Many other big oil companies, consultants and bankers tell me, are also angling for CO₂ pipeline incentives. "They can't let anyone know they're jockeying," explains one well-placed consultant who doesn't want to be identified, "because then people would know they're not doing it for society—they're doing it for themselves."

T O MONETIZE CCS, companies need permission from regulators to shoot CO₂ underground. The rules governing such storage are young, they differ among jurisdictions, and they have yet to be tested. This spring, they're prompting lobbyist combat in Washington, where the Internal Revenue Service is formulating rules to govern who qualifies for the federal tax credit—and in California, where a potentially bigger financial prize awaits.

In natural CO₂ deposits, rock securely traps gas much as, elsewhere, it traps oil. The IPCC, the global climate-science group, says more than 99% of injected CO₂ is "likely" to stay put for 1,000 years in a well-designed and man-

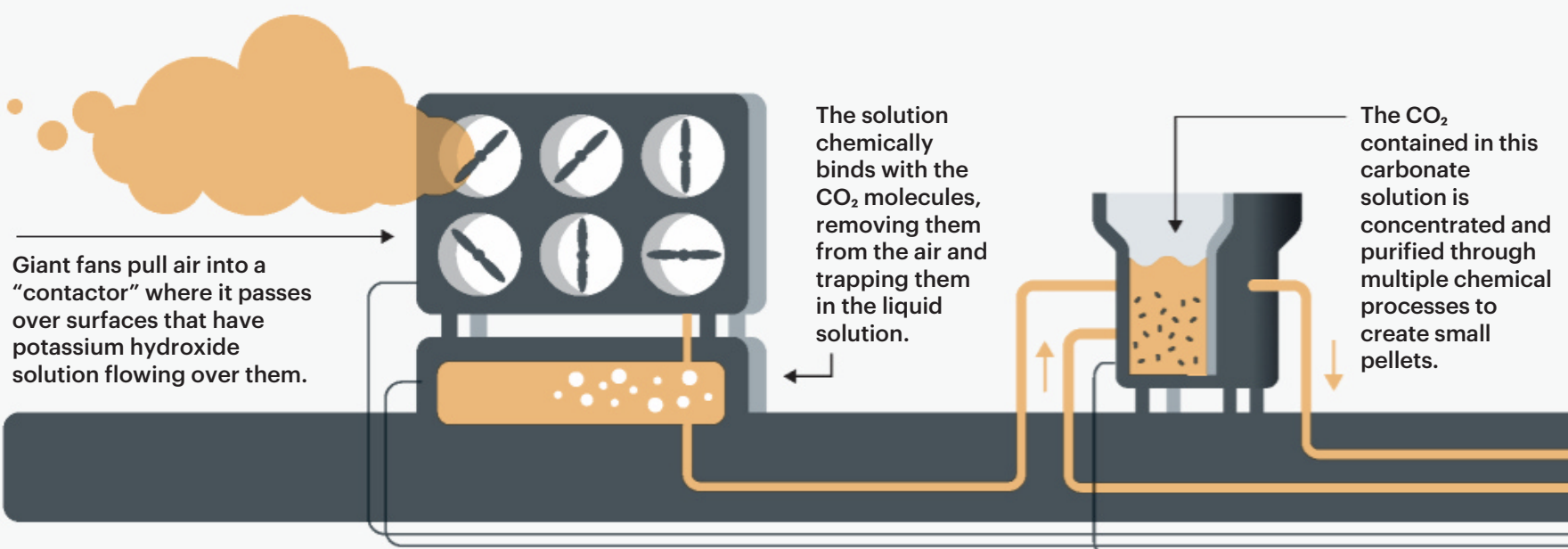
aged project. What's more, the IPCC says, CO₂ tends to grow more "immobilized" over time, and thus a project could retain essentially all of its CO₂ "for up to millions of years."

The question is how to ensure CCS is done well. Regulators want to prevent CO₂ from seeping into other underground areas—either into someone else's property, or into geologic layers, such as drinking-water sources, where it could cause harm. They also want to make sure it doesn't waft back up, years or even centuries later. If sequestered CO₂ leaked into the sky, its climate-saving value would be negated, and the polluter that pocketed subsidies for capturing it would have contributed no lasting benefit.

The industry's D.C. drama boils down to whether an independent third party should verify that oil companies have safely stored as much CO₂ as they claim. An industry group that Oxy helps fund, the Carbon Capture Coalition, whose roster also includes Shell, recently wrote to the IRS that such verification is "vitaly important" to the viability of the credit. That puts them at odds with another group, the Energy Advance Center, which lists ExxonMobil and Denbury Resources, both of which have extensive CCS operations, among its members; it opposes mandatory third-party verification. BP recently quit that group, and the company endorsed mandatory verification.

Beyond Washington, however, Oxy is trying to loosen some rules. Even richer than the federal tax break is a subsidy that California is rolling out. When companies can substantiate that they've used low-carbon processes to produce transportation fuel they sell in California, the state grants them "carbon credits," which they can sell to other, less-green fuel producers. A credit representing one metric ton of CO₂ saved currently sells for about \$200. And that's cash, not merely a credit against taxes. Oxy has tussled with California over what it must do to monitor man-made CO₂ that Oxy wants to inject at West Seminole. The source of that gas: two ethanol plants in the Texas Panhandle.

ONE WAY TO CLEAR THE AIR "Direct air capture" technology aims to vacuum man-made CO₂





GAS STATION Excess CO₂ from this ethanol plant in Plainview, Texas, could eventually be stored in Oxy oilfields.

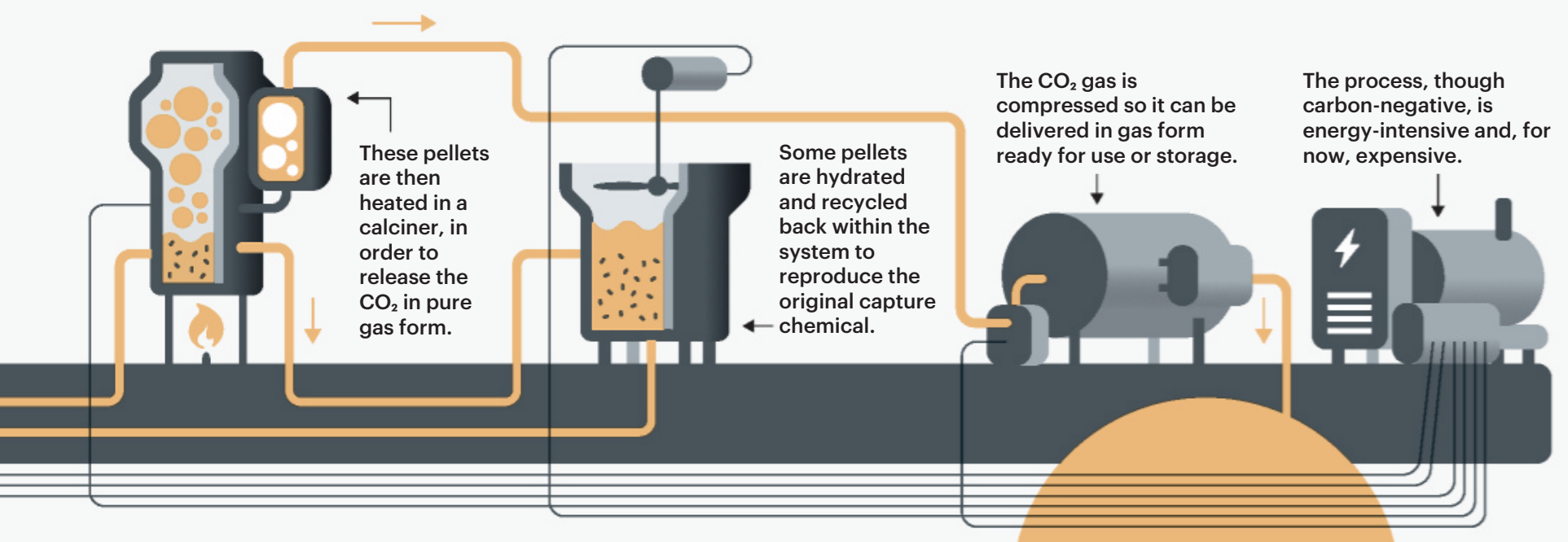
Plainview, Texas, lies between Lubbock and Amarillo, on a highway whose speed limit is 75 miles per hour but doesn't seem to much matter. The town's name fits: On the early morning I visit, the pancake-flat landscape, offset by a vast orange sky, affords what seems an endless vista. Dominating the horizon on the eastern edge of town are the seven 807,000-gallon fermentation tanks at an ethanol plant owned by Frisco, Texas-based White Energy.

Ethanol, made in the U.S. primarily from corn, has long been marketed as a clean fuel. But its production, a process of fermentation that resembles—and smells like—

beermaking, produces gobs of CO₂. Soon after sunrise, I circle the plant with Brian Steenhard, White Energy's chief executive. As we linger at the ethanol tanks, he points to a pipe atop one. It belches as much as 350,000 tons of CO₂ yearly. White Energy's Hereford plant, an hour away, emits about the same amount.

White Energy and Oxy have applied to the California Air Resources Board, known as CARB, to receive credits for capping those

out of the atmosphere. Here's how Carbon Engineering, a startup backed by Occidental and Chevron, carries out the process.



pipes and sending the CO₂ to the West Seminole field for burial. Steenhard estimates that if regulators signed off, and if White Energy figured out how to ship to California all the ethanol it produced in Plainview and Hereford, the credits would generate between \$360 million and \$720 million over 12 years. The project could receive federal incentives over that same span, potentially offsetting some \$275 million in taxes. CCS projects being hatched elsewhere would be far, far larger.

The obstacle: California has tougher requirements than the feds for ensuring injected CO₂ stays put. But those rules' effects on the ground still are taking shape. Origin-

nally, for instance, CARB wanted Oxy to insert fiberoptic "geophones" into each West Seminole CO₂-injection well to listen for signals that the injection might be prompting an earthquake, Bill Raatz, Oxy's chief geologist, tells me. Oxy argued that was "a complete nonstarter" for cost reasons, Raatz says, so Oxy asked CARB to let it put a geophone down no more than a handful of the wells and use cheaper aboveground seismic monitors elsewhere.

CARB officials say they won't comment on their discussions with Oxy and may rule on the West Seminole application later this spring. In March, CARB was reviewing a 520-page document from Oxy that argues that the field would safely sequester CO₂. When I asked to see it, both Oxy and CARB refused to give it to me. Only after *Fortune* submitted an open-records request to CARB did

GEOENGINEERING

SCI-FI TECH TACKLES CLIMATE CHANGE

Researchers are working on some unlikely remedies to counteract global warming, such as "planting" artificial trees and growing algae in the ocean at a massive scale. But critics worry that some of the ideas risk harming nature rather than helping it.

BY JENNIFER ELSEVER

● For two decades, Klaus Lackner has been fixated on trees and how they pull carbon dioxide from the air. What if, the Arizona State University engineering professor theorized, you could create a machine that worked like a tree—but a thousand times more efficiently—thereby reducing the effects of climate change?

In January, Lackner's first such artificial tree—which looks less like a real tree and more like a super-

size lamp—came off the manufacturing line in Boston, and, along with more than 250 others, will be installed near Phoenix. Unlike a real tree, which absorbs 10 tons of carbon in its lifetime, these mechanical trees may one day collect up to 32 tons of CO₂ each in a single year—the equivalent of what seven passenger vehicles emit annually. "We need to start cleaning up after ourselves," Lackner says.

Fake trees may



An artificial tree designed by Klaus Lackner of ASU sucks CO₂ from air that moves through the device.

the agency relent. And only after that did Oxy hand over a heavily redacted version that it had submitted to CARB. That version blacked out big chunks of information the company calls “business confidential.” What wasn’t redacted boils down to a four-word argument that Zeller, the Oxy technology executive, had lobbed at me in Houston. I asked him about the likelihood that man-made CO₂ at Oxy’s Permian fields might escape. Said the engineer: “It ain’t coming out.”

A

ROADSIDE ENTRANCE to the West Seminole field is marked by a worn, rusty sign, pocked with what appear to be bullet holes. On sections of the field, among the pump jacks still rocking, chunks of old

machinery lie atop the dry brush. The scene evokes an oil-patch graveyard.

