FORTUNE

NOVEMBER 2018

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THE 2018 FUTURE 50

LAST YEAR'S PICKS CRUSHED THE MARKET


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1
Anna 9:40 AM
The boss says it's good... approved!
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NOVEMBER 1, 2018

▲ ON THE COVER: PHOTOGRAPHS BY **MARK MAWSON**

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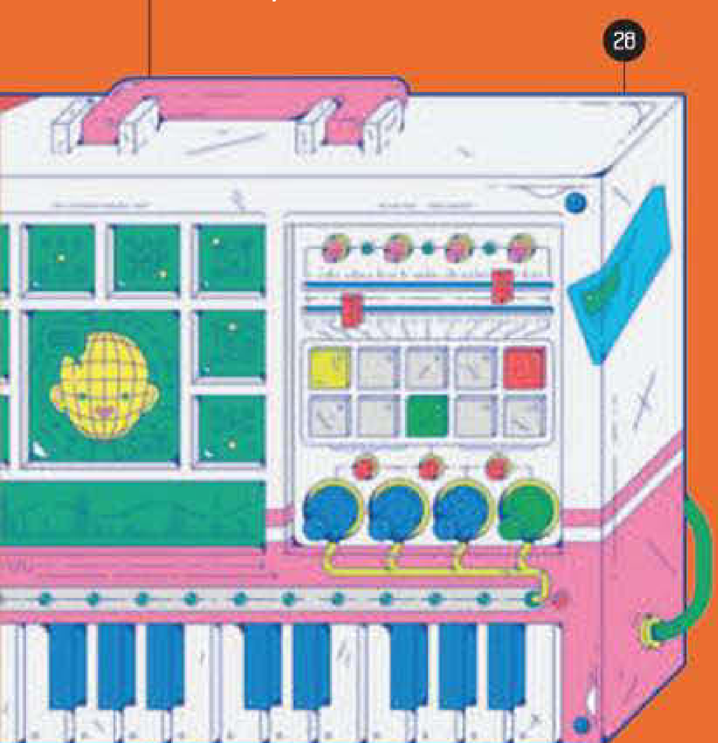

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THE NEXT FRONTIER

SOMETHING EXTRAORDINARY HAPPENED while we weren't looking: business caught up with science fiction. That's the message of *Fortune*'s cover package this issue—which explores how companies around the world are streamlining, speeding up, error-proofing, and otherwise reinventing their daily operations with the help of a versatile, futuristic tool.

Financial institutions such as HSBC and Danske Bank are using it to get better at fighting money laundering and fraud—and a slew of mortgage lenders already use it to predict loan default rates. Vodafone, Nielsen, and Unilever are using it to find job applicants with more fine-tuned social and emotional sensitivities. And Airbus used it to design an interior partition on its A320 jet—arriving at a structure that was scarcely half the weight of the previous version.

That tool is artificial intelligence—or A.I., as it's now universally known. And though its capabilities and limitations are only barely understood, companies large and small aren't waiting to test it out. Home Depot is feeding vast amounts of store transaction data into a deep-learning algorithm to help figure out what's frustrating do-it-yourselfers (and what else the store can sell them to fix the problem). BMW and Mercedes-Benz are using A.I.-fueled collaborative robots, or "cobots," to turn their human car assemblers into "Ironman" superworkers. And Swiss investment bank UBS teamed up with IBM Watson and a New Zealand startup to "digitally clone" its chief economist Daniel Kalt so that the avatar Kalt could "interact with clients just as he would in the flesh," *Fortune*'s McKenna Moore reports.

For this special package, our reporting staff delved deep into the industries they cover to learn more about how A.I. has been transforming business. We highlight 25 great examples (please see page 96), but you'll find others as well throughout the issue.

In an introductory essay to that package, A.I. pioneer and venture capitalist Kai-Fu Lee, who is also a veteran of Apple, Microsoft, and Google, says we're now immersed in not just one wave of A.I. but rather four simultaneously—each "with different starting points and velocity" (page 92). The A.I. feeding off the vast repository of Internet data is driving a second wave of business process–focused A.I., which is being enhanced further by a wealth of sensors that are now giving intelligent machines the ability to hear, see, and feel. Together, these three waves are building to an age of "autonomous A.I." That, of course, is the realm of self-driving cars and other autonomous devices—machines that can make decisions about how to move themselves through space.

This sudden confluence of machine-learning advances, Lee acknowledges, comes with no shortage of challenges for us slower-learning humans—from issues of privacy and security to inherent biases and unavoidable job displacement. But as our special report reveals, this new algorithmic science is also making business smarter, better, and more efficient in the process.

Some companies, naturally, are more poised to embrace the future than others. As *Fortune* discovered with the help of consultancy BCG, there is something in the DNA of forward-thinking firms that drives them to invest proactively in their businesses, adapt quickly to change, and attract workforces that have that same mindset. For the second year in a row, we've highlighted dozens of those companies—a list we call our Future 50 (please see page 63).

At the very top of that ranking is enterprise software-maker Workday, run by cofounder Aneel Bhusri. So what exactly gives this California company a line to the future? That's where the supernatural intelligence of *Fortune* executive editor Adam Lashinsky comes in. Please read his eye-opening story on page 66.

Enjoy tomorrow. It turns out it's already here.

CLIFTON LEAF
Editor-in-Chief, *Fortune*
@CliftonLeaf

THE WORLD IN 7 PAGES

BRIEFING

Full Employment? The Economy Isn't Acting Like It

Low levels of joblessness have historically preceded catastrophe. But maybe not this time.

By Geoff Colvin

ECONOMY

WHEN UNEMPLOYMENT fell to 3.7% in September, the lowest in almost 50 years, it was hard to know whether to cheer or tremble. A white-hot labor market means it's easy to get a healthy raise, which many workers could certainly use. Booyah! Except that whenever unemployment has fallen anywhere near this low in the past 60 years, a recession has inevitably followed, often very quickly, and inflation has usually surged. *No bueno.* ▷▷

▷▷ All of which leads to a large question that turns out to be profound: Why is neither the good stuff nor the bad stuff happening? Pay isn't rocketing; the economy is booming, with no incipient recession apparent in at least the next few quarters; inflation remains subdued.

The explanation is that an unemployment rate of 3.7%, which long signaled a job market as tight as a drumhead, just isn't as low as it used to be. "The 3.7% rate overstates the true strength of the labor market," says Peter Ireland, a Boston College economics professor and former Fed researcher. "Things are good but not that good." The reasons for this shift will have implications for the economy in several ways for years to come.

Pay is supposed to be rising smartly because, at 3.7% unemployment, practically everyone who wants a job has got one, with the few jobless workers reflecting mainly the "frictional" unemployment of those briefly between jobs. But this time another factor is in the mix: an unusually large number of people who aren't working or looking for work, so they aren't counted as unemployed, but who *could* rejoin the labor force if they saw the right opportunity. Among Americans of prime working age, 25 to 54, some 29 million aren't working or looking for work, but many of them are waiting just offstage. "The labor force participation rate of prime-age workers is still way below its peak in the last expansion," says Mickey Levy, an economist at Berenberg Capital Markets and an adviser to several Federal Reserve banks. That means the labor market holds more slack than it seems to. One result: Upward pressure on wages isn't as strong as we'd expect.

Plus, "an unemployment level consistent with a healthy, fully recovered economy is lower than it used to be because of demographic changes," says Adam Ozimek, a senior economist at Moody's Analytics. The average age of the workforce, like that of the overall population, is rising, and older people are more likely than younger ones to have jobs. The population is also better educated—34% of Americans over age 25 have completed four years of college or more vs. just 28% before the last recession—and the highly educated are more likely to be employed. Lower unemployment is becoming a new normal.

So it's clear why inflation isn't accelerating the way previous economic models would have predicted: The hidden slack in the labor market is moderating upward pressure on wages and thus prices—consumer prices rose a measly 0.1% in September—even as the economy expands at the fastest pace in years. That's not great news, of course, if you hold a middle-income job in a pricey market like San Francisco.

The biggest worry arising from 3.7% unemployment is that it may signal an imminent recession. The last time the rate was this low—October 1969—a recession started two months later, and every recession since has been preceded by an unemployment trough. To economic historians, this moment looks scary.

But history isn't an oracle. Given the evolving makeup of today's labor force, unemployment rates aren't comparable with those of past decades. They could go even lower; the Congressional Budget Office forecasts that by next year's fourth quarter, unemployment will be just 3.3% with the economy still growing.

"We're at the top of the cycle," Fed chairman Jerome Powell acknowledged recently, and the next recession is lurking out there, maybe nearby. External shocks—a worsening trade war, regional conflict, some type of corporate debt crisis—could always stop growth in its tracks. Yet there's a plausible argument for substantially more growth. Levy agrees: "There are several million more jobs we can add before hitting the upper limit."