Whether this acreage should become a graveyard of a different sort—a resting place for CO₂—is, fundamentally, a question about how humanity will wrestle with the wicked complexities of global warming. Proceeding will signal that a technology widely seen as crucial to addressing climate change may finally scale. Delay will leave the future of that technology in the same place where a lone bird is gliding above West Seminole on the gray afternoon I glimpse the field. It’s the place where, every day, more CO₂ is heading: up in the air. ■

seem like a far-fetched solution to climate change. But today, they’re one of many sci-fi ideas gaining momentum amid ominous scientific studies showing rising earth temperatures and increasing carbon dioxide in the atmosphere.

These out-there technologies are part of a scientific field called geoengineering, which is aimed at manipulating the environment to offset climate change’s impact. Unlike, say, solar or electric vehicles, whose widespread adoption would depend on changing consumer behavior and established industries, geoengineering technologies attack climate change directly—and, theoretically, have an impact more quickly.

But critics argue that such technologies may make it more difficult to curb the core problem, because they remove any incentive for hu-

mans to stop emitting greenhouse gases. If we cool the earth with new technology, then companies and people will fail to reduce pollution, they say.

Adding to the backlash is the fear that large-scale interventions can negatively change the earth’s natural systems by altering rainfall and weather patterns or causing flooding and drought. And some of the possible effects can’t simply be turned off.

Here are four other ideas that researchers hope will offset some of humanity’s impact on the environment.

ALGAE FARMING

Over the past several years, scientists in Germany, Canada, and India have explored fertilizing the ocean with iron sulfate to stimulate the growth of algae, the sea life that absorbs carbon dioxide and releases oxygen. In

2012, for example, an American businessman dumped iron sulfate off Canada’s Pacific coast that created an artificial algae bloom over as much as 10,000 square kilometers. But such efforts are controversial because algae competes with other aquatic life and can reduce fish population. Meanwhile, in February, researchers at the Massachusetts Institute of Technology published a paper saying, in fact, that kick-starting beneficial algae growth on a global scale is nearly impossible.

GLACIAL SANDBOXES

Researchers are considering the idea of building massive underwater sand berms where glaciers meet the ocean to keep glaciers from disappearing, thereby preventing sea levels from rising. The sand would form walls around the submerged glacial ice and, theoretically,

keep chunks from breaking off. The scientists, who hail from Princeton University, Beijing Normal University, and Finland’s University of Lapland, are also considering building artificial islands and large pumping stations that would channel cold water under glaciers, which, on land, slide on a thin layer of ice, to slow their movement.

SPRAYING THE STRATOSPHERE

Scientists are taking a cue from volcanic eruptions, which naturally spray sulfur dioxide into the stratosphere and cool the earth below. Harvard University scientists want to spray a shield of mist made of calcium carbonate—found in chalk and seashells—into the stratosphere and reflect sunshine back into space. They plan to test the theory by using a balloon sent into the stratosphere to release the light-

reflecting particles, and then, if it works, deploy high-altitude planes to do the same thing on a larger scale.

SALTING CLOUDS

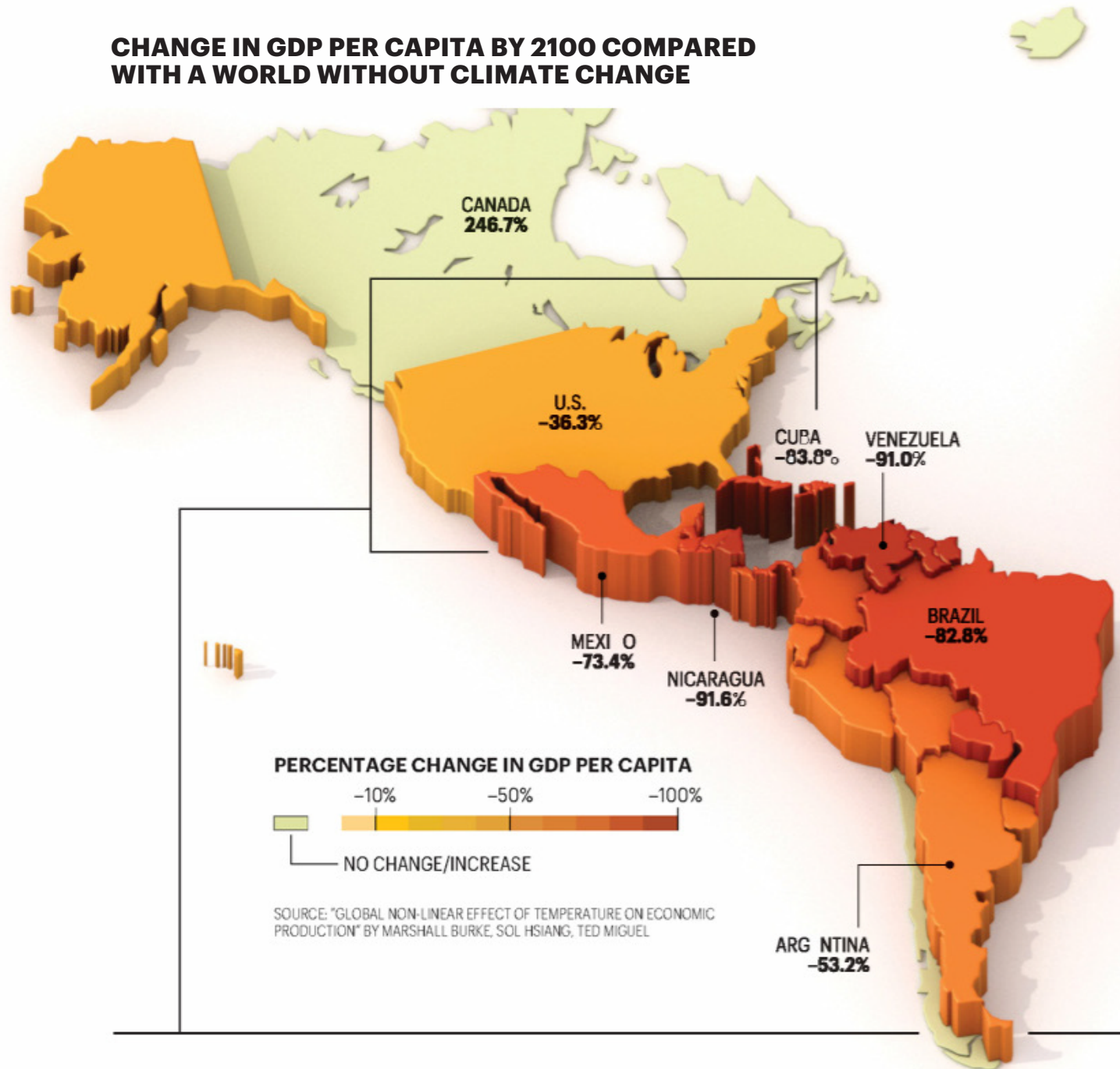
In an effort to reduce the earth’s temperature, scientists hope to refashion clouds so that they’re brighter and thereby reflect more sunlight back into space. Their tool? Powerful nozzles affixed to boats that each can spray 3 trillion particles of seawater per second drawn, hundreds of feet into the air. Computer models from the University of Washington team working on the idea suggest that spraying just 20% of the earth’s clouds could cool the entire planet by two or three degrees Celsius. The technology would mimic an already-known phenomenon in which exhaust from oceangoing ships creates streaks in marine clouds and cools the earth temperatures below them.

PROJECTING THE COST OF CLIMATE CHANGE

The world's five warmest years on record have been its past five, according to the National Oceanic and Atmospheric Administration, part of the U.S. Department of Commerce. And as the planet continues to heat up, a growing body of academic research shows that rising temperatures will have profound effects on the global economy. While some countries may actually prosper, one study projects average global incomes will fall 23% by the end of the century.

THERE IS an optimal temperature, believe it or not, at which economic performance peaks: 55° F. That's according to researchers at Stanford and UC-Berkeley who examined long-term economic data from 166 countries to project the impact of changing climate on the global economy. New York City and Palo Alto, it's worth noting, both have average annual temperatures near 55°. For cooler countries, rising to the mid-50s can boost output. But the hotter it gets above that, the more productivity slides, thanks to factors such as increased energy demand, lower crop yields, and even declines in cognitive function. (It's hard for humans to concentrate when it's scorching.) The same trend applies to the U.S. economy: Places where it's already relatively hot are likely to be hit harder as temperatures rise. A separate study by researchers from UC-Berkeley, Princeton, and other institutions found that counties in the West, Midwest, and Southeast would be disproportionately hurt by unmitigated warming, with some losing up to 20% of GDP by 2100. —*Brian O'Keefe*

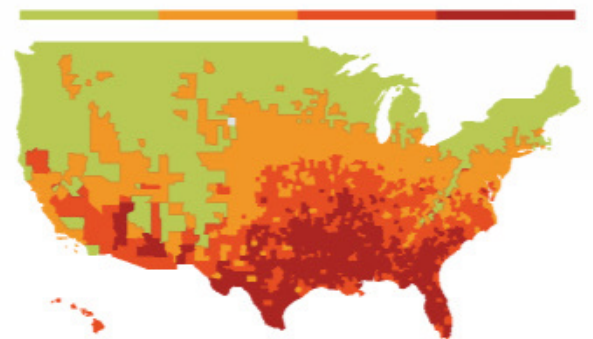
CHANGE IN GDP PER CAPITA BY 2100 COMPARED WITH A WORLD WITHOUT CLIMATE CHANGE



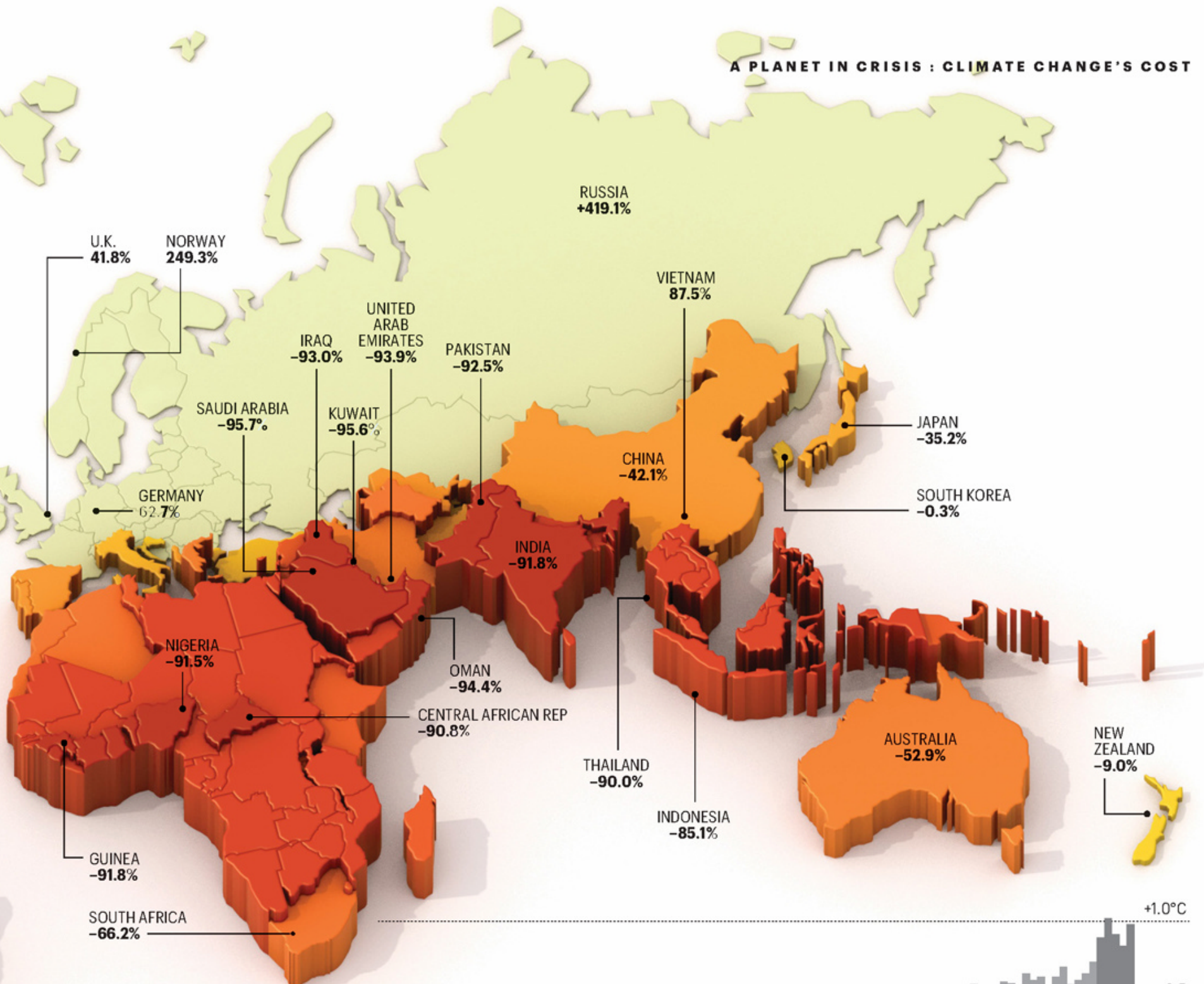
PROJECTED CLIMATE-RELATED DAMAGES IN THE U.S., 2080-2099

If warming continues to be unmitigated, Southern states will have to contend with huge increases in energy costs, rising damage from coastal storms, lower crop yields, and even higher mortality rates owing to extreme heat.

TOTAL DAMAGES (% COUNTY INCOME)



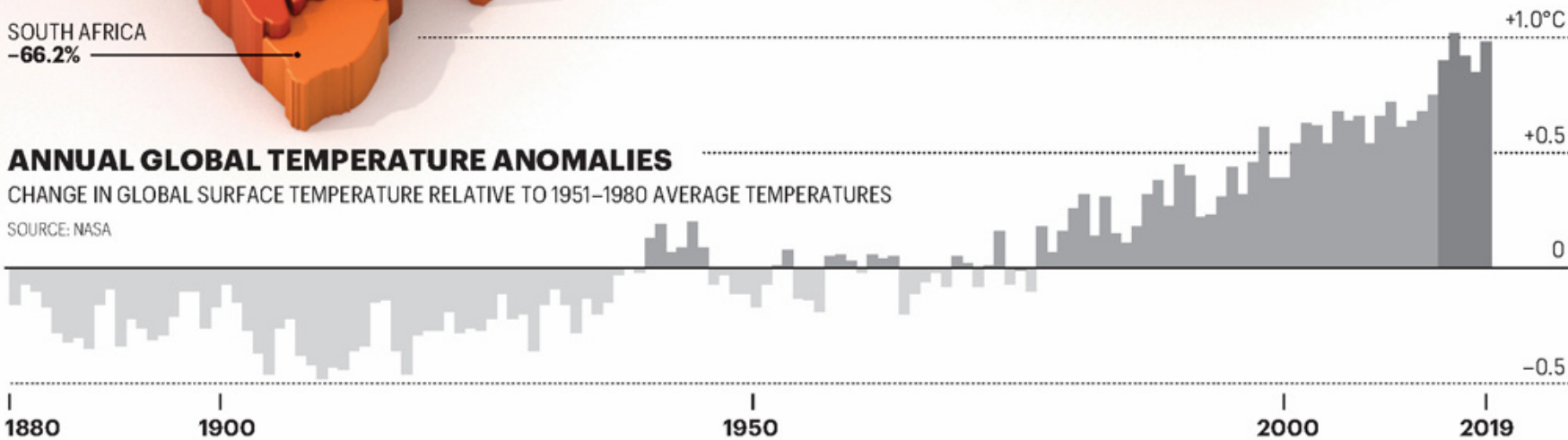
SOURCE: "ESTIMATING ECONOMIC DAMAGE FROM CLIMATE CHANGE IN THE UNITED STATES" BY HSIANG, KOPP, JINA, RISING, DELGADO, MOHAN, RASMUSSEN, MUIR-WOOD, WILSON, OPPENHEIMER, LARSEN, HOUSER (SCIENCE, 2017). ANNUAL DAMAGES IN MEDIAN SCENARIO FOR CLIMATE DURING 2080-2099 UNDER A BUSINESS-AS-USUAL EMISSIONS TRAJECTORY (RCP8.5). NEGATIVE DAMAGES INDICATE BENEFITS. AGRICULTURAL YIELDS BASED ON MAIZE, WHEAT, SOYBEANS, AND COTTON.



ANNUAL GLOBAL TEMPERATURE ANOMALIES

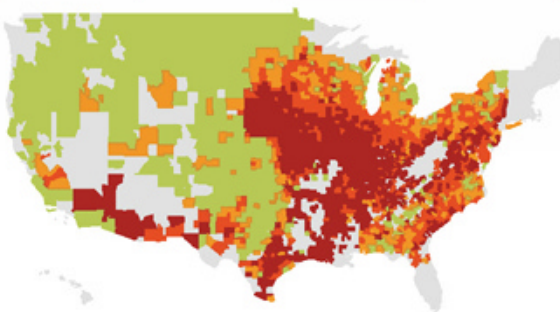
CHANGE IN GLOBAL SURFACE TEMPERATURE RELATIVE TO 1951-1980 AVERAGE TEMPERATURES

SOURCE: NASA



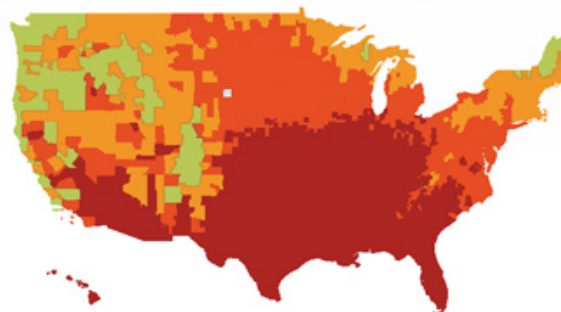
AGRICULTURAL YIELDS (%)

+ 0% -15% -30% -45%



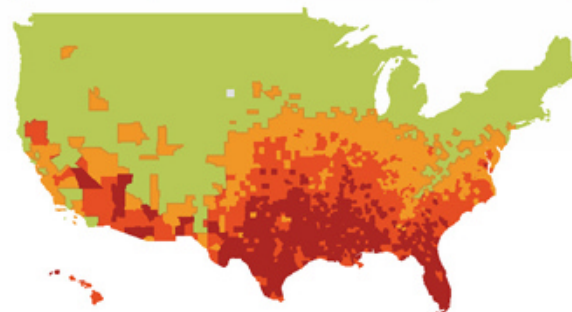
ENERGY EXPENDITURES (%)

- 0% 5% 10% 20%



MORTALITY (DEATHS PER 100,000)

- 0% 15% 30% 80%



RESPONSIBLE COMPANIES ARE SUSTAINING RESOURCES— AND A PROFIT

Successful impact initiatives are proof that businesses don't have to choose between doing well and doing good.



ACCORDING TO A GLOBAL SCIENTIFIC CONSENSUS, the single largest threat to the health of the planet in the decades to come is climate change. With diminishing resources and a growing population that's expected to reach 10 billion by 2050, how can we possibly generate food, clothing, housing, energy, and transportation to meet our needs?

Part of the answer to that question lies in creating a circular economy, which gradually decouples economic activity from the consumption of finite resources and eliminates waste. To get where we need to go, it's imperative that corporations reduce their carbon footprints.

"There's a role for policy," says Dr. Kevin Dooley,

a professor in supply chain management at Arizona State University and chief scientist at the Sustainability Consortium (TSC), a global nonprofit organization leading the transformation of the consumer goods industry to deliver more sustainable consumer products. "But I don't think that policy is going to be created at scale and speed to drive more sustainable consumer products. Not at the speed and scale that we need."

One company meeting the challenge of creating a circular economy is HP, which used 21 metric tons of recycled plastic in its printers, supplies, and personal computers in 2018 and has reached zero deforestation with its branded paper. Next on the list? Sustainable packaging.

"Part of our approach to packaging is transitioning from materials like single-use plastics to more sustainable materials like molded pulp," says Ellen Jackowski, global head of sustainability strategy and innovation at HP. "It's important that, as we transition from plastic packaging to other materials, we're doing it in a way that focuses on regeneration to support a circular economy and our planet for future generations," she adds.

And as it turns out, sustaining resources is not at odds with sustaining a profit. Sustainable impact programs drove more than \$900 million dollars of new revenue for HP in 2018, a 35%

year-over-year increase. To fulfill its vision to create technology that makes life better for everyone, everywhere, HP is committed to delivering on its sustainable impact goals.

"Climate action is a business imperative," says Christoph Schell, HP's chief commercial officer. "At HP, we believe we have a responsibility to take immediate action to address today's global challenges. For example, innovation like the world's first PC made with ocean-bound plastics, the first sustainable home printing system, plus 3-D printing and digital manufacturing to accelerate a more sustainable industrial revolution. It's not only the right thing to do, our customers prefer it and it's good for business." ■



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keep reinventing

VICIOUS (RE)

With the world drowning in plastic, the need for recycling is more acute than ever. But the industry



A PLANET IN CRISIS : THE PLASTIC FLOOD

CYCLE

BY **VIVIENNE WALT**
PHOTOGRAPHS BY
SEBASTIAN MEYER

IN PARTNERSHIP WITH
THE PULITZER CENTER ON CRISIS REPORTING

that handles all that waste is on the verge of collapse.



OVERFLOW
Plastic waste
in Smithtown,
N.Y., where
plunging prices
have pushed
the recycling
system beyond
its limits.



CUT INTO A HILLSIDE in northern Malaysia, amid oil palms and rubber trees, stands a large, open-air warehouse. This is the BioGreen Frontier recycling factory, which opened last November in the village of Bukit Selambau. On a searing-hot afternoon in January, Shahid Ali was working his very first week on the job. With his feet square in front of a chute on the production line, he stood knee-deep in soggy, white bits of plastic. Around him, more bits floated off the conveyor belt and fluttered to the ground like snowflakes.

Hour after hour, Ali sifts through the plastic jumble moving down the belt, picking out pieces that look off-color or soiled—rejects in the recycling process. Though it looks like backbreaking work, Ali says it is a great improvement over his previous job, folding bedsheets in a nearby textile factory, for much lower pay. Now, if he eats frugally, he can save money from his wages of just over \$1 an hour and send \$250 a month to his parents and six siblings in Peshawar, Pakistan, 2,700 miles away. “As soon as I heard about this work, I asked for a job,” says Ali, 24, a squat, bearded man with glasses and an easy smile. Still, he’s working 12 hours a day, seven days a week. “If I take a day off, I lose a day’s wages,” he says.

In the warehouse, hundreds of bales are stacked more than 60 feet high—each stuffed with plastic wrappers and bags tossed out weeks earlier by their original users. The address labels still stuck inside the bags offer clear clues to their origins. You can see toilet-tissue wrappers from a household in Half Moon Bay, Calif., packaging from El Paso, and polymeric film from energy-drink maker Red Bull’s U.S. headquarters in Santa Monica.

For this detritus, factories like Ali’s are the

end of an odyssey of as much as 8,000 miles. The fact that the waste has traveled to this distant corner of the planet in the first place shows how badly the global recycling economy has failed to keep pace with humanity’s plastics addiction. This is an ecosystem that is deeply dysfunctional, if not on the point of collapse: About 90% of the millions of tons of plastic the world produces every year will eventually end up not recycled, but burned, buried, or dumped.

Plastic recycling enjoys ever-wider support among consumers: Putting yogurt containers and juice bottles in a blue bin is an eco-friendly act of faith in millions of households. But faith goes only so far. The tidal wave of plastic items that enters the recycling stream each year is increasingly likely to fall right back out again, casualties of a bro-

“THE GLOBAL WASTE TRADE IS ESSENTIALLY BROKEN.”

GRAHAM FORBES, HEAD OF THE GLOBAL PLASTICS CAMPAIGN, GREENPEACE

ken market. Many products that consumers believe (and industries claim) are “recyclable” are in reality not, because of stark economics. With oil and gas prices near 20-year lows—thanks in large part to the fracking revolution—so-called virgin plastic, a product of petroleum feedstocks, is now far cheaper and easier to obtain than recycled material. That unforeseen shift has yanked the financial rug out from under what was until recently a viable recycling industry. “The global waste trade is essentially broken,” says Graham Forbes, head of the global plastics campaign at Greenpeace. “We are sitting on vast amounts of plastic, with nowhere to send it and nothing to do with it.”