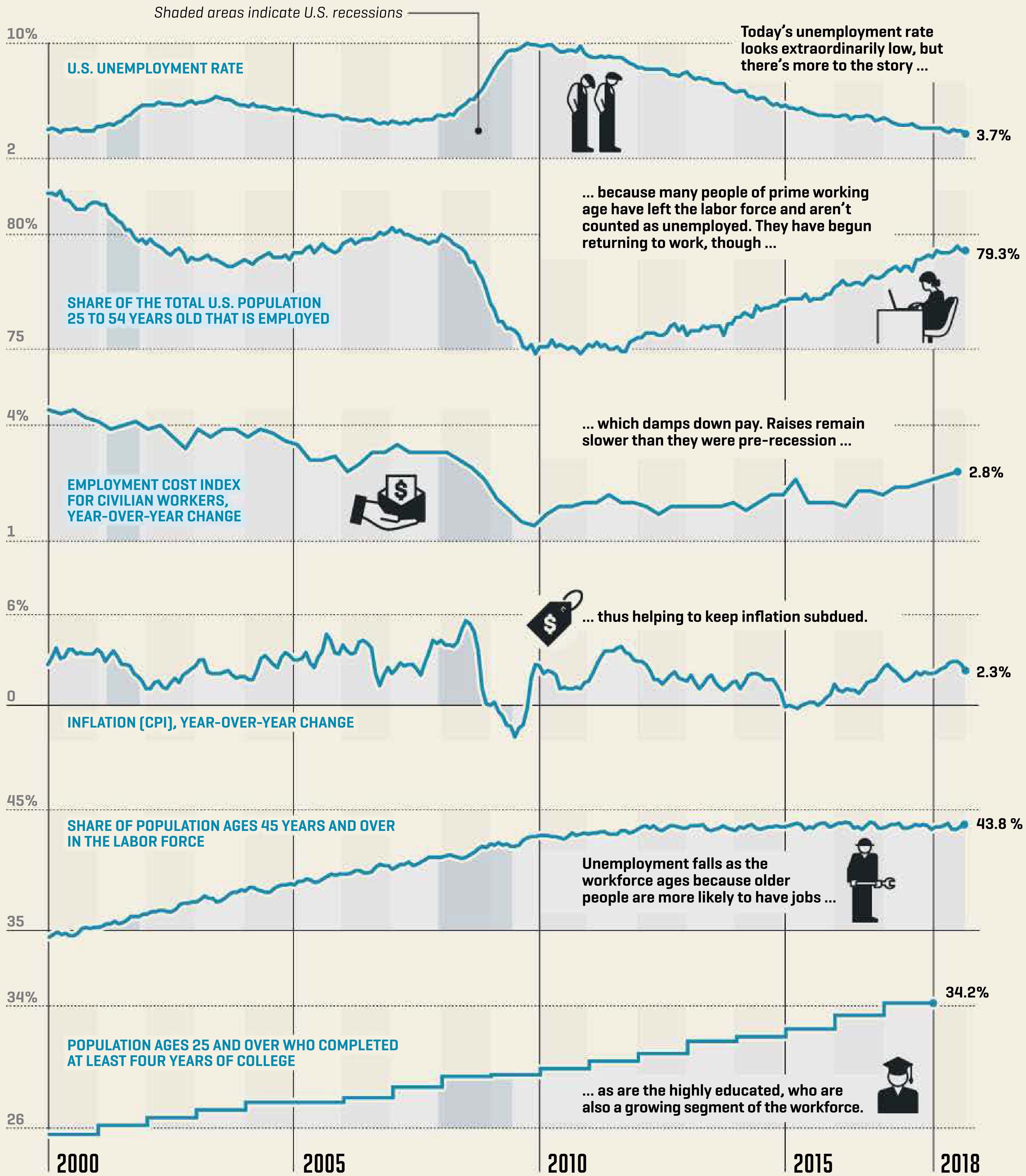
Unemployment at 3.7% is less exciting than it used to be. On the whole, that's a good thing.

BUILD-UP: 278,000 manufacturing jobs have been filled in the past 12 months.

© BRYAN ANSELM—THE REDUX

ANALYTICS Seeing Trends in the Data

The unemployment rate doesn't mean what it used to, as tectonic forces reshape the labor market. The good news: Today's 3.7% rate, once considered alarmingly low, may not signal inflation or a recession as strongly as before. The bad news: Neither does it signal such a tight jobs market, so pay raises will likely remain only moderate. —*G.C.*



GRAPHICS BY **NICOLAS RAPP**

SOURCES: BUREAU OF LABOR STATISTICS; CENSUS BUREAU

RETAIL

Christmas Without Toys 'R' Us

Who will move in to fill the space under your tree?

By Phil Wahba

THE UPCOMING holiday season will be the first one in decades without Toys "R" Us around, leaving about $4 billion in sales up for grabs. Any retailer who wants a chunk of that will need to move fast: According to the National Retail Federation, 30% of toy sales happen in November and December.

Walmart, already the nation's biggest toy seller, said it will increase its holiday selection by 30% in stores and 40% online. The chain has already picked up 26% of what would have been Toys "R" Us business this year, according to one analyst. Target will open 500 mini toy shops in its stores and double the number of exclusive toys it carries. And of course, Amazon is already touting its selection.

The battle is also prompting retailers not known for toys to be more aggressive this year. Kohl's is bringing in brands like FAO Schwartz and Lego, and Party City will open 50 pop-up shops for the holiday season. Who can blame them? NPD Group says toy sales are up 7% in 2018, and with the year's biggest prize still in front of them, it's easy to see why retailers are going all out to stuff your kid's stocking this season.

#METOO

TIME'S UP GETS CEO, EXPANDS MISSION

IT'S NOT JUST a slogan on a pin. Time's Up will be taking on paid family leave, pregnancy discrimination, and more as the anti-sexual-harassment organization comes out of stealth mode. The nonprofit—founded in the wake of sexual assault allegations against Harvey Weinstein—just brought on its first president and CEO: Lisa Borders, a Coca-Cola veteran and until October president of the WNBA. Under Borders' leadership, Time's Up will move beyond Hollywood to push for reform in industries including venture capital, advertising, and health care. The legal defense fund that for months was the organization's only public project has worked with 3,500 people who faced sexual harassment and retaliation. It also distributed $750,000 in grants to other nonprofits for workers and domestic violence victims. "I would frame this as the civil rights movement of the 21st century," Borders says.

—EMMA HINCHLIFFE

"THIS IS THE CIVIL RIGHTS MOVEMENT OF THE 21ST CENTURY."

BOX: BAURIZIO CIGOGNETTI—GETTY IMAGES; BORDERS: TAYLOR BALLANTYNE—SPORTS ILLUSTRATED/GETTY IMAGES

This Vaccine CEO Doesn't Get a Flu Shot. Should You?

America spends $1.8 billion on flu shots every year. Are they worth it?

By Sy Mukherjee

PUBLIC HEALTH

AT FORTUNE'S recent Most Powerful Women Summit, the CEO of an Alzheimer's vaccine company made a striking statement about flu shots: She doesn't always get one. Asked whether she's optimistic that a successful Alzheimer's vaccine would gain widespread use given that Americans aren't exactly great at getting their flu shots—United Neuroscience chief Mei Mei Hu pointed out that flu vaccines "aren't very effective."

The data shows that plenty of Americans feel the same way. In fact, less than 40% of people old enough to get a flu shot got one in fall 2017, according to the Centers for Disease Control (CDC).

Perhaps that's not surprising, given that flu vaccine effectiveness oscillates wildly from year to year. Since 2004, the vaccine's efficacy has ranged from 10% to a high of 60%. Last year's flu shot was about 40% effective, although the number of hospitalizations related to the flu spiked sharply.

Public health officials insist that everyone 6 months of age and older should get a seasonal flu shot, since it's the most reliable method of preventing transmission. The elderly and young children are most at risk. The vaccine's effectiveness varies because batches have to be made before the flu season begins, meaning it's essentially a guessing game for scientists. But even if you're not at high risk for contracting the infection, health experts point out that it's still important to get a shot in order to preserve "herd immunity"—or having enough people inoculated against the flu to minimize the risk of passing it on to more vulnerable people.