This gargantuan overload is creating a conflict that industry and government can no longer ignore—one that pits the profitability and usefulness of plastic against its threat to public health and the environment. There are few places where that conflict is more visible than in Malaysia. Here, rock-bottom wages, cheap land, and a still-evolving regulatory climate have enticed entrepreneurs to build hundreds of factories in a last-ditch bid to stay profitable. The real economic and environmental costs of plastic recycling are on vivid display, as I discovered traveling across the country with photographer Sebastian Meyer. Over the course of 10 days, we visited 10 recycling factories—some of them, including BioGreen Frontier, operating without official registration, under threat of a shutdown—as they grappled with



waste shipped by the boatload from across the world. And we saw how the consequences of the broken plastics economy spill over into waste dumps, container dockyards, private homes, and out into the ocean.

F

OR HALF A CENTURY, plastics have seen rocketing growth, for good reason: They are cheap, lightweight, and virtually indestructible.

“There’s a great future in plastics,” a nervous young Benjamin Braddock (played by Dustin Hoffman) is told by a would-be mentor in the 1967 movie *The Graduate*. Acting on that tip would have yielded spectacular returns. Global production soared from 25 million tons a year in 1970 to more than 400 million tons in 2018.

Behind this polyethylene deluge is an economic colossus: a global plastics market worth about \$1 trillion last year, according to U.K. data analysts the Business Research Co. Demand for plastics has doubled since 2000 and could double again by 2050. “We have a growing middle class around the world

END OF THE LINE
Shahid Ali (right) and a coworker at BioGreen Frontier, one of scores of recycling factories that popped up in Malaysia after China banned most plastic waste.

**500
MILLION**

Estimated number of U.S. short tons of virgin plastic produced in 2018

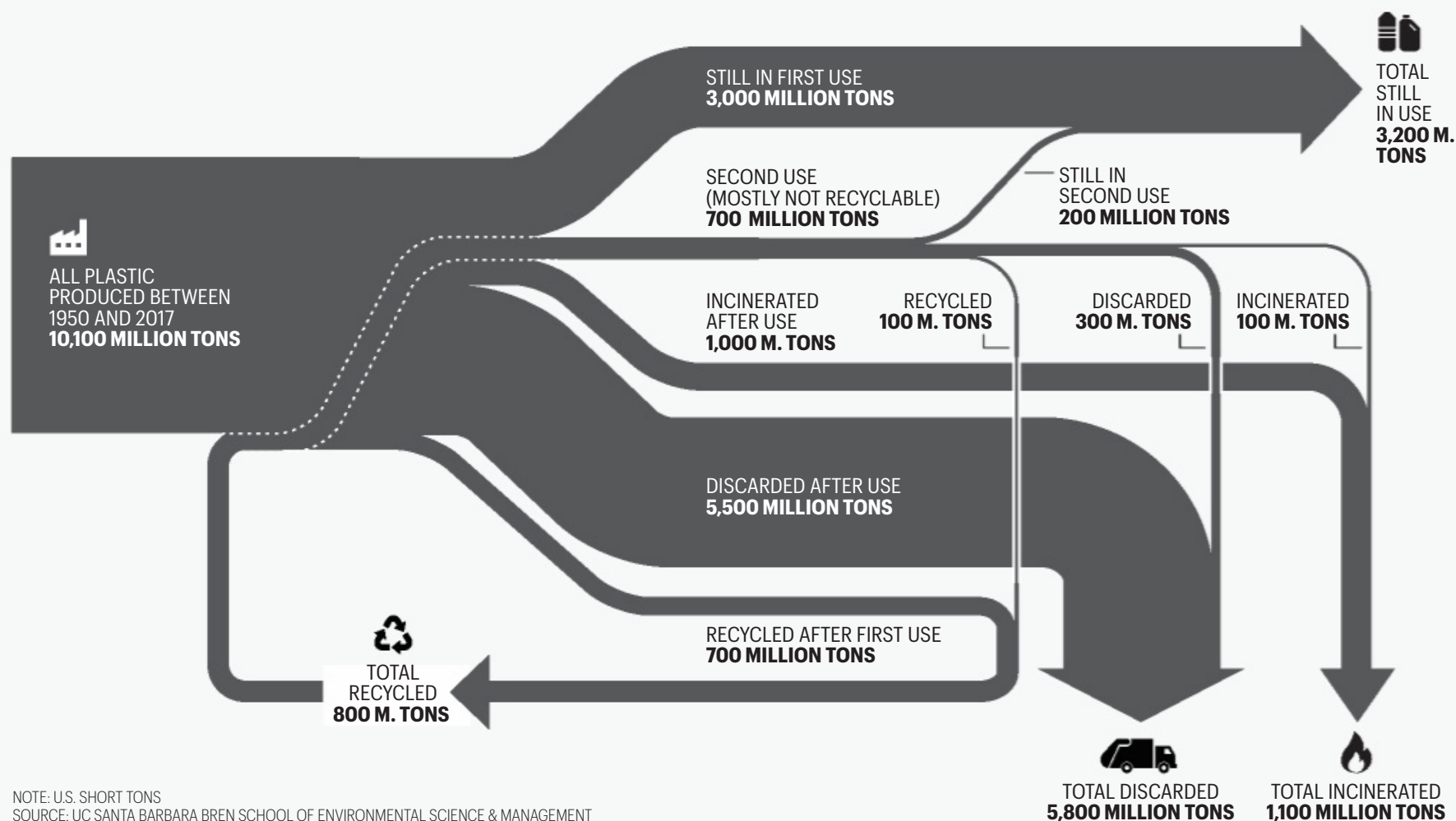
SOURCE: UC-SANTA BARBARA BREN SCHOOL OF ENVIRONMENTAL SCIENCE & MANAGEMENT

that needs to improve their quality of life,” says Keith Christman, managing director of plastic markets for the American Chemistry Council, an industry organization whose members include major producers like Dow, DuPont, Chevron, and Exxon Mobil. “Plastic is a part of that.” You can find plastic not just in your water bottles and sandwich bags, but in sweatshirts and wet wipes, home insulation and siding, chewing gum, tea bags, and countless other items.

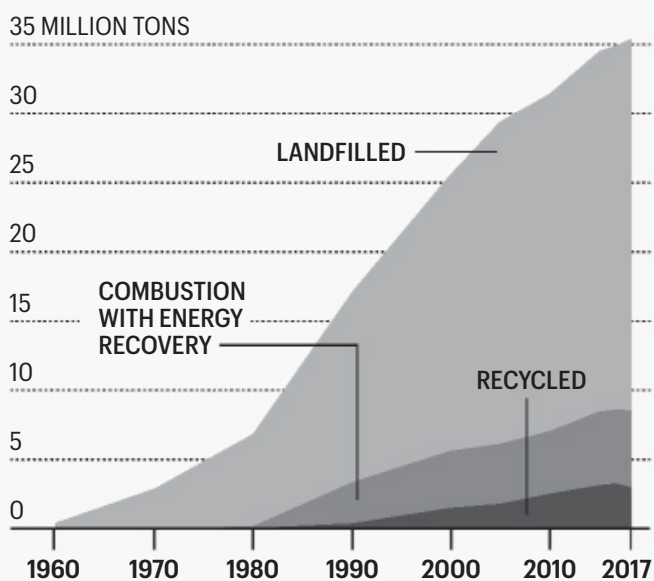
Concerns about plastic have often been eclipsed by debates over carbon dioxide emissions. But the two are closely interlinked, with plastic production emitting considerable greenhouse gases itself. Now the world has fully awakened to the plastics crisis. Images of turtles choking on drinking straws or dead whales with stomachs engorged with plastic junk have gone viral—signifiers of the 8 million tons of plastic disgorged into oceans every year. (The UN Environment Program estimates that by 2050, the oceans will contain more plastic than fish.) The human toll

PLASTICS ARE FOREVER

The global consumer revolution might not have been possible without plastic, which is inexpensive and durable. But that latter quality has come back to haunt us. According to industrial ecologist Roland Geyer, 90.5% of all the plastic made since 1950 is still on the planet, somewhere. Here's where it goes—and doesn't go.



PLASTIC WASTE MANAGEMENT IN THE U.S.



NOTE: U.S. SHORT TONS SOURCES: EPA; AMERICAN CHEMISTRY COUNCIL; NAPCOR

is equally worrying. According to a study commissioned by the World Wildlife Fund, the average American consumes at least a teaspoon's worth of plastic a week through food—roughly the amount in a credit card—with unforeseeable health consequences.

The durability that makes plastic so appealing, it turns out, also makes it an environmental time bomb. An estimated 90.5% of all the plastic produced since 1950 is still in existence, according to analysis by Roland Geyer, an industrial ecology professor at the University of California at Santa Barbara's Bren School of Environmental Science & Management. Only 8.4% of plastic waste in the U.S. was recycled in 2017, according to the Environmental Protection Agency. An additional 15.8% was burned to generate energy; the rest wound up in landfills. Recycling rates are even lower in parts of Asia and Africa. Even Europe, with its stringent environmental laws, recycles only about 30% of plastics.

For decades, plastics producers and their biggest customers—consumer-goods giants like Coca-Cola,

Nestlé, PepsiCo, and Procter & Gamble—have argued that improving these recycling numbers is the solution to the plastic-waste crisis. They frame the problem as one of behavior—ours. “It’s a knee-jerk reaction to say the problem is with plastic,” Tony Radoszewski, president and CEO of the Plastics Industry Association, tells me. “The culprit is the consumer who does not dispose of products properly.”

It’s true that recycling rates are low. But to blame that fact on consumers alone is disingenuous. The bigger problem is a huge shift in energy markets. Prices for oil and natural gas have plummeted over the past decade. That in turn has made it far cheaper for petrochemical companies to produce virgin plastics than for factories to create recycled plastic. And with big profits to be made, companies have sharply increased virgin production, further driving down prices. Recycling used plastic is labor-intensive and therefore expensive—and the shifting economics now work against recycling in much of the world.

In 2018, this ecosystem endured another major blow when China halted the importation of almost all plastic scrap, saying that its own recycling industry was becoming an environmental hazard. The decision has caused chaos in the world’s plastic-resuscitation economy. Up until then, for example, the U.S. had been sending about 70% of its plastic waste to China. Now, “recycling is on life support,” says Mike Engelmann, solid waste coordinator for Smithtown, N.Y., a town of 120,000 people on suburban Long Island. “Hopefully things will turn around. But I am not sure how.”

One turnaround option, curbing the production and use of virgin plastics, faces long odds, given the petrochemical and energy industries’ political clout. Indeed, a thriving plastics market has become pivotal to the energy sector’s long-term health. As automakers transition to electric vehicles, and renewable energy takes off, plastics will pick up the slack in oil-and-gas industry growth, according to the International Energy Agency. It estimates that petrochemical feedstocks, much of which go to make plastics, could rise from 12% of total global oil demand today to 22% in 2040—at which point the agency says feedstocks could be the only segment of the industry that’s growing at all.

It’s no surprise, then, that big companies’ responses to consumer concerns don’t emphasize the supply side. In January, big players like Dow, DuPont, Chevron, P&G, and other major players launched the Alliance to End Plastic Waste. The plastics crisis “demands swift action from all of us,” P&G CEO David Taylor told reporters.

But “swift action” did not include cutting production. Instead, companies committed to spending \$1.5 billion over five years on projects to reclaim and recycle waste. Christman of the American Chemistry Council cites as one example the Renew Oceans project, which targets plastic pollution in India’s Ganges River. He says the alliance aims to make plastic packaging “100% recyclable” by 2030 and to make sure it all goes into the recycling stream by 2040.

But when I ask who will bear the enormous cost of recycling such a mammoth amount, he hesitates, then says, “This will take funding. Part will come from industry, part from governments.”

Environmentalists say the sheer life span of plastics undermines that argument. What’s more, as Geyer’s research points out, most plastic that’s recycled after first use can’t be recycled again. Put another way: Almost every new piece of plastic we add to the planet may well stay here—along with almost all the old ones.



O N A STEAMY AFTERNOON, plastics trader Steve Wong sits at a small sidewalk eatery in the city of Ipoh, in central Malaysia. He’s meeting an old client, Saikey Yeong, CEO of local recycler AZ Plastikar. Under a roaring fan, the two men sit down to business over plates of spicy dumplings and pork rolls, washed down with jasmine tea. Their table is plastic, and so are their yellow chairs.

Wong takes out several bags and lays the contents in front of Yeong. In one are bits of clothing hangers he has collected from Paris fashion houses. In another is a tangle of plastic rope, the remnants of a polypropylene fishing net, which Wong acquired in the Netherlands. Hunched over the table, the men pull apart the net to check the polymers, at one point holding the flame of a plastic lighter up to the strands, to smell the smoke and determine its chemical makeup. “Look, this is good—we can recycle this, and there is a lot of it,” Wong tells Yeong. “The fishermen usually just dump this at the bottom of the sea.”

Wong is CEO of Fukutomi Recycling, a venerable name in the plastics industry, which he founded in 1984 in Hong Kong. He has the rough-and-ready mien of a door-to-door salesman, which, in a sense, he is. He spends much of his time traveling between the U.S., Europe, and Asia, attempting to match the hundreds of different polymers in plastic waste with whichever factories can process them. It is in settings like these—over \$5 lunches and endless pots of tea, rather than in sleek corporate boardrooms—that crucial recycling deals are really decided.

(On another afternoon, at another meeting, a Chinese factory owner plied Wong with homemade rice wine. As his wife cooked up a spread of Chinese dishes for us, he and Wong tested plastic samples in a rickety toaster oven.)

In Ipoh, Yeong agrees to buy about 600 tons of the polypropylene each month, for about \$228,000 a month. But he fears being stuck with depreciating stock—a common experience these days. “Producing new plastic is so much cheaper than recycling,” Yeong says. “It is a very big problem for us.”

In factories across Malaysia, we hear similar tales. “If you came to me now and asked me to start this business, you had better just kill me,” says Yap Koon Fatt, 59, managing director of YB Enterprise, miming a gun to his head. Yap’s 10-acre recycling factory is set among oil palm trees in his hometown of Padang Serai, where he started recycling at 17. He currently recycles about 1,000 tons of plastic a month. But prices for his products have dropped 20% over the past six months, and Chinese orders have dropped by half.

In the Fizlestari factory, in Nilai, south of Kuala Lumpur, enormous bales of used water and juice bottles from Australia, the U.S., and Britain sit stacked to the ceiling. The factory brought in about \$10 million in revenue last year, but its finished product sells for 25% less than in 2017, when the factory opened. “Prices have dropped a lot, a lot, a lot,” CEO Cecil Chan tells me. “And I don’t see them going back up anytime soon.”

Wong, 62, has heard it all before, and he too is feeling the economic pain. He began as a boy in Hong Kong—“I was in primary school, not even teenage years,” he says—collecting trash for his father’s small recycling operation. He eventually grew the business into a profitable enterprise, and in 2000 he moved his wife and six children to Diamond Park, Calif. By then Wong operated more than 20 factories across the world, including in Germany, Britain, South Africa, and Australia. He says that most years he made \$10 million in profit from his Hong Kong operation alone. Like most recyclers, his biggest market was China.

That all came crashing down in 2018, when China launched the ban it calls Operation

National Sword. The country had long allowed enormous quantities of plastic-waste imports. But the vibrant industry that sprang up to process that waste eventually prompted complaints about the pollution it generated. Today, China will accept only waste that’s almost completely uncontaminated—a threshold barely 1% of items can clear. Globally, about 111 million tons of plastic waste will need to find other destinations within the next decade, according to the University of Georgia College of Engineering.

China’s actions shut the pipeline that had made Wong rich. He estimates his business has plummeted more than 90% since National Sword, and he has closed all but five of his factories. Now he makes most of his livelihood as a middleman, brokering waste to the thousands of recyclers that have opened in response to China’s drastic change. Many have relocated from China to Thailand, Vietnam, and Malaysia, drawn by cheap land—and even cheaper labor, in the form of migrants from Bangladesh, Pakistan, and Myanmar.

Venturing into the factories of Wong’s customers shows just how labor-intensive the work can be and why communities might not want the factories as neighbors.

Inside, workers comb through containerloads of plastic waste. They sort through used plastic, separating materials such as PET (polyethylene terephthalate), which is widely used in drinking bottles and packaging, and LDPE (low-density polyethylene), the plastic in throwaway shopping bags. Each of the hundreds of polymers requires different processing. Once sorted, the waste is machine-washed and turned into yarn-like string. The string is then fed into a grinder, which turns it into pellets the size of grains of rice, known as nurdles. Recyclers pack the pellets into bales and sell them back to manufacturers as raw material. Much of the supply goes to factories in China, where it reenters the consumerism bloodstream as material for car parts, toys, water bottles, and thousands of other products.

The process is remarkable—but it has never been close to 100% efficient. Many polymers that users try to recycle are too low-grade for manufacturing. Soiled and damaged plastics often can’t be repurposed. And the price pressures created by the virgin plastic glut have only disrupted things further. “At the moment, there is no economic value to

**“CUT THEIR WATER,
CUT EVERYTHING.
THEY ARE GANGSTERS.”**

YEO BEE YIN, FORMER MALAYSIAN ENVIRONMENT MINISTER, SPEAKING ABOUT LOCAL PLASTIC RECYCLERS WHO VIOLATE POLLUTION LAWS

TOXIC TIDE
Plastic waste along the
waterline at low tide in
Port Klang, Malaysia.



recycle this,” says Muralindran Kovindasamy, operations director in Ipoh for ResourceCo Asia, an Australian company. He buys some of the plastic Malaysian factories can’t use and sells it to cement companies as material for road paving. Most other recyclers simply burn or bury it. “Enforcement is poor,” he says, “and it’s cheap to dump it in the landfill.”

Y

EO BEE YIN, then Malaysia’s environment minister, looked almost pained when I asked her how quickly Malaysia’s plastic-scrap trade

has grown. Sitting in her top-floor office in the federal administrative center, Putrajaya, Yeo estimated that the trade contributes only \$1 billion a year to the economy. Yet she saw herself as waging an all-out war against the operators. Malaysian recyclers require 19 different environmental permits to operate, and Yeo closed more than 200 factories last year alone, for lack of paperwork. If need be, she said, the government should “cut their electricity, cut their water, cut everything that is possible. They are gangsters.”

Yeo’s war awaits a new general: A few weeks after we spoke, she resigned with the rest of Malaysia’s cabinet amid a parliamentary crisis. But whoever succeeds her will have allies among health experts and ordinary citizens, for reasons evident even to the casual observer.

On our first morning in Malaysia, Sebastian Meyer and I climb a plastic mountain 50 feet high in the heart of Sungai Petani, a town of about 200,000 people near the island of Penang. This waste dump comprises plastics that nearby factories have deemed unrecyclable. It is the very end of the plastic supply chain. Burning it seems about the only next step, and someone is doing just that. Tneoh Shen Jen, a physician who directs the city’s Metro Hospital, says residents have experienced breathing problems as factories repeatedly and illegally burn the waste; they “smell burning plastic most nights,” he says.

In a neighborhood nearby, Tei Jean, 40, sits in her living room with her 6-year-old daughter. Their windows are sealed, and the house is stripped of toys, blankets, and curtains. It is a desperate effort by Tei to stop



DEALMAKERS Plastics trader Steve Wong (left) shows plastic samples to recycling-factory owner Saikey Yeong.

the girl’s respiratory infections, which she says began soon after recycling factories opened in their area last year. The girl has been hospitalized three times since then and last year stayed home from school for six months. “She kept getting worse,” Tei says. “Every time she left the house, her eyes would turn red.” Now the girl spends her days in the quiet, dark living room, drawing at a small pink table.

After protests from activists in Sungai Petani, factory owners stopped burning plastic last fall. But the two sides remain hostile. Last April, arsonists set ablaze two factories overnight. Their owners blame environmental groups. When we visited the town dump, a security guard snapped our photograph with his phone, then texted it to factories across Malaysia, to alert them to our presence. For days after, factory owners eyed us with suspicion, asking, “Are you with the environmentalists?”

On one occasion, we were. One day, near Sungai Petani, two activists guided us down a dirt road that ran alongside the Mudah River, a source of water for local farms. There, a short walk from a kindergarten, a large, unlicensed dump had sprung up. A chemical reek wafted up from pools of orange-colored water, filled with plastics instantly recognizable to Western consumers: Tide laundry soap bottles, Poland Spring water bottles, Green Giant frozen-pea packets. Locals explained that recyclers had discarded un-

“WE HAVE TO STOP GROWING THE PRODUCTION OF VIRGIN PLASTIC.”

ROLAND GEYER, PROFESSOR OF INDUSTRIAL ECOLOGY, UC-SANTA BARBARA

wanted stocks here, in violation of Malaysian law. When a dump-truck driver spotted us, he hurriedly left the area. (Two days later, the site was set alight; local newspapers showed photos of thick black smoke rising over the trees.)

Malaysians hope to defend themselves from some of these depredations with the help of the Basel Convention on hazardous waste, which goes into effect next January. The convention bars the shipment of plastic contaminated with any kind of waste, and it has been signed by almost every country in the world—though not the U.S.

Malaysian officials have already begun blocking containers that they suspect violate the rules. On a blustery Sunday afternoon, customs officials escort us around Penang's dockyard, showing us which containers are marked for return to the U.S., France, and Britain—at the shippers' expense. Those returns can quickly get mired in a bureaucratic labyrinth, however. One container from Oakland, marked for repatriation, has sat on the dockside in Penang since June 2018.

Yeo, the former minister, believes plastic waste imports should be limited until the new Basel rules are strictly enforced, not only in Malaysia but also in nearby recycling hubs like the Philippines and Indonesia. People are increasingly rankled by the trade, she says. "Why are we a dumping ground for you? Because it is more convenient for you?" she asks me. "The feeling is there is perhaps injustice in it."

I**N TRUTH**, few people give even a passing thought to where their trash goes. Most assume that after they wheel their garbage bins to the sidewalk, a well-oiled recycling system takes over.

Early one January morning, we tracked Smithtown's garbage trucks as they proved how far off the mark that assumption is. On the first recycling day of 2020, the trucks tipped out 103 tons of plastic at a collection center that was once a full-service recycling facility. In 2014, Smithtown earned about \$878,000 selling its waste to eager recyclers. Now, they pay nearly \$80,000 a year to get disposal companies to take it off their hands.

Smithtown's difficulties typify what has happened across the U.S.—and they predate China's ban. As oil and gas prices crashed, the market for the town's used plastic dried

up; virgin plastic was simply cheaper. So it drastically cut its recycling and now accepts only higher-quality polymers, called "ones" and "twos"—the numbers inside the triangle recycling icon. Lower-grade plastics, numbered three to seven, are no longer marketable. Hundreds of towns across the U.S. have made similar decisions, and dozens have simply stopped curbside recycling altogether.

These days, a trucking company collects Smithtown's plastic waste and delivers it to the Sims Municipal Recycling Center in Brooklyn. Since Long Island, where Smithtown is located, bans solid-waste landfilling, many low-grade plastics wind up being burned for electricity at a plant in nearby Huntington. Actual recycling of the waste is almost out of the question, says Smithtown sanitation supervisor Neal Sheehan. "It is still cheaper to ship it across the world to someplace, to come back as something," he says.

If current trends continue, that's unlikely to change. Oil and gas companies are making major investments in a future virgin-plastic boom. Multinational goliath Royal Dutch Shell is building a mammoth complex near Pittsburgh—one of America's fracking epicenters—that will produce about 3.5 billion pounds a year of polyethylene plastic. (The plant won a 25-year tax break from the Pennsylvania state legislature that's worth an estimated \$1.6 billion.) In January, Taiwan's Formosa Plastics Group won approval from state lawmakers to build a \$9.4 billion plastic-production complex in Louisiana, which it says will create 1,200 jobs.

These plants are an environmental problem in their own right. The Center for International Environmental Law, an advocacy group, argues that the industry's expansion could pose "a significant and growing threat to the earth's climate." It calculates that the greenhouse gases emitted in the production of plastics will equal the output of about 615 new coal plants by 2050. And Geyer, the UC-Santa Barbara professor, estimates that by then, the world will be creating more than 1.1 billion tons of virgin plastic a year.