PAGE 5

FILL UP NOW

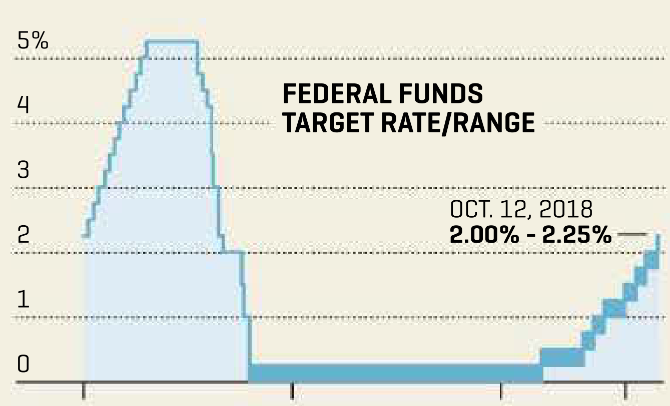
A PINCH AT THE PUMP IN 2019

WE'VE BEEN FILL-ing up our SUVs for under $50 for the past three years, as prices for crude have hovered between $50 and $60 per barrel. No more. Despite President Trump's UN speech imploring OPEC to increase output, traders are expecting sanctions on Iran will result in the cartel delivering significantly fewer barrels in the last quarter of 2018, pushing crude to $100 in early 2019. Another wrench: Saudi Arabia, usually an ally in OPEC, could use oil prices as a defense against sanctions related to the death of journalist Jamal Khashoggi.

CHEAP MONEY

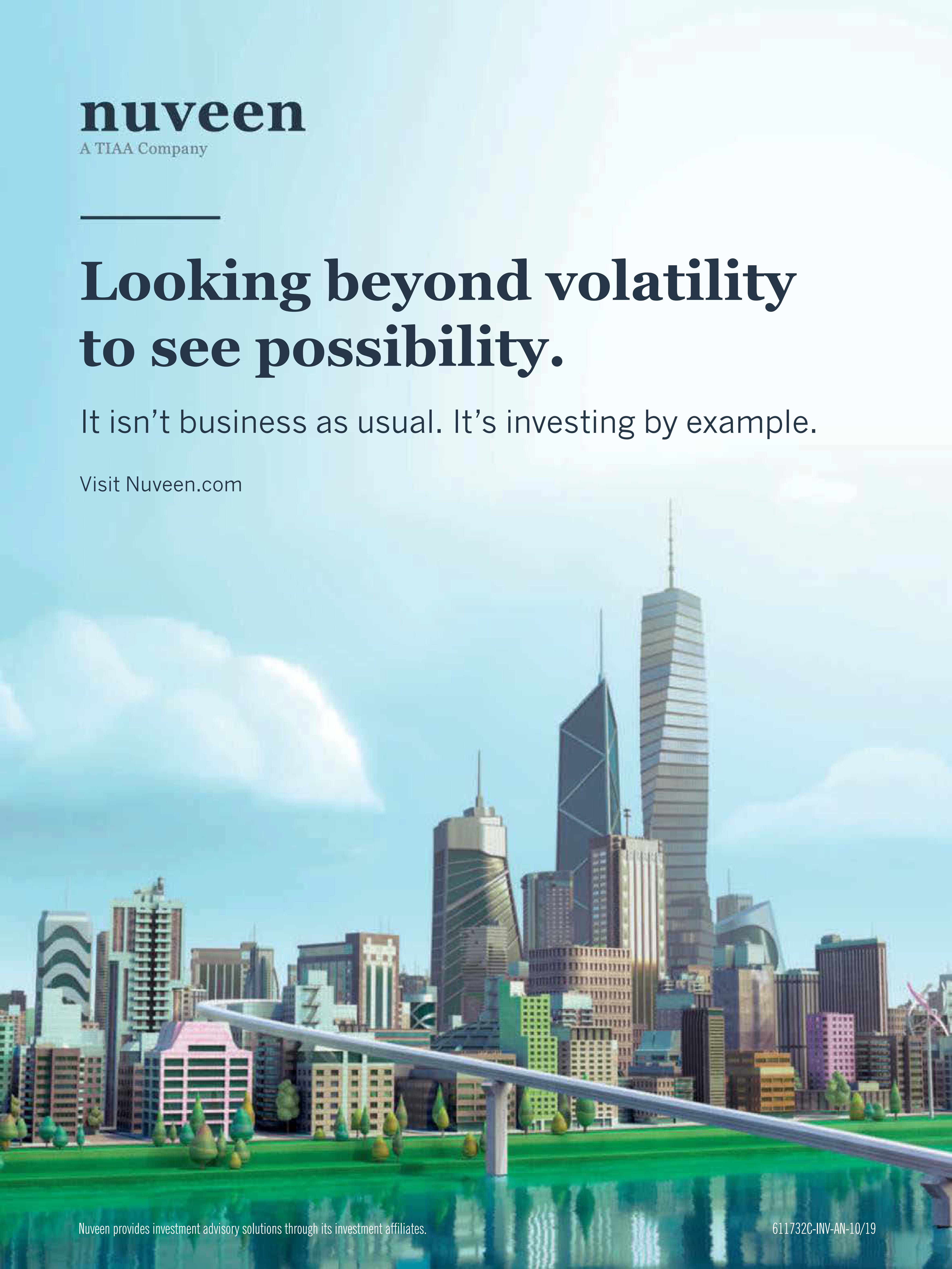
THE POLITICIZED FED SPARKS YELLEN'S CONCERN

JEROME POWELL is feeling the heat after increasing interest rates in September, a move that brought fierce criticism from the President who appointed him as Federal Reserve chair. His predecessor, Janet Yellen, has sounded a warning on the White House criticizing monetary policy, recounting that Bill Clinton was inclined to comment on Alan Greenspan raising rates in 1994 before being talked out of it. "There's no law against it," she said. "But I don't think it's wise."
—**DANIEL BENTLEY**



SOURCE: FEDERAL RESERVE

SYRINGE: TS PHOTOGRAPHY—GETTY IMAGES; GAS NOZZLE: STEVE MCALISTER—GETTY IMAGES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WILD-FIRES

$10B

INSURED LOSSES FROM WILDFIRES IN OCTOBER 2017

California's Tubbs Fire in October 2017 was the most destructive in the state's history. Insurers and public safety officials see it as a taste of things to come.

+77%

INCREASE IN AREA BURNED BY 2100

California's Fourth Climate Change Assessment, a compilation of state-funded research, projects a massive increase in affected areas.

+18%

PREMIUM INCREASE

Residents in areas at risk for wildfires could see double-digit insurance premium increases by 2055, according to the assessment.

—RADHIKA MARYA

Facebook Portal has Amazon's Alexa voice assistant built in.

Facebook's Poorly Timed Gadget Play

The company lost your private data. Now it wants to put a camera in your home.

By Jonathan Vanian

HOME TECH

FACEBOOK couldn't have picked a worse time to unveil its first consumer gadget for the home, an Internet-connected video calling device dubbed Portal.

Just a little over a week prior to Facebook's milestone release of the Portal, the social networking giant announced it had suffered a major hack. Facebook initially believed up to 50 million people were impacted; it later reduced that figure to 30 million but said personal data like email addresses and phone numbers may have been compromised.

The hack comes roughly six months after Facebook's calamitous Cambridge Analytica scandal, which had dinged the company's reputation, raising concerns over how the company safeguards its data.

But as Facebook executives told *Fortune*, the company couldn't afford to be picky about timing. It needed to release the Portal in time for the upcoming holiday season. Any later and Facebook risks being further behind Google, Amazon, and Apple, which have spent the past few years releasing "smart speakers," television controllers, and web-connected household gadgets. (For more, see "It Might Get Loud," on page 112.)

Facebook is emphasizing privacy controls with Portal. It said the device doesn't record calls, and people have to manually turn on the camera. If people are extra scared about their Mark Zuckerberg–approved gadget suddenly turning on and recording their household movements, they can slip on a small plastic latch to cover the camera—a decidedly low-tech approach to appease those concerned.

FOR ADULTS WITH UNCONTROLLED MODERATE-TO-SEVERE **ECZEMA** (ATOPIC DERMATITIS)

Jennifer W., actual DUPIXENT patient. Individual results may vary.

DUPIXENT®
(dupilumab) Injection 300mg

HELP HEAL YOUR SKIN FROM WITHIN

DUPIXENT IS THE FIRST ECZEMA TREATMENT OF ITS KIND

DUPIXENT is not a steroid. It is a biologic treatment that helps manage the inflammation deep beneath the surface that causes the flare-ups you see and feel on your skin–and keeps working, even when your skin looks clear.

In Two Clinical Trials with DUPIXENT*:

- Nearly half of patients saw 75% skin improvement and some even saw 90% improvement
- Almost 4 times more patients taking DUPIXENT saw clear or almost clear skin as compared with those not taking DUPIXENT
  - 37% taking DUPIXENT as compared with 10% not taking DUPIXENT
- Patients experienced significant itch reduction, some patients as early as 2 weeks

*16-week trials compared to placebo.

Learn more. Talk to your eczema specialist. Visit DUPIXENT.com, or call 1-844-DUPIXENT (1-844-387-4936).

INDICATION

DUPIXENT is a prescription medicine used to treat adult patients with moderate-to-severe atopic dermatitis (eczema) that is not well controlled with prescription therapies used on the skin (topical), or who cannot use topical therapies. DUPIXENT can be used with or without topical corticosteroids. It is not known if DUPIXENT is safe and effective in children.

IMPORTANT SAFETY INFORMATION

Do not use if you are allergic to dupilumab or to any of the ingredients in DUPIXENT.

Before using DUPIXENT, tell your healthcare provider about all your medical conditions, including if you:

- have eye problems
- have a parasitic (helminth) infection
- have asthma
- are scheduled to receive any vaccinations. You should not receive a "live vaccine" if you are treated with DUPIXENT.
- are pregnant or plan to become pregnant. It is not known whether DUPIXENT will harm your unborn baby.
- are breastfeeding or plan to breastfeed. It is not known whether DUPIXENT passes into your breast milk.

Tell your healthcare provider about all the medicines you take, including prescription and over-the-counter medicines, vitamins and herbal supplements. If you have asthma and are taking asthma medicines, do not change or stop your asthma medicine without talking to your healthcare provider.

DUPIXENT can cause serious side effects, including:

- **Allergic reactions.** Stop using DUPIXENT and go to the nearest hospital emergency room if you get any of the following symptoms: fever, general ill feeling, swollen lymph nodes, hives, itching, joint pain, or skin rash.
- **Eye problems.** Tell your healthcare provider if you have any new or worsening eye problems, including eye pain or changes in vision.

The most common side effects include injection site reactions, eye and eyelid inflammation, including redness, swelling and itching, and cold sores in your mouth or on your lips.

Tell your healthcare provider if you have any side effect that bothers you or that does not go away. These are not all the possible side effects of DUPIXENT. Call your doctor for medical advice about side effects. You are encouraged to report negative side effects of prescription drugs to the FDA.

Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

Use DUPIXENT exactly as prescribed. If your healthcare provider decides that you or a caregiver can give DUPIXENT injections, you or your caregiver should receive training on the right way to prepare and inject DUPIXENT. **Do not** try to inject DUPIXENT until you have been shown the right way by your healthcare provider.

Please see accompanying Brief Summary on next page.

SANOFI GENZYME REGENERON

You may be eligible for a $0 copay† for DUPIXENT. †Limitations apply. Visit DUPIXENT.com for full program terms.

Summary of Information about DUPIXENT® (dupilumab) Rx Only
(DU-pix'-ent)
Injection, for Subcutaneous Use

What is DUPIXENT?

- DUPIXENT is a prescription medicine used to treat adults with moderate-to-severe atopic dermatitis (eczema) that is not well controlled with prescription therapies used on the skin (topical), or who cannot use topical therapies.
- DUPIXENT can be used with or without topical corticosteroids.
- It is not known if DUPIXENT is safe and effective in children.

Who should not use DUPIXENT?

Do not use DUPIXENT if you are allergic to dupilumab or to any of the ingredients in DUPIXENT. See the end of this summary of information for a complete list of ingredients in DUPIXENT.

What should I tell my healthcare provider before using DUPIXENT?

Before using DUPIXENT, tell your healthcare provider about all your medical conditions, including if you:

- have eye problems
- have a parasitic (helminth) infection
- have asthma
- are scheduled to receive any vaccinations. You should not receive a "live vaccine" if you are treated with DUPIXENT.
- are pregnant or plan to become pregnant. It is not known whether DUPIXENT will harm your unborn baby.
- are breastfeeding or plan to breastfeed. It is not known whether DUPIXENT passes into your breast milk.

Tell your healthcare provider about all of the medicines you take including prescription and over-the-counter medicines, vitamins, and herbal supplements. If you have asthma and are taking asthma medicines, do not change or stop your asthma medicine without talking to your healthcare provider.

How should I use DUPIXENT?

- **See the detailed "Instructions for Use" that comes with DUPIXENT for information on how to prepare and inject DUPIXENT and how to properly store and throw away (dispose of) used DUPIXENT pre-filled syringes.**
- Use DUPIXENT exactly as prescribed by your healthcare provider.
- DUPIXENT comes as a single-dose pre-filled syringe with needle shield.
- DUPIXENT is given as an injection under the skin (subcutaneous injection).
- If your healthcare provider decides that you or a caregiver can give the injections of DUPIXENT, you or your caregiver should receive training on the right way to prepare and inject DUPIXENT. **Do not** try to inject DUPIXENT until you have been shown the right way by your healthcare provider.
- If you miss a dose of DUPIXENT, give the injection within 7 days from the missed dose, then continue with the original schedule. If the missed dose is not given within 7 days, wait until the next scheduled dose to give your DUPIXENT injection.
- If you inject more DUPIXENT than prescribed, call your healthcare provider right away.
- Your healthcare provider may prescribe other topical medicines to use with DUPIXENT. Use other prescribed topical medicines exactly as your healthcare provider tells you to.

What are the possible side effects of DUPIXENT?
DUPIXENT can cause serious side effects, including:

- **Allergic reactions.** Stop using DUPIXENT and go to the nearest hospital emergency room if you get any of the following symptoms: fever, general ill feeling, swollen lymph nodes, hives, itching, joint pain, or skin rash.
- **Eye problems.** Tell your healthcare provider if you have any new or worsening eye problems, including eye pain or changes in vision.

The most common side effects of DUPIXENT include: injection site reactions, eye and eyelid inflammation, including redness, swelling, and itching, or cold sores in your mouth or on your lips
Tell your healthcare provider if you have any side effect that bothers you or that does not go away.
These are not all of the possible side effects of DUPIXENT. Call your doctor for medical advice about side effects. You may report side effects to FDA 1-800-FDA-1088.

General information about the safe and effective use of DUPIXENT.

Medicines are sometimes prescribed for purposes other than those listed in a Patient Information leaflet. Do not use DUPIXENT for a condition for which it was not prescribed. Do not give DUPIXENT to other people, even if they have the same symptoms that you have. It may harm them.
This is a summary of the most important information about DUPIXENT. If you would like more information, talk with your healthcare provider. You can ask your pharmacist or healthcare provider for more information about DUPIXENT that is written for healthcare professionals.
For more information about DUPIXENT, go to www.DUPIXENT.com or call 1-844-DUPIXENT (1-844-387-4936)

What are the ingredients in DUPIXENT?

Active ingredient: dupilumab
Inactive ingredients: L-arginine hydrochloride, L-histidine, polysorbate 80, sodium acetate, sucrose, and water for injection

Manufactured by: Regeneron Pharmaceuticals, Inc., Tarrytown, NY 10591 U.S. License # 1760; Marketed by sanofi-aventis U.S. LLC, (Bridgewater, NJ 08807) and Regeneron Pharmaceuticals, Inc. (Tarrytown, NY 10591) / DUPIXENT is a registered trademark of Sanofi Biotechnology / Issue Date: April 2017

ART LIFE

BANKSY SHREDS PAINTING, CREATES NEW MASTERPIECE

BANKSY isn't the first artist to destroy his own work, but he's the first to do so after an auction sale in excess of $1 million. Sotheby's auction of *Girl with Balloon* went viral when a device built into its frame shredded the canvas after the hammer went down. Banksy's representatives reauthenticated the 2006 stencil and said it is now called *Love Is in the Bin* (2018), indicating that the shredder created a new work. It's also an acknowledgment that the painting was hardly "destroyed." Experts say the stunt doubled its value.

Netflix's *Narnia* will go toe-to-toe with HBO's *Game of Thrones* and Amazon's *Lord of the Rings* series.

Netflix Looks in the Wardrobe to Find a Fantasy Hit

Tales of myth make the big bucks. By Aric Jenkins

STREAMING

MOVE OVER, *Game of Thrones*, there's a new fantasy series in town—though the latest adaptation isn't exactly new but rather a beloved classic. Netflix in October signed a multiyear deal acquiring the rights to C.S. Lewis's *Chronicles of Narnia* book series, a step in the streaming giant's plans to develop a TV series and set of movies. It's the first time the entire *Narnia* catalog, which includes *The Lion, the Witch, and the Wardrobe*, has been held by a sole company.