Geyer says that after years of studying industry data, he has reached one conclusion. "There is one thing we absolutely must do, and it is also the hardest," he says. "We

76
PERCENT

Share of U.S.
used plastic that
ends up in landfills

SOURCE: U.S.
ENVIRONMENTAL
PROTECTION AGENCY

\$1
TRILLION

Estimated
annual revenue
of the global
plastics industry

SOURCE: THE BUSINESS
RESEARCH COMPANY



MOUNTAIN VIEWS Dumps like this one in Sungai Petani, Malaysia, have angered neighbors and regulators.

have to commit ourselves to stop growing the production of virgin plastic.”

Yet plastic producers’ capacity to resist that outcome seems as sturdy as a laundry-soap bottle, especially in the U.S. Bans on bags and other “single use” plastics are a case in point. Beginning in 2021, single-use plastics will be strictly controlled in the European Union’s 27 countries, and plastic bags will be banned in major cities in China. In the U.S., petrochemical companies have largely stymied such proposals. Only eight U.S. states ban single-use plastics. At the national level, a measure introduced in February by two Democratic U.S. senators would make companies share the burden of recycling and impose a moratorium on virgin-plastic growth. But Radoszewski, CEO of the Plastics Industry Association, calls the second measure “a nonstarter.”

Radoszewski says plastic-ban proposals are simply “virtue signaling” by politicians, and argues that alternatives like glass, metal, and paper are more polluting over their life span. The association lobbies relentlessly to send similar messages to lawmakers. “Don’t let naysayers dictate the story of plastics,” the group told its members in announcing its

national conference on March 25. “Educate those on Capitol Hill about what we already know: Plastics help change people’s lives for the better.”

F

OR ALL THE fighting words, there are signs that some businesses are rethinking plastics—in part because of pressure from concerned customers.

Some clothing companies have proved that recycled plastics can command a luxury premium. In 2017, Adidas began selling high-end sneakers made of plastic waste hauled from the ocean off the coast of the Maldives. The \$200 shoes have been a sold-out hit, and Adidas made 11 million pairs last year. The company says it now aims to eliminate virgin plastic from its production completely. Nike has also designed sportswear from recycled polyester and plans to expand that effort.

Behavioral changes in the packaged-goods world could have an even bigger impact. Unilever CEO Alan Jope said last October that the company would “fundamentally rethink” its packaging—its plastic footprint exceeds 700,000 tons a year—and halve virgin-plastic use by 2025.

Advances in recycling also show promise. Unilever has partnered with SABIC, a company owned by Saudi Aramco, to create packaging using chemical recycling, a process that breaks down used plastics and converts them into material it says is as good as virgin. And IBM last year said it had created a chemical process to eat through PET and turn it into nurdles—in a process it says is far more efficient and scalable than the painstaking wash-



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PUSHING BACK ON PLASTIC

Our appetite for plastic is almost limitless; the planet's ability to absorb it is not. Barely 9% of used plastics are recycled worldwide, and about 8 million tons are dumped into the oceans every year. A growing wave of popular anger over plastic waste is pushing companies to take bolder steps to tackle the problem. These three approaches are gaining momentum.



1

CHEMICAL RECYCLING

The plastics industry is bullish on this strategy to address the global glut. The method involves breaking down plastics that are typically landfilled or burned, like plastic wrappers, film, and coffee pods, into their raw chemical ingredients. Those are then mingled with virgin resins to make materials that are just as strong as new plastic. There are downsides, however. The process generates a substantial carbon footprint, for example, limiting its overall benefit to the climate.

2

BIOPLASTICS

Unlike traditional plastic, which is made from petroleum feedstocks, bioplastics are produced by extracting sugar from corn or sugarcane and turning it into polylactic acids or polyhydroxyalkanoates. Those materials look and feel much like carbon-based plastics, without the fossil fuel consumption. Critics note that crops for bioplastics require pesticides and hog land on which food could be grown. And recycling bioplastics requires high heat in composting plants, increasing the risk that used items will be landfilled.

3

PAY-PER-PACKAGE

One way to counteract a broken recycling market: require companies to pay city governments to recycle their plastic packaging. In most of the European Union and some Asian countries, such laws already exist. In the U.S., Maine's legislature is considering a similar bill. Plastic makers say they would prefer to boost recycling rates rather than shoulder the costs. But in Europe, the laws have helped spur companies to cut packaging and rethink their use of plastic.

ing and sorting in factories like the ones we visited in Malaysia.

Several owners of those factories see promise in these moves—a glimmer of hope that their nurdles might finally become desirable commodities again. “Nike and Adidas want to tell customers they care about the earth and will use 100% recycled plastics,” says Adu Wu, chief operating officer for Grey Matter Industries, a Taiwanese recycler. The recent announcements might signal a turning point, he says. “We want to be part of that.”

Back at BioGreen Frontier, company director Engboon Ooi, 56, says he too hopes changing behavior among multinationals could help him land big deals. In the meantime, he's preoccupied with short-term woes. Ooi is still waiting for official permits for his factory and risks being shut down. And in late January, BioGreen and other recyclers, like much of the global economy, were hit with a body blow from the coronavirus. Within weeks, China shut down factories and ports and canceled orders for recycled-plastic pellets, causing havoc for recyclers. By phone in mid-February, Ooi told me he has begun stockpiling nurdles in the warehouse, while hunting for other clients. “I don't want to send the workers home,” he says.

Those workers continue to flood into Malaysia from some of the world's poorest countries, eager to recycle the waste from some of its richest. For them, the plastic-waste industry, even in its depressed state, remains a large step up the economic ladder. “I have worked here for two months,” says Aung Aung, 25, from Yangon, Myanmar, as he stands on the BioGreen production line. He says recycling plastic pays far more than his previous restaurant jobs in Penang. “I need to think about my family,” he says.

Shahid Ali, meanwhile, has big plans. He says he will work at BioGreen for two more years before returning to Peshawar. “I will get married then,” he says, standing amid the sodden washed plastic. “I have already chosen a girl.” Until then, he's willing to spend 84 hours a week on the recycling line—building a home, figuratively speaking, out of plastic scraps. ■

With additional reporting by Selvanaban Mariappen and Sebastian Meyer



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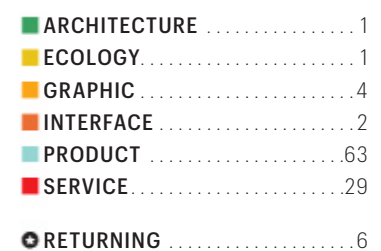
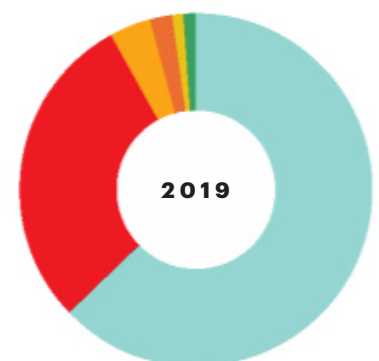
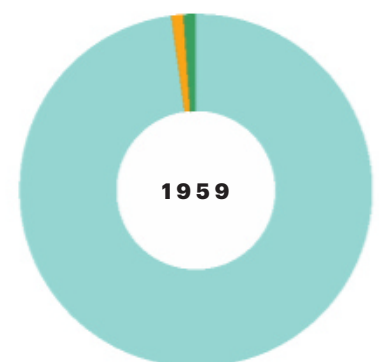
BY DANIEL BENTLEY
PHOTOGRAPHS BY DAN SAELINGER

IN 1959, **FORTUNE** PUBLISHED a “fascinating and brash” project that set out to discover the 100 best-designed products of the modern era. The list was compiled by Jay Doblin, the director of the Institute of Design at the Illinois Institute of Technology (IIT), based on a survey sent out to 100 of the era’s top designers, architects, and design teachers. The result is a fascinating document for modern eyes—perfectly illustrating mid-century design philosophy, yet often mirroring contemporary tastes: sleek sports cars by Porsche and Cisitalia, and even sleeker armchairs by Eames, Aalto, and Saarinen. Domestic appliances with forms foreshadowing Sputnik and the start of the Space Age. Above all, a deep appreciation for the aesthetic beauty not just of luxury goods but also of the practical items that improve people’s lives on a daily basis.

In 2019, to recognize the 60-year anniversary of the original list, *Fortune* again partnered with the IIT Institute of Design (ID), now under the deanship of Denis Weil, to re-create the survey. Following Doblin’s methodology as

AT YOUR SERVICE
IN THE YEARS SINCE OUR ORIGINAL LIST DEBUTED, INTERNET SERVICES HAVE MADE THEIR MARK ON DESIGN

LIST BY CATEGORY





1

IPHONE

DESIGNED BY
Apple, 2007

“An iPod, a phone, an Internet communicator” was how the late Steve Jobs announced the iPhone to the world in 2007. At the time it was an impressive claim. Now it seems like a massive understatement for a device that changed how we live. Analysts were initially skeptical that Apple could succeed selling a premium phone for \$499 in a market in which most devices were subsidized or given away by carriers. But by relentlessly pushing the envelope of hardware and software design, adding a professional-grade camera, and creating an ecosystem of apps and services, Apple has sold more than 2 billion iPhones—and in the process has become the most valuable company in the world.

closely as possible—with some sensible modern tweaks—ID polled educators, influencers, freelance designers, and corporate design teams on the creations they consider truly great. After more than a year of planning, surveying, and consolidation, we present to you the iconic designs that rose to the top—the highest-ranked 50 in the pages that follow, and 50 more online.

Just as in 1959, respondents were asked to name up to 10 examples of what they considered the best-designed products of the “modern era”—though this time we asked them to provide a reason for the nomination. Our respondents came back with more than 300 different products. But there was a clear convergence around the top 25, which were ranked by the number of nominations they received. For the rest of the list, where there was less consensus, the researchers at ID used language analysis of the submissions to rank products based on five criteria: how adaptable and expandable the product is; its impact on society or the environment; its ease of use; its commercial success; and whether it redefined its category.

The results show a clear shift in design philosophy over the past six decades. “Design has graduated from ‘value-adding,’” says Weil. “Now it’s value-driving, unlocking and making accessible the value in new technology.” Sixty years ago, the word design was almost synonymous with the aesthetics of the finished product. Today the emphasis is on how elegantly the product or service performs its specific purpose or function. Perhaps the clearest example of this evolution is a new category that appears on our updated list: Internet services. Google Search, ranked No. 3, is a great design not because of visual adornment, but because it eschews all unnecessary elements to do its job—organizing vast troves of information—near perfectly.

In his 1970 book *One Hundred Great Product Designs*, published only 11 years after compiling his original list, Doblin was already aware of where design was going next. “Process must become more important than product,” he wrote. “In the future, pride of ownership ... will give way to human values—education, intelligence, contributions to society, creativity.” While optimistic, and even in 2020 not fully realized, elements of his prediction can be seen in the updated list. In 1959, 14 automobiles made it into the top 100. Our new ranking includes just four—and Uber, an entire system of transportation rather than a single vehicle, ranks higher than all of them.

With regards to No. 1 on our list, Apple’s iPhone, respondents did not speak so much to its physical design—as handsome as its various iterations have been—but to the way in which the device has transformed human communication and nearly every aspect of how we live.

“Not only an instant way to be constantly connected,” said Kathleen Brandenburg of design consultancy IA Collaborative, of the device, “but a flexible, ever-evolving design that becomes whatever each user wants it to be.”

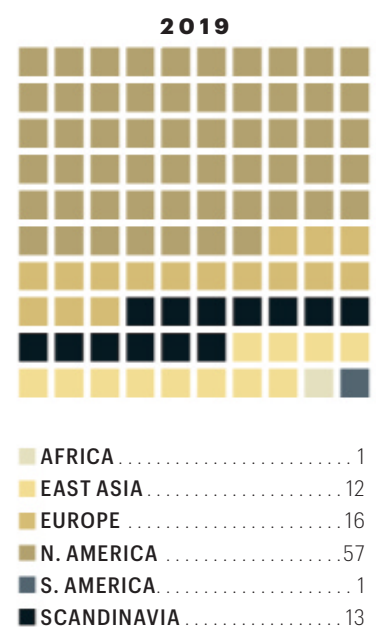
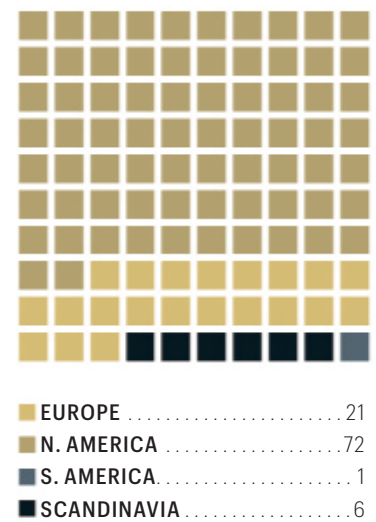
While more than one-third of the ranking comprises designs from the past 15 years, our respondents acknowledged what one might call timeless creations. Six designs—marked by a star—are so iconic that they made both the 1959 list and today’s version. A handful of creators also appear on both editions, including Ray and Charles Eames, Alvar Aalto, and Eero Saarinen, whose furniture and home accessory designs are a shortcut for achieving mid-century cool; typeface designer Paul Renner, whose Futura font was used by *Vogue*, the Apollo program, and streetwear brand Supreme; and Ferdinand Porsche, whose car designs were both democratic, as is the case with the Volkswagen Beetle, and cutting-edge, as with the Porsche 911.