Netflix now has an iconic fantasy franchise to match HBO's prestige Emmy winner. The deal also shores up its defense against Amazon's upcoming *Lord of the Rings* series, slated to begin production in 2020. But Netflix's rivals won't go down without a fight. AT&T's newly rebranded WarnerMedia recently announced plans to launch a streaming service combining its film and television properties—which include HBO—by late next year. Amazon is said to be investing close to $1 billion in its J.R.R. Tolkien universe. Of course, Prince Caspian, Aslan, & Co. aren't exactly scrubs either. *Narnia*'s three film adaptations, distributed by Disney and 20th Century Fox, have grossed more than $1.5 billion worldwide to date.

Making MINDS MATTER

With a focus on innovation and discovery, Samsung is driving the advancement of neural networks and shaping the future of AI.

SAMSUNG ELECTRONICS IS no stranger to making bold bets on new research. The company, which spends roughly 7% of revenue on R&D every year, announced in August a new initiative in the field of artificial intelligence (AI). From opening up new research centers around the world to recruiting top-notch experts in the field, the company is slated to invest billions of dollars over the next three years in fueling the advancement of AI.

As part of the initiative, Samsung hired Dr. Sebastian Seung of Princeton University as its Chief Research Scientist earlier this year. Dr. Seung, a world-renowned AI scientist and professor of neuroscience and computer science, will help lead Samsung's global R&D efforts to pursue its ambitions in AI.

Dr. Seung says some of his colleagues were surprised by his interest in industrial research after spending 20 years as a university professor. "They probably don't know I started my career at a storied industrial research organization, Bell Laboratories, and have great nostalgia for that era of my life."

Originally schooled in the esoteric discipline of theoretical physics, it wasn't until after beginning his career at Bell Labs that Seung learned the importance of grappling with "real world" challenges. "It is often said 'Art' lives from constraints and dies from freedom,'" he says. "Just substitute the word 'research' for 'art' and you will understand the vitality of industrial research."

As AI continues to become more sophisticated, its applications to drive innovation are endless. There are even those who worry about robots becoming conscious and taking over the world. "But the hype has run far ahead of reality," Dr. Seung says. "Why can't I buy a robot that picks up my children's toys and puts them away? I'd pay a lot for such a helper. It doesn't even have to be conscious."

Such robots don't exist yet, and creating them will require fundamental advances in AI. "The complexity and messiness of real households are powerful constraints that keep research from going stale," he says. "AI that can come home to pick up toys is far more interesting to me than one that hides only in virtual worlds."

That's where "deep learning" and "neural networks" come in. "Deep learning," now the dominant approach to AI, is based on "neural networks," which were invented decades ago as mathematical models of the brain. Exciting recent advances in AI, such as computers that can accurately recognize objects by sight or play games of strategy like Go, are based on convolutional networks, a particular kind of neural network that was originally inspired by Nobel Prize-winning brain research in the 1960s.

"Today, the pace of discovery is accelerating in neuroscience, and our improved understanding of the brain is bound to have an impact on AI in the future," says Seung. "From fundamental questions about our brains and ourselves to technologies and products that are revolutionizing the way we live, AI has given rise to a new golden age of industrial research."

In these exciting times, Samsung is laying the foundation for new products and services that depend on AI to create experiences that are accessible, meaningful, and delightful.

Samsung is a well-known consumer electronics brand, selling more than 500 million products annually—ranging from smartphones and televisions to washing machines, air conditioners, chipsets, and even 5G technology. With AI spanning all layers of the organization—from services and software to hardware and chips—the company has the potential to become the most vertically integrated AI company in the industry.

Dr. Geunbae Lee, who heads the Samsung AI Center in Korea, says that this product portfolio, open platform, and business scale allow Samsung to offer AI experiences that are more accessible, inclusive, effortless, and—most importantly—user-centric. "If it's not continuously learning, personal, and relevant, artificial intelligence will remain artificial," he says. "This is another major benefit of a multidevice ecosystem—AI has more chances to learn through multiple points of interaction."

"The AI centers are already enhancing our culture of innovation and attracting young talent to Samsung," Seung adds. "We're at the start of a great adventure, and we at Samsung know the importance of research for realizing the promise of AI," he says.

SEBASTIAN SEUNG is Chief Research Scientist at Samsung Research and a professor at Princeton University. Seung previously studied at Harvard University, worked at Bell Laboratories, and taught at the Massachusetts Institute of Technology. He is an External Member of the Max Planck Society and the winner of the 2008 Ho-Am Prize in Engineering.

About Samsung Research

Samsung Research is the advanced research & development hub of Samsung's Consumer Electronics (CE) Division and IT & Mobile Communications (IM) Division, and it leads the development of future technologies with 22 R&D centers in 15 countries, six AI research centers in five countries, and 20,000 researchers around the globe.

With a pivotal role in maximizing synergy from technological convergence and securing state-of-the-art technologies, Samsung Research actively conducts research to identify new future growth areas for the company, creating new value to improve people's lives.

Core research themes include artificial intelligence, data intelligence, Internet of Things, Tizen, smart machine, security, and next generation media through collaboration with worldwide universities, research institutes, and partner companies. Samsung Research aims to reach its goal to "Shape the Future with Innovation and Intelligence" together.

For more information, please visit **research.samsung.com.**

SAMSUNG

Mark Devlin catches Bird scooters in Venice, Calif., on Oct. 10, 2018.

MEET TECH'S NEW BOUNTY HUNTERS

Some are called "Bird Chargers." Others, "Lime Juicers." Together they are the human engine powering the booming, multibillion-dollar electric scooter business. By Lucinda Shen ▷▷

▲ PHOTOGRAPHS BY **JOE TORENO**

▷▷ **AROUND FOUR O'CLOCK IN THE AFTERNOON,** well before the sun begins to set on the seaside city of Santa Monica, Mark Devlin hits the streets in search of electric scooters on life support. The wireless, dockless devices are wildly popular here, propped up on seemingly every corner of town in bright red, pink, black, or green. But humans must take them off-line to charge them. By late afternoon, there are usually a few here and there that have fallen below a functioning battery threshold. So Devlin goes hunting.

"You have to watch the Birds, see where they go, and see where they have congregated," Devlin, 57, says. "Then I strategize what my night is going to look like."

The real action starts after sundown. Many of the scooters, provided by at least four companies including Bird, Lime, Lyft, and Uber, deactivate at 9 p.m., when the services shut down for the night. So at 8 p.m., Devlin parks the U-Haul truck he rents for the occasion next to the largest flock he can find—to "preclaim them," he says—and waits.

At the stroke of nine, Devlin kicks into gear. He homes in on a flock of Birds using the app on his mobile phone, tosses each one into his truck, and makes his way to the next location—only to find that another charger (or "Juicer," as they're known for Lime) has seized the spoils. No sweat; Devlin moves on. At another scooter gathering, Devlin sprints, successfully claiming one mere seconds before another charger. By 10 o'clock, streets once flush with scooters are swept clean.

Devlin, by day a stage designer for rock acts like Metallica and Judas Priest, makes about $200 to $300 a night (at $5 to $20 per scooter), picking up between 40 and 60 scooters for recharging as part of Bird and Lime's bounty system for retrieval. The nightly gig helps pay the bills for his family of four and allows him to be his own boss. "I'm actually making more money doing this than what my chosen job is willing to pay," he says. "The instant gratification—it gets addictive."

Without a garage at home, Devlin charges scooters in his living room, half of which has been converted into a charging station. His wife doesn't love the new decor, but "she really likes what picking up 60 Birds is doing to my body," Devlin says with a chuckle. (Each scooter weighs 20 pounds or more.) Twelve hours later, he's back on the street to deposit his catch at an official drop spot—a "Bird Nest."

TECH

Using a rented truck, Devlin transports scooters to his home for recharging overnight.

Hundreds of millions of dollars raised, billions of dollars in value—to say that the humble electric scooter has taken Silicon Valley and its sister to the south, Silicon Beach, by storm is an understatement. Santa Monica has authorized 2,000 motorized scooters as part of a new pilot program to solve the "last mile" of local journeys; San Francisco has green-lit 2,500 as part of its own effort. And e-scooters are appearing in cities across the nation including Atlanta, Baltimore, Denver, Detroit, Indianapolis, Miami, and St. Louis.

The logistics companies behind these electric scooters are valued like software startups, but many rely heavily on hardware and an army of independent contractors like Devlin to maintain their fleet. Without the help ▷▷

▷▷ of freelance workers, some of these billion-dollar businesses would fold. But the job, if not the entire business, is still in its infancy, and its effects on the local community remain to be seen. Under cover of night, scooter chargers compete with one another in a gamified gig for which the rules are hazy at best.

Some scooter chargers have faced violence. Devlin, for example, says he called the police after he was physically and verbally assaulted by a fellow charger who believed Devlin was gaming the system. Deedee Deschanel, a 29-year-old video producer, wears a bulletproof vest stocked with pepper spray when he goes Bird hunting on Saturday nights in Santa Monica. "You never know," he says.

And for women like Brooke Thompson, who goes out at night, often alone, with a minivan to pick up scooters in the beach town, the darker hours can be daunting. She says she's been catcalled, even stalked, on the job in the wee hours of the morning. "It's fun being out," she says, "but as a woman, I'm a bit more vulnerable too."

Electric scooters are a mixed bag for the cities in which they are deployed. Though many riders appreciate them, some residents are less keen, seeing them as an eyesore and a nuisance. The companies' launch tactics have also drawn scrutiny. In Santa Monica, Bird burst on the scene in 2017—the company is headquartered there—without permission from the local government. The city eventually sued; Bird agreed to pay a $300,000 fine. Even today, the anger over the incident hasn't entirely abated; on a recent stroll in Santa Monica, a Bird scooter was vandalized to read "TURD."

Thompson says she's felt the heat firsthand. She's received glares, snide remarks, and complaints about Bird when she's out collecting scooters for money. Devlin's 11-year-old son avoided telling friends that his father participated in Bird's scooter bounty program; the name has "a certain amount of negativity," the father says. "It's like saying, 'My dad works at the DMV.'"

"We found that Juicers enjoy the flexibility of an hour or two of work in the evening and working in the morning," says Colin McMahon, who leads Lime's Juicer program. He adds that the company correlates its supply of Juicers with demand for its scooters in a given community. As for Bird, a spokesperson says the company's program can be a "great source" of supplemental income for its freelance chargers.

Unlike Bird and Lime, Lyft—which only deployed its Santa Monica fleet of electric scooters in September—uses full-time employees for recharging. It does help reduce some of the competitiveness, says Caroline Samponaro, head of bike, scooter, and pedestrian policy at the San Francisco company: "We can't control operational excellence if we aren't in control."

Which charging system is better, and which startup will prevail in the Great Scooter Wars of 2018 and beyond? Ask the chargers themselves, and the bigger picture becomes clear.

"There's no doubt that Bird chargers won't exist in the near future," says Devlin, pointing to the inevitability of technological progress. "But I don't know that I'll ever retire. I love working. I hope I never have to stop."

ELECTRIC SCOOTERS … BY THE NUMBERS

Six things you need to know about an explosive new logistics business that's sweeping across the globe. —L.S.

$3.1B
The combined valuation of Bird and Lime, which together have raised $882 million in funding

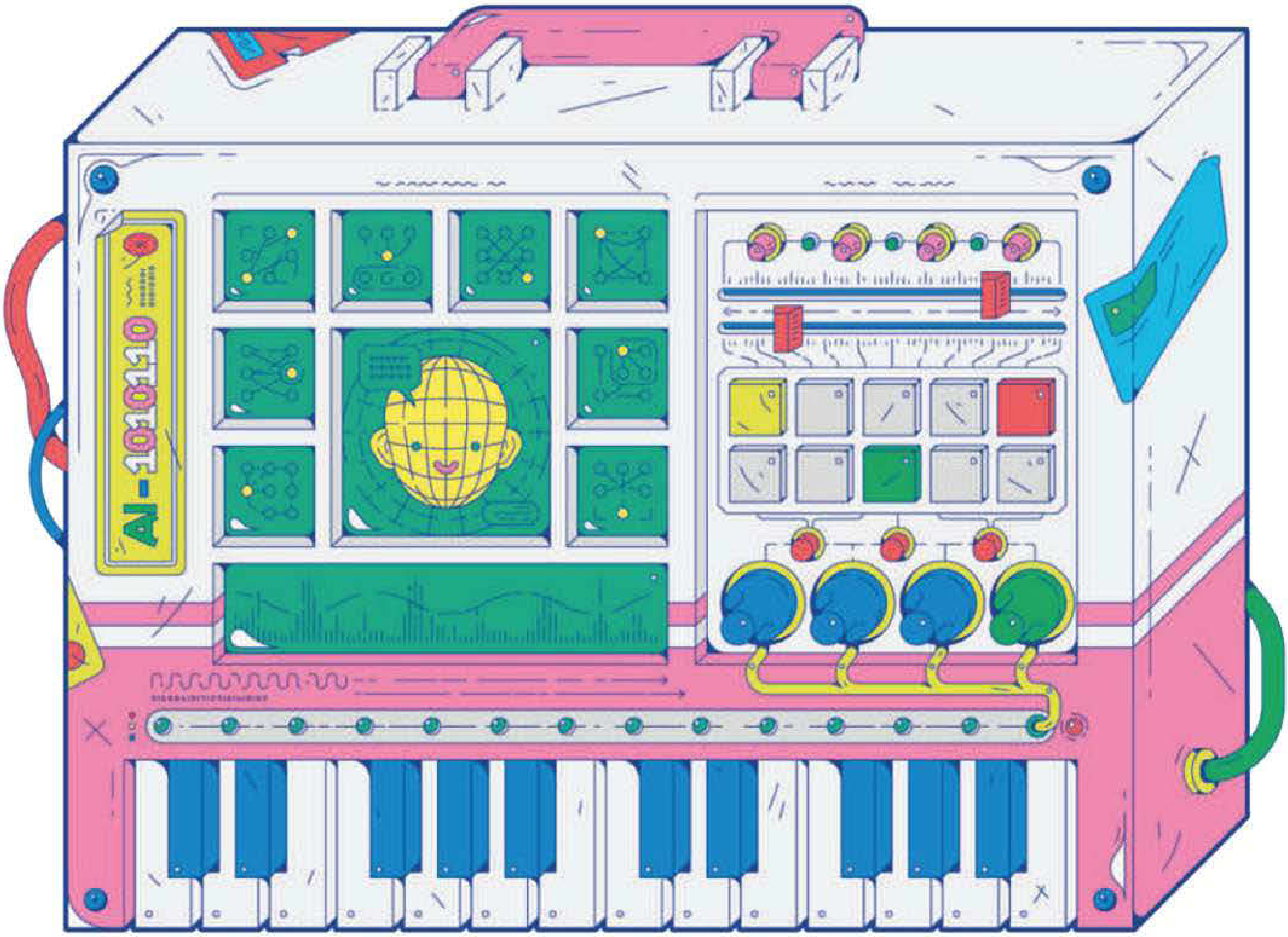
10,000
Number of Juicers, in 42 cities and counting, who have signed up to charge Lime scooters for money

70%
U.S. city slickers who have a positive outlook on electric scooters, according to a survey by Populus

14.3M
Miles traveled by Bird riders (during 10 million rides) as of the company's first anniversary

1,263
Citations issued to e-scooter riders, across more than 15,000 stops, by the Santa Monica Police Department in 2018 to date

1
Number of known e-scooter fatalities (a Dallas man died after falling sans helmet from a Lime scooter, according to police).