Our hope is that this list inspires you to think about the ways you encounter design every day. It’s a reminder that great design is more than window dressing—it’s about making life easier, simpler, better. And that’s beautiful.

A WELL-DESIGNED WORLD

OUR VIEW OF WHERE GREAT DESIGN IS CREATED HAS BECOME MORE GLOBAL IN THE PAST 60 YEARS

LIST BY GEOGRAPHY



4



EAMES FIBERGLASS ARMCHAIR

DESIGNED BY Ray + Charles Eames, 1950

Say "Eames chair," and one might think of the leather and plywood lounge chair created by husband and wife design team Charles and Ray Eames in 1956. But it's the distinctly more democratic molded plastic and fiberglass armchair introduced six years earlier that ranks high on our list. Available in a variety of styles and colors, the design can be found everywhere from conference rooms to downtown lofts. Another testament to its greatness: The chair remains in production today.



2



MACINTOSH

DESIGNED BY Apple, 1984

Apple started the personal computer revolution with the Apple II, but the Macintosh defined the category.

3



GOOGLE SEARCH ENGINE

DESIGNED BY Google, 1997

A minimalist gateway to a universe of information.

4

5



SONY WALKMAN TPS-L2

DESIGNED BY Norio Ohga, 1979

The Walkman allowed us to set the world to our own soundtrack.

6



OXO GOOD GRIPS PEELER

DESIGNED BY Sam Farber + Smart Design, 1990

Farber created this ergonomically superior peeler for his arthritic wife.

7



UBER RIDESHARE

DESIGNED BY Uber, 2009

By leveraging the gig economy and GPS, Uber created a global transportation system.

8



NETFLIX STREAMING

DESIGNED BY Netflix, 1997

The DVD rental company turned streaming service upended the movie and TV industries.

9

LEGO BUILDING BLOCKS

DESIGNED BY
Lego + Hilary Fisher
Page, 1939

A delight to children and the bane of any parent who has stepped on an errant brick, Lego is the most popular toy in the world, with 75 billion pieces made annually. Though the company is famously Danish, the design originates with English toymaker Hilary Fisher Page, who created an “Interlocking Building Cube” in the late 1930s. Lego founder Ole Kirk Christiansen brought the bricks back from a trip to London and later acquired permission from Page to make them.



“BRINGS TOGETHER A CENTURIES-OLD JAPANESE TECHNIQUE WITH MODERN TECHNOLOGY.”

Spencer Bailey,
PHAIDON EDITOR-AT-LARGE, ON THE
AKARI LAMP [13]

9



IPOD

DESIGNED BY
Apple (Jonathan Ive),
2007

The heir to the Walkman’s throne. Put *all* your music in your pocket.

10



GOOGLE MAPS

DESIGNED BY
Where2Technologies,
2005

Maps transformed our relationship with our environment. Nowhere is unknown.

12



APOLLO 11 MISSION

DESIGNED BY
NASA, 1969

“Put a man on the moon.”

NATHAN VAN HOOK,
SENIOR CREATIVE
DIRECTOR, NIKE

13



AKARI LAMP 1A

DESIGNED BY
Isamu Noguchi, 1951

Marrying function and sculpture, Noguchi’s endlessly imitated lamps are a domestic work of art.

14



MACBOOK PRO

DESIGNED BY
Apple (Jonathan Ive),
2006

Untethered creative professionals from workstation computers.

15



POST-IT NOTE

DESIGNED BY
3M (Spencer Silver +
Arthur Fry), 1977

The majority of the great designs on this list began as solutions to problems. But the Post-it began life as a solution without a problem. In the late 1960s, 3M chemist Spencer Silver—in pursuit of a superstrong adhesive—accidentally created a low-tack, reusable adhesive that could hold two surfaces together but easily be pulled apart. And the iconic yellow of the paper that eventually became home to that new substance? Also an accident. It was the color of the scrap available to the design team.

15



BOEING 747

DESIGNED BY
Joe Sutter
+ Boeing Team, 1970

“Making travel easier
and bringing the
world together.”

BAS VAN DE POEL,
DIRECTOR, SPACE10

16



POLAROID SX-70

DESIGNED BY
James Gilbert Baker
+ Edwin Herbert
Land, 1972

Kodak gave us the
camera; Polaroid
gave us an entire
film lab.

17



MODEL S SEDAN

DESIGNED BY
Tesla (Franz von
Holzhausen), 2012

The car that took
Tesla from upstart
to global player.
High-performance,
zero emissions.

18



NOKIA 3210

DESIGNED BY
Alastair Curtis, 1999

The first phone
to sell more than
100 million units.
The pinnacle of
pre-smartphone
design.

19



SAVOY VASE

DESIGNED BY
Alvar + Aino Aalto, 1972

“Holds flowers
similarly to a
human hand.”

RENÉE CHENG,
DEAN, UNIVERSITY
OF WASHINGTON

20



PHILIPS HUE LIGHTING SYSTEM

DESIGNED BY
Philips (Signify), 2012

Made lighting our
homes as personal
as the music we
listen to.

21

25

■ **MUJI RICE COOKER**

DESIGNED BY Naoto Fukasawa, 2014

Compact, sleek, and intuitive, this simple rice cooker shows the “subtle and strong systematic coherence” that’s become Muji’s hallmark, says Alok Nandi of the Interaction Design Association. Though TV food personality Alton Brown loves to rail against kitchen “unitaskers”—devices with only one function—when that function is to quickly and simply cook the staple grain of half the world’s population, we think an exception can be made.



“STAYING IN THE HOME OF A LOCAL EXPONENTIALLY INCREASES THE LEARNING POTENTIAL OF TRAVEL.”

Jason Ring, SENIOR DESIGN MANAGER, UBER, ON AIRBNB [26]

22



■ **APP STORE**

DESIGNED BY Apple, 2008

Manufacturers used to control what was on your phone. The App Store lets you decide.

23



■ **SPOTIFY**

DESIGNED BY Spotify, 2006

The history of recorded music—on your desktop, on your phone, in your pocket.

24



■ **AMAZON PRIME**

DESIGNED BY Amazon, 2005

“Press a button and get almost anything delivered to your door, without paying shipping.”

JASON RING, UBER

25

26



■ **AIRBNB**

DESIGNED BY Airbnb, 2008

Airbnb’s model of staying with a local was a radical approach to travel that made us feel less like tourists.

27



■ **WIKIPEDIA**

DESIGNED BY Wikipedia, 2001

“Addresses the complex problem of democratizing and sharing knowledge.”

BARBARA BARRY, DESIGN STRATEGIST

28



NYC SUBWAY MAP
DESIGNED BY
Unimark
(Massimo Vignelli),
1972

The challenge: Design a legible guide to the sprawling transit system of New York City. Italian designer Massimo Vignelli's solution? Ignore the overground geography and create a simplified, color-coded abstraction. Designers love the map, but the straphangers of the era did not: The MTA had it redesigned just five years later. But many of Vignelli's original design cues persist, including the color-coding, heavy use of Helvetica, and liberties taken with the geography of the five boroughs.

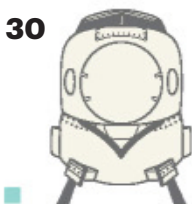
28



IOS
DESIGNED BY
Apple, 2007

A mobile operating system installed on 1.5 billion devices. Simple to use; powerful enough for serious work.

29



SHINKANSEN
DESIGNED BY
Japanese National
Railways, 1964

Japan's bullet trains reach 200 mph and have recorded zero passenger fatalities.

31



WECHAT
DESIGNED BY
Tencent (Zhang
Xiaolong), 2011

Integrating a host of essential mobile apps, WeChat has become users' one-stop shop.

32



NEST LEARNING THERMOSTAT
DESIGNED BY
Nest Labs
(Tony Fadell), 2011

A thermostat that programs itself.

33



606 SHELIVING SYSTEM
DESIGNED BY
Vitsoe (Dieter Rams),
1960

Modular shelving that works anywhere and holds anything.

"A USER EXPERIENCE THAT EVEN BABIES CAN FIGURE OUT WITHOUT BEING TAUGHT."

Hitachi Design Team,
ON APPLE'S IOS [29]

38

ROUND THERMOSTAT

DESIGNED BY
Honeywell (Henry
Dreyfuss), 1953

Honeywell is a conglomerate with 114,000 employees, annual revenues of \$42 billion, and businesses ranging from aerospace, industrial control systems, and chemicals. Yet the thermostat created by Henry Dreyfuss is so iconic and ubiquitous that, for many, the company has become synonymous with his design. And while Honeywell makes a plethora of digital and smart thermostats, the humble round thermostat—the design of which was inspired by the über-analog radio dial—is still in production today.



“IT’S NOT A
PILL BOTTLE
AS MUCH AS
IT IS A SYSTEM.”

Brandon Schauer,
FORMER HEAD OF
ENTERPRISE DESIGN,
CAPITAL ONE,
ON CLEARRX [36]

34

**SKYPE**

DESIGNED BY
Skype, 2003

A videochat service so successful that it’s become a verb: to Skype.

35

**MODERN CLASSICS**

DESIGNED BY
Penguin (Jan
Tschichold), 1952

Designed to cost no more than a pack of cigarettes and fit in a pocket.

36

**CLEARRX**

DESIGNED BY
Deborah Adler, 2005

Clearly labeled drug containers use color coding and clever design to aid patient safety.

37

**MOBIKE**

DESIGNED BY
Beijing Mobile Bike
Technology, 2015

An elegant solution to the “last mile” problem: the first cashless, dockless bike share.

38

39

**STOOL 60**

DESIGNED BY
Artek (Alvar Aalto),
1933

“A seat, table, storage unit; democratic, cheap, stackable.”

REBEKKA BAY, CREATIVE
DIRECTOR, UNIQLO

43

LIA PREGNANCY TEST

DESIGNED BY
Bethany Edwards +
Anna Simpson 2017

A home pregnancy test accidentally discovered in a bathroom trash can is something of a cliché in sitcoms and romantic comedies. But behind that plot point is a design flaw: Most tests are made from nonbiodegradable plastic and can't be flushed. Inspired to find something environmentally sound, Bethany Edwards and Anna Simpson created Lia, a home pregnancy test produced from paper that disintegrates in water. The upshot is more privacy for women and less plastic waste.

40



FACEBOOK
DESIGNED BY
Facebook, 2003

For better or worse, Facebook connected the world and transformed advertising, politics, and society at large.

41



BILLY BOOKCASE
DESIGNED BY
Ikea, 1979

The Billy embodies Ikea's affordable design; the company has sold some 100 million to lit lovers worldwide.

42



PRIDE FLAG
DESIGNED BY
Gilbert Baker, 1979

"Unmistakable, customizable, and speaks pride for LGBTQ+ people."

SARA CANTOR AYE, CO-FOUNDER, GREATER GOOD

43

44



SUPER MARIO BROS.
DESIGNED BY
Nintendo (Shigeru Miyamoto), 1985

The first smash of the home console era sold more than 40 million copies.

45



VÉLIB' BIKE SERVICE
DESIGNED BY
JCDecaux, 2007

Paris's e-bike share aims to cut traffic and emissions and rekindled the city's love of cycling.

"DISCREET,
SANITARY,
AND ENVIRONMENTALLY
SUSTAINABLE."