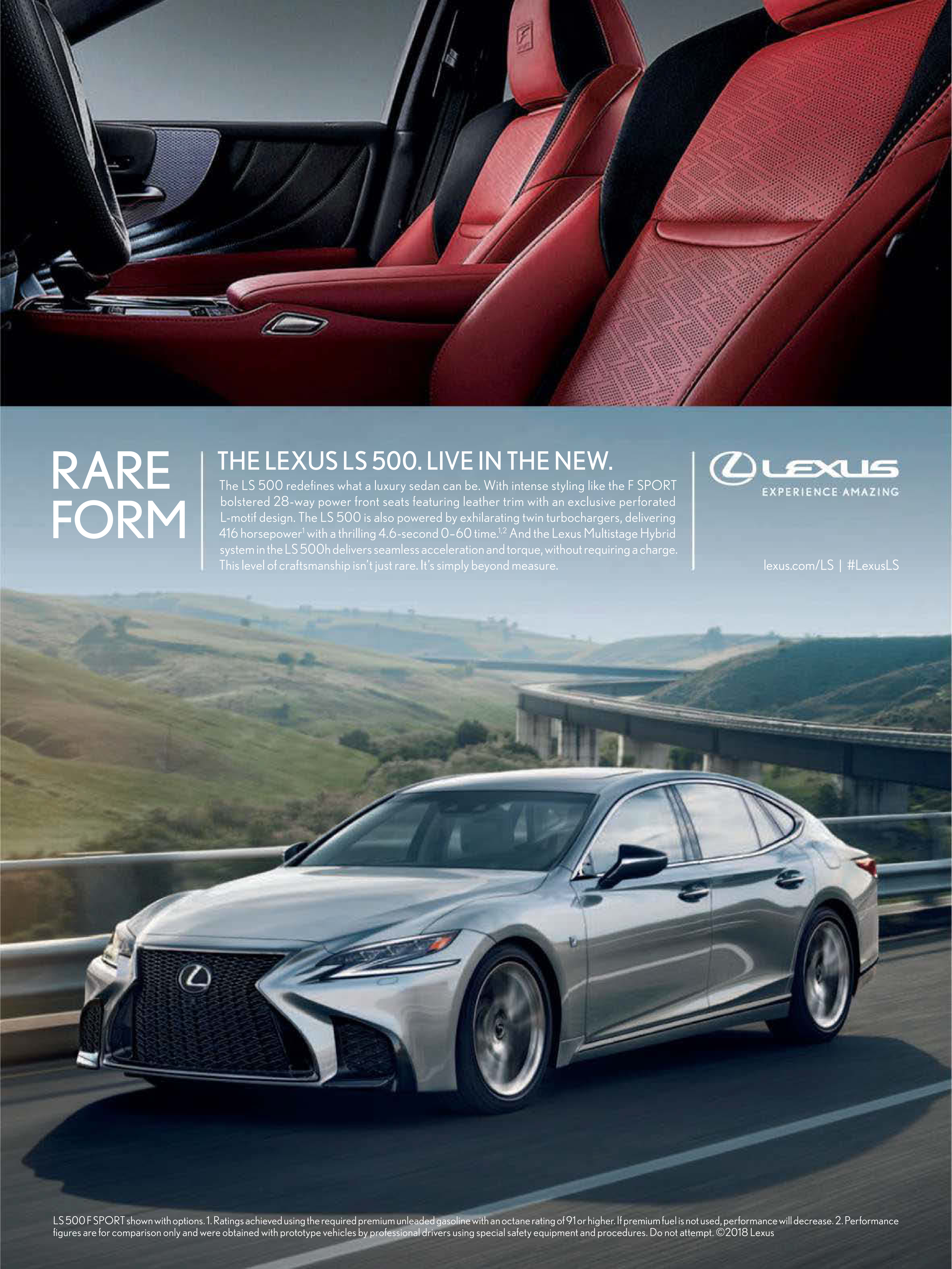
A.I. SONGWRITING HAS ARRIVED. DON'T PANIC

Welcome to the next great debate about the legitimacy of creativity. **By Dan Reilly**

"IT'S CHEATING." That's the response you'll hear from self-proclaimed music purists talking about technological innovation in song creation. Sampling, synthesizers, drum machines, Auto-Tune—all have been derided as lazy ways to make chart-topping hits because they take away the human element. (With apologies to Vanilla Ice, Gary Numan, Prince, and T-Pain.)

The new argument among fans and musicians will be about the use of artificial intelligence in songwriting. According to several estimates, in the next decade, between 20% and 30% of the top 40 singles will be written partially or totally with machine-learning ▷▷

▲ ILLUSTRATION BY **AARON FERNANDEZ**


RARE FORM
THE LEXUS LS 500. LIVE IN THE NEW.
The LS 500 redefines what a luxury sedan can be. With intense styling like the F SPORT bolstered 28-way power front seats featuring leather trim with an exclusive perforated L-motif design. The LS 500 is also powered by exhilarating twin turbochargers, delivering 416 horsepower[1] with a thrilling 4.6-second 0–60 time.[1,2] And the Lexus Multistage Hybrid system in the LS 500h delivers seamless acceleration and torque, without requiring a charge. This level of craftsmanship isn't just rare. It's simply beyond measure.
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LS 500 F SPORT shown with options. 1. Ratings achieved using the required premium unleaded gasoline with an octane rating of 91 or higher. If premium fuel is not used, performance will decrease. 2. Performance figures are for comparison only and were obtained with prototype vehicles by professional drivers using special safety equipment and procedures. Do not attempt. ©2018 Lexus

▷▷ software. Today, recording pros can use A.I.-powered programs to cue an array of instrumentation (from full orchestral arrangements to hip-hop beats), then alter it by mood, tempo, or genre (from heavy metal to bluegrass). (See more ways A.I. is changing how people work on page 96.)

"It's like the future of self-driving cars," says Leonard Brody, entrepreneur and cofounder of Creative Labs, a joint venture with Creative Artists Agency that invests in programs to help audio creators get their works delivered to the public. "Level 1 is an artist using a machine to assist them. Level 2 is where the music is crafted by a machine but performed by a human. Level 3 is where the whole thing is machines."

A.I. claiming ownership of a third of the top 40 may be surprising to the casual listener, but it's a low bar for Drew Silverstein, CEO of Amper, an A.I.-based music composition software company in New York City. Amper's product allows musicians to create and download "stems"—unique portions of a track like a guitar riff or a hi-hat cymbal pattern—and rework them. Silverstein sees predictive tools as an evolution in the process of music creation. "Starting from quill and parchment centuries ago, then moving into analog and tape and mobile [devices]—A.I. is really just the next step," he says.

Silverstein isn't the only one with that view. Large technology companies also offer A.I.-powered tools and services for musicmaking. Among them: IBM Watson Beat, Google Magenta's NSynth, Sony's Flow Machines, and Spotify's Creator Technology Research Lab. The resources, intended for use by artists and labels, use algorithms to analyze libraries of songs and sales charts to predict what may have the best chance of charting (and when).

Though the latest developments in A.I. are helping fuel its use in popular music, it's not really a new idea. More than two decades ago, David Bowie helped create the Verbasizer, a program for Apple's Mac that randomized portions of his inputted text sentences to create new ones with new meanings and moods—an advanced version of a cut-up technique he used, writing out ideas, then physically slicing and rearranging them to see what stuck. Bowie made use of the Verbasizer for his 1995 album *Outside*. "What you end up with is a real kaleidoscope of meanings and topic and nouns and verbs all sort of slamming into each other," said the influential pop star in a 1997 documentary featuring the tool.

Like-minded artists insist A.I.-assisted songwriting is a boon, not a threat. Taryn Southern, a singer and former *American Idol* contestant who released her debut album, *I Am AI*, last year, composed the eight-song work with Amper, Watson Beat, and other software, plus human help.

"A person who's been trained on guitar since they were 8 years old is going to be masterful," says Southern. "It would take them an hour to bang out a song. For people who don't have that skill set, it could take weeks." As with arguments against synths and samples, "It's not putting anyone out of work, just making them work differently," she says.

Producer, songwriter, and Black Eyed Peas member Will.i.am has another take: There's nothing artificial about music created by A.I. "When you say 'artificial intelligence' to compose music, what part of it is helping creative songwriters? Is the A.I. helping you compose? Distribute? Who's listening? How much money will it make? No, bro. That's a new machine-learning tool"—and nothing more.

For artists and their reps, money—for everything from production costs to copyright and royalties—is a key issue. Southern, for example, shares writing credits on her album with Amper. But the software allowed her to use funds that would have been conventionally spent on human songwriters, session musicians, and studio time for a management team, publicists, and videographers—other essential components for the modern professional entertainer.

Or, as Will.i.am puts it: "Michael Jackson, Quincy Jones, Luther Vandross—think about all of those composers. Microphones, engineers, and tape cost money." In other words, A.I. can't replicate the innate talent of those songwriters, let alone the complicated recording processes they used to create their best-known works.

So don't expect artificial intelligence to write the next "Space Oddity" anytime soon. But an artist with the right chops and ingenuity might get there faster with A.I.—even if, as Luddites and futurists surely agree, this universe will never see another David Bowie. ■

TIN PAN VALLEY

12

Debut position of "Not Easy," written by Grammy-winning producer Alex da Kid and IBM Watson, on *Billboard*'s Hot Rock Songs chart in July 2018

13,000

Pieces of sheet music analyzed by Sony's Flow Machines to create Benoît Carré's Beatles-esque "Daddy's Car" in 2016

$6B

Venture investment across 643 machine-learning/A.I. deals in 2017, per PitchBook

"IT'S NOT PUTTING ANYONE OUT OF WORK, JUST MAKING THEM WORK DIFFERENTLY."


LITTLE
BLACK
STRETCHY
PANTS
NOW AVAILABLE ON
amazon + kindle
THE
UNAUTHORIZED
STORY OF LULULEMON
BY FOUNDER
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Achieving Excellence Through Quality Service

At **Senior Star** retirement communities, associates find purpose and meaning in caring for their customers as well as for one another—and they have fun along the way. It's no wonder the company is No. 3 on *Fortune*'s list of the 50 Best Workplaces for Aging Services.

SERVICE MARKS PRACTICALLY EVERY ASPECT of the workplace at Senior Star, which operates 14 vibrant senior living communities in six states—Ohio, Illinois, Missouri, Iowa, Oklahoma, and New Mexico—for more than 2,000 residents.