Zoë Ryan,
CURATOR, THE ART
INSTITUTE OF CHICAGO,
ON THE LIA PREGNANCY
TEST [43]

49

**VOLKSWAGEN
BEETLE**DESIGNED BY
Ferdinand Porsche,
1938

They say you can't outrun your past. Tell that to the VW Beetle, which pulled off one of the great reinventions of our time. Commissioned by Adolf Hitler to be an affordable "people's car" for the citizens of the Third Reich, the Bug, as it's now lovingly known, overcame its sinister origins to be embraced by hippies and Disney alike. Designed by Ferdinand Porsche, the undeniably cute little car uses a rear-mounted, 25-horsepower air-cooled engine to keep things as mechanically simple as possible.



46

**APPLE WATCH**DESIGNED BY
Apple, 2015

The power of an iPhone in a package not much bigger than a postage stamp.

47

**BIALETTI
MOKA POT**DESIGNED BY
Alfonso Bialetti, 1933

As essential as the beverage it brews, it took espresso from coffee shop to stove top.

48

**POÄNG**DESIGNED BY
Ikea (Noboru
Nakamura), 1974

Ikea continues to sell about 1.5 million of these elegant-yet-affordable chairs annually.

49

50

**MICROSOFT
OFFICE**DESIGNED BY
Microsoft, 1990

Can you imagine doing business without Excel or PowerPoint?

READ MORE

Go to Fortune.com to see the rest of the 100 Greatest Designs of Modern Times.

ACKNOWLEDGMENTS

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NEXT-GENERATION A.I. IS READY FOR LIFTOFF

Companies are integrating A.I. into physical infrastructure to make new 5G services possible.

WIDESPREAD USE OF ARTIFICIAL INTELLIGENCE

[A.I.] and virtual reality [VR] has been on the horizon for quite some time, contingent in part on the successful rollout of fifth-generation [5G] wireless technologies. Over the past few years, A.I. adoptions have begun to gain momentum, a trend that will only continue. Global A.I. software revenues are projected to increase from \$9.5 billion in 2018 to \$118.6 billion by 2025, according to reports from market intelligence firm Tractica.

A.I. capabilities and components are being embedded in 5G infrastructure to enable everything from VR-enhanced gaming and smart consumer products to intelligent machine learning in heavy industries and A.I.-enhanced health care. To be sure, the use cases are exciting. Fleet management companies can gather logistical data about every aspect of vehicle performance. By using A.I. to apply algorithms that analyze that data, managers can optimize routes based on weather and traffic conditions. They can also flag operator driving patterns that lead to excessive vehicle wear, eliminate unnecessary repairs, and increase savings.

Smart cities can employ A.I. to ease congestion by monitoring pedestrian crossings and changing the tempo of signal lights to let vehicles flow freely when

foot traffic is light. The use of A.I. in retail will continue to create more sophisticated self-service interactions. And in health care, outpatient monitoring through connected wearables will provide real-time data to improve medical treatments and physician response times.

Multinational technology company Huawei uses embedded A.I. in the infrastructure it builds, such as antennas and networking hardware, helping it to accelerate installation site preparation, optimize bandwidth allocation, and shorten incident and problem resolution times.

“We use deep learning-based image-recognition A.I. technology to inspect the quality of wireless base-station installations as well as to analyze and save on energy usage,” says Peter Liu, distinguished technologist for Huawei’s R&D subsidiary in the U.S.

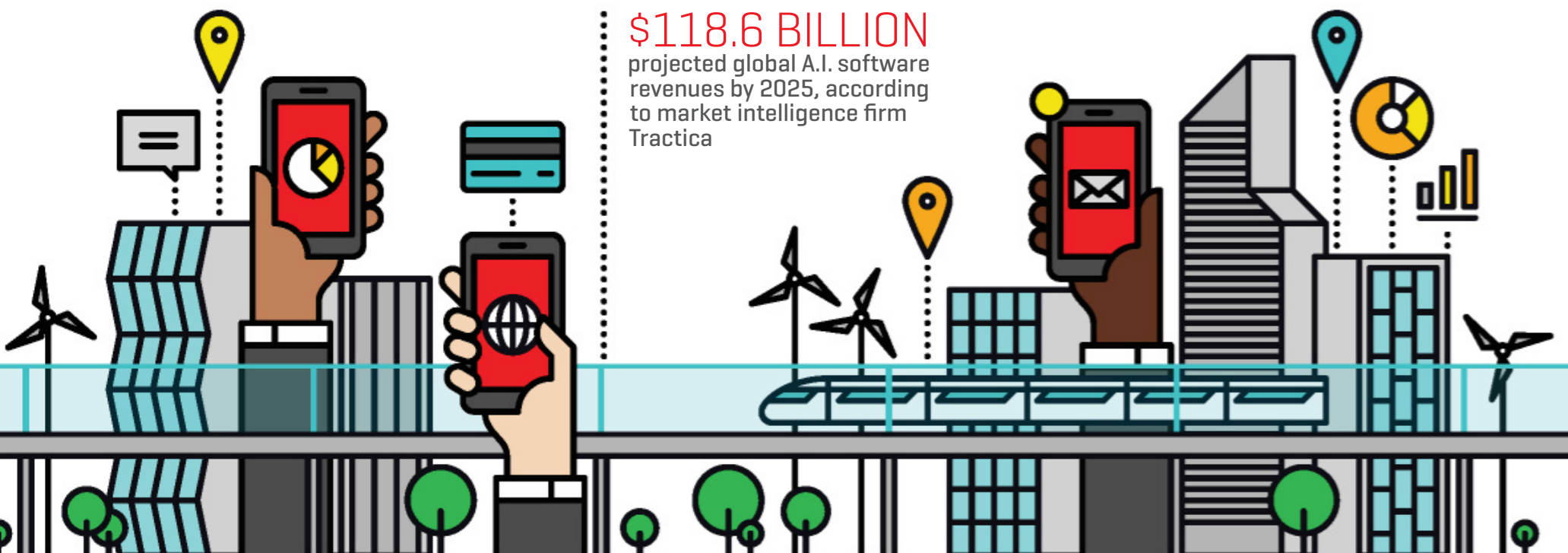
The success of all the possible use cases for 5G, including A.I. and VR deployments, is the result of bringing compute power and storage closer in proximity to the devices and data sources. Edge computing ensures the nanosecond data transfers and low latencies that smart homes, enterprises, factory floors, and autonomous vehicles will require.


A.I. is even helping those who don’t yet have access to 5G networks. As businesses and consumers continue to rely on current 4G LTE data speeds, they’ll benefit from infrastructure improvements made possible by companies like Huawei. In addition to using A.I. algorithms to ensure seamless connectivity and improve 5G site designs through simulation models, Huawei is driving new A.I. edge capabilities to make intelligent 5G services a reality for consumers and businesses across the U.S. ■



\$118.6 BILLION

projected global A.I. software revenues by 2025, according to market intelligence firm Tractica





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TIME WELL SPENT

PASSIONS



TRAVEL

The Accidental Hotelier

A French retail mogul delivers his vision for luxury hospitality: smaller, sustainable, and with purpose. **BY LINDSEY TRAMUTA**

THE INTENTION was never to open four hotels in the span of six months. But French retail mogul Frédéric Biousse is used to seeing his projects take on a Herculean dimension. “There were construction delays and permit issues, and before we knew it, they were all ready for unveiling



“The luxury of tomorrow isn’t money or recognition—it’s meaning and purpose. And that’s especially true in travel. It’s tied to conserving local heritage, agriculture, and permaculture. It’s putting local first.”

—FRÉDÉRIC BIOUSSE



needs was familiar to Biousse, but life as a serious hotelier, winemaker, and even farmer was new territory.

The foray into hospitality was a life change precipitated by what could be called retail burnout. As the founder and former CEO of the Sandro Maje Claudie Pierlot Group (SMCP), Biousse fast-tracked international growth for the clothing lines Sandro and Maje, saving them from bankruptcy in 2007 and catapulting them into profitable, accessible luxury brands with boutiques around the world. But by 2015 he had also taken on a role as a board member

for Uniqlo and spent more time hopping from one global meeting to another than doing what he loved most: building and growing brands with potential. “It was during one meeting that the vanity of it all fully hit me. People around me behaved as though they were changing the world—I lost it,” he confesses. He sold the group to the global investment firm KKR and prepared for a different life.

Initially, that life was meant to involve reviving an old winery and restoring the estate’s 18th-century manor house—a veritable find in a secluded section of the Luberon in southern France. It was intended to

ILLUSTRATION BY SAM KERR; ORIGINAL PHOTO: SYLVIE CASTIONI

around the same time,” says the 50-year-old during a candlelit dinner on the stone terrace of Torre Vella, one of two converted fincas he and his husband, Guillaume Foucher, opened last year as intimate agritourism hotels on the southern tip of Minorca in Spain. Juggling gargantuan budgets and customer

DOMAINE
DE FONTENILLE

A restored 18th-century manor house and winery in a secluded section of the Luberon in southern France.

be the couple's new family home, a deliberate move toward a slower routine. Foucher, the seventh generation in a family of farmers, wanted to reconnect with his agricultural heritage. The restless Biousse, who had moved 23 times in 20 years, was eager to lay down roots for the first time. But the scale of the project outgrew their needs. "[32,000 square feet] of space for two people and a dog was simply too large. We realized to restore the structure's grandeur, we needed to make it a commercial project, and making it a hotel was the most natural format."

The duo invested more than \$15 million into the refurbishment of the estate and opened it in 2016 as *Domaine de Fontenille*, a boutique hotel complete with vines, produce gardens, a state-of-the-art wine cellar, and a one-Michelin-star restaurant. The move proved to be a worthy expenditure of time and money: *Fontenille* quickly became a popular getaway for Parisians, in-the-know travelers, and high-profile personalities including singer Vanessa Paradis and Manuel Valls, a former French Prime Minister.

Biousse and Foucher's future as hoteliers was as much about transforming their lives as it was about capitalizing on a business opportunity. "When I was on the road, I was sleeping in different hotels around the world that were beautiful but without any real character or vision,"

FONTENILLE
MENORCA:
TORRE VELLA

Two historic fincas on the Balearic island of Minorca were converted into boutique hotels and working farmland.

explains Biousse. On top of that, he realized he had already identified the ideal client for the kinds of hotels he envisioned creating—the same people who loved the mid-range luxury brands he previously had built and grown. The only difference in 2019, he says,

is what luxury entails. "The luxury of tomorrow isn't money or recognition—it's meaning and purpose. And that's especially true in travel. It's tied to conserving local heritage, agriculture, and permaculture. It's putting local first."

In the past year, Biousse





FROM LEFT: COURTESY OF YANN DERET; COURTESY OF WEARECONTENT

and Foucher have applied that vision to Les Bords de Mer, a 19-room boutique hotel in an iconic Art Deco villa perched directly on the beach in Marseille, France; to a refurbished surf lodge called Les Hortensias du Lac in Hossegor; and to Torre Vella and Santa Ponsa on Minorca, two historic fincas converted into agritourism escapes with a combined 740 acres of working farmland on which the men produce olive oil, aromatics, and organic vegetables to supply their locavore restaurants. Plans

to expand the hotel business in the next two years are ambitious: an estate in Normandy; a 10-room inn in Siena, Italy; and an island getaway in Greece.

Still, these hotel projects haven't kept Biousse out of retail altogether. In 2016, LVMH chairman Bernard Arnault approached him to run an affordable luxury firm within the group's portfolio. He declined, but he saw the need to give support to rising stars on his own terms—the kind of support a big group wouldn't be able to offer. With Experienced Capital,

his four-year-old accelerator, he and his team help scale emerging French brands with solid convictions. This includes Bali-baris, a fast-growing menswear label; NV Gallery (which Biousse calls the “Sandro of home design”); Jimmy Fairly sunglasses; and skin-care line Oh My Cream, among others.

“The raison d'être in everything I do now is pleasure,” says Biousse. “And if I can use my success to build brands and experiences with meaning, then I've done something right.” ■

LES BORDS
DE MER

An Art Deco villa turned boutique property perched on the Marseille waterfront. Each of its 19 rooms has a stunning view of the Mediterranean.

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OF
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“When
my mom
was diagnosed with cancer,
I wanted her
to have access to
the best
treatments
available.”

SONEQUA MARTIN-GREEN
Stand Up To Cancer Ambassador



Photo By
MATT SAYLES

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