"We believe in servant leadership, in giving our best to each other, and in giving back to the community," says Senior Star CEO Anja Rogers.

Service and giving extend well beyond the company's walls. At one of Senior Star's annual "Leadership Forum" gatherings, a team-building exercise involved making tie-knot blankets out of fleece. While Rogers gave the teams of associates instructions on *how* to make the blankets, she didn't tell them *why* they were making them.

The only clue to the purpose of the exercise? "Tie each knot," she told the associates, "with love."

At the end of the fun-filled competition, Rogers asked each team to select a member who had gone above and beyond the instructions. Calling those members to the front of the room, she explained what they had actually made: one hundred and fifteen blankets for children at a nearby hospital. And when the associates returned from delivering the blankets that day and shared how the experience affected them, "There was hardly a dry eye in the room," she recalls.

Exercises of this kind help create experiences that have meaning and purpose—for residents as well as Senior Star associates.

Earlier this year, for example, employees climbed aboard the *Flagship Detroit*, a historic Douglas DC-3 aircraft that American Airlines operated between 1936 and 1947—the years during which current Senior Star residents were growing up and flying with their families. Some employees had never flown before.

"Taking our associates on this ride was more than a happy surprise," observes Rogers, who has been with the company since 1983. "It was a way they could experience what life was like for the residents in our communities. Creating experiences that deeply touch people requires understanding the people you are working to serve and a sincere desire to impact their lives positively."

At Senior Star, aligning service with purpose creates not only fulfilling communities in which to live but also great places for people to work. ■

SENIOR STAR EMPLOYEES ENJOY WHAT THEY DO. LEFT: ASSOCIATES DEPLANE THE HISTORIC *FLAGSHIP DETROIT* DC-3 AIRCRAFT. RIGHT: ASSOCIATES DELIVER BLANKETS THEY MADE TO CHILDREN AT A NEARBY HOSPITAL.

BLACK AND BLUE ALL OVER

Behind the inky picture of OLED display technology is a bruising brawl among some of the world's wealthiest electronics companies. By Andrew Nusca

TECH **LOOK AT ANY DIGITAL DISPLAYS LATELY?** Of course you have. You've craned your neck over a smartphone, glanced at a car's entertainment system, and gaped at a big-screen TV. Deep down, you're horrified that someone might see the telling totals calculated by the Screen Time app on your iPhone. (Time spent responding to political social media posts by your extended family: two hours above average.)

Attendees gaze at an overhead OLED display made by LG at the 2017 IFA consumer electronics show in Berlin.

Sure, your attraction to glowing panels of light is a little animalistic, a bit mothlike. But have you actually *looked* at them lately? They're just ... better than they used to be. Lines are crisp, colors pop, and you get lost in their inky blackness. They look different from the displays on your old devices. That's because of a technology called OLED.

OLED—which stands for organic light-emitting diode—may share a few letters with LED and LCD, the predominant display technologies of the past decade. But it's fundamentally different. "OLED emits its own light, and that really offers distinct advantages when it comes to pixel quality," says LG Electronics USA spokesman John Taylor. "Every pixel can be individually controlled, so that means it can create perfect black levels—the most important element to a great picture."

OLED also commands a much higher price. It dominates the high-end market segments it's in, from phones (Samsung's $720 Galaxy S9) to televisions (LG's $2,000 C8). Most important, only a handful of corporations—including Samsung, LG, and Sony—control its limited supply.

"Almost every company is investing to compete with Samsung," says Jerry Kang, who leads display technology analysis at IHS, the market research firm, from Seoul. "The other companies are trying to rapidly follow."

Kang's firm believes the global OLED market will grow from about $26 billion in sales this year to $37.5 billion in 2022, driven largely by mobile devices. Who's winning or losing depends on the device: Samsung supplies OLED displays to the world's top two phonemakers (itself and Apple), yet an early decision against OLED inadvertently handed the premium-TV market to LG and Sony, each of which claimed more than a third of all sales last year, according to IHS. ("We firmly believe that we can continue to expand the world of possibilities with our OLED displays," says a Samsung Display spokesman, adding that the company started investing in development of the technology 18 years ago.)

The war rages on as OLED prices continue to plummet and a once-premium innovation goes mainstream—just in time for the winter holiday shopping season. "It's still relatively young technology," says LG's Taylor. "We're not going to take our foot off the accelerator."

KRISZTIAN BOCSI—BLOOMBERG VIA GETTY IMAGES

FOCUS

EVERY STEP YOU TAKE, THEY'LL BE WATCHING YOU

Local Chinese governments are using cameras and A.I. made by SenseTime and Megvii to identify citizens on the street. *Minority Report*? No—reality. **By Eamon Barrett**

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TECH

AT A CROSSING IN SHENZHEN, a giant screen displays the faces of pedestrians who dared to jaywalk, unaware they were being watched. But it wasn't police who caught them—it was street-side surveillance cameras equipped with the latest in facial recognition technology. The miscreants' mug shots are broadcast on the screen to shame others into compliance.

The technology behind the stunt was provided by a local company called Intellifusion, one of the smaller players in China's advanced surveillance market. At the forefront of this booming industry are two other Chinese startups, SenseTime and Megvii, whose A.I.-powered facial recognition systems are likely the most powerful in the world.

Where's Waldo? Monitors at the Beijing offices of A.I.-software startup Megvii play a video showing how its facial recognition software works.

SenseTime began as a research project at the Chinese University of Hong Kong. The company was established in 2014 by professor ▷▷

Police officers use A.I.-powered eyewear on the street in Luoyang, Henan province, China, in April 2018.

▷▷ Tang Xiao'ou, an expert in the field of computer vision technology, and his protégé, Xu Li, who now serves as CEO. Today SenseTime is the world's most valuable A.I. startup, with a valuation of at least $4.5 billion.

At an estimated $2 billion, rival Megvii is less valuable. But the company is the originator of the world's largest open-source facial recognition platform, Face++. More than 300,000 developers use Face++ to build their own face detection programs. Founded in 2011 by three graduates of Tsinghua University—China's MIT equivalent—Megvii claims it wants to "build the eyes and the brain" of Chinese cities and extend police powers to a point "beyond what is humanly possible."

For China's government, that means not only being able to identify any of its 1.4 billion citizens within a matter of seconds but also having the ability to record an individual's behavior to predict who might become a threat—a real-world version of the "precrime" in Philip K. Dick's *Minority Report*.

To get there, the government is both benefactor to and beneficiary of companies like Megvii and SenseTime. More than 40 municipal police forces, known locally as Public Security Bureaus, have purchased surveillance systems from SenseTime. The company says its tech has helped Guangzhou police identify more than 2,000 suspects, arrest more than 800 people, and solve close to 100 cases since it was deployed in the city last year.

"THE INTENTION IS TO WEAVE A TIGHTER NET OF SOCIAL CONTROL THAT MAKES IT HARDER FOR PEOPLE TO PLAN ACTION OR PUSH THE GOVERNMENT TO REFORM."

Megvii, meanwhile, supports the state's nationwide surveillance program, which China, with troubling inferences, calls Skynet. Launched in 2005, Skynet aims to create a nationwide panopticon by blanketing the country with CCTV. Thanks to Face++, it now incorporates millions of A.I.-enhanced cameras that have been used to apprehend some 2,000 suspects since 2016, according to a *Workers' Daily* report.

China claims such tech will be used to track fugitives and locate missing people, but the potential for misuse is obvious. Both SenseTime and Megvii have absolved themselves of any responsibility for how their technology is used, claiming to simply be suppliers, not rulemakers. (Both companies declined to comment.)

For Luciano Floridi, director of Oxford University's Digital Ethics Lab, this shirking of responsibility doesn't fly. "The justification of saying 'Oh, we're just producing a tool' has not worked since we started sharpening stones a long time ago," he says.

In the U.S., some companies are actively seeking oversight for A.I. applications. In July, Microsoft, which both researches and commercializes A.I., called for "a government initiative to regulate the proper use of facial recognition technology." Meanwhile, Axon, formerly Taser, has established an external advisory board to guide its development of A.I.-fitted police gear.

Jeffrey Ding, an Oxford University researcher focused on Chinese A.I., believes there is more pushback in the West against deploying facial recognition technology for security purposes. "There's more willingness in China to adopt it," he says, "or at least to trial it."

But there's also less freedom to oppose the onslaught. "The intention of these systems is to weave a tighter net of social control that makes it harder for people to plan action or push the government to reform," explains Maya Wang, senior China researcher at Human Rights Watch. With ever more intelligent cameras, who will watch the watchers? ■

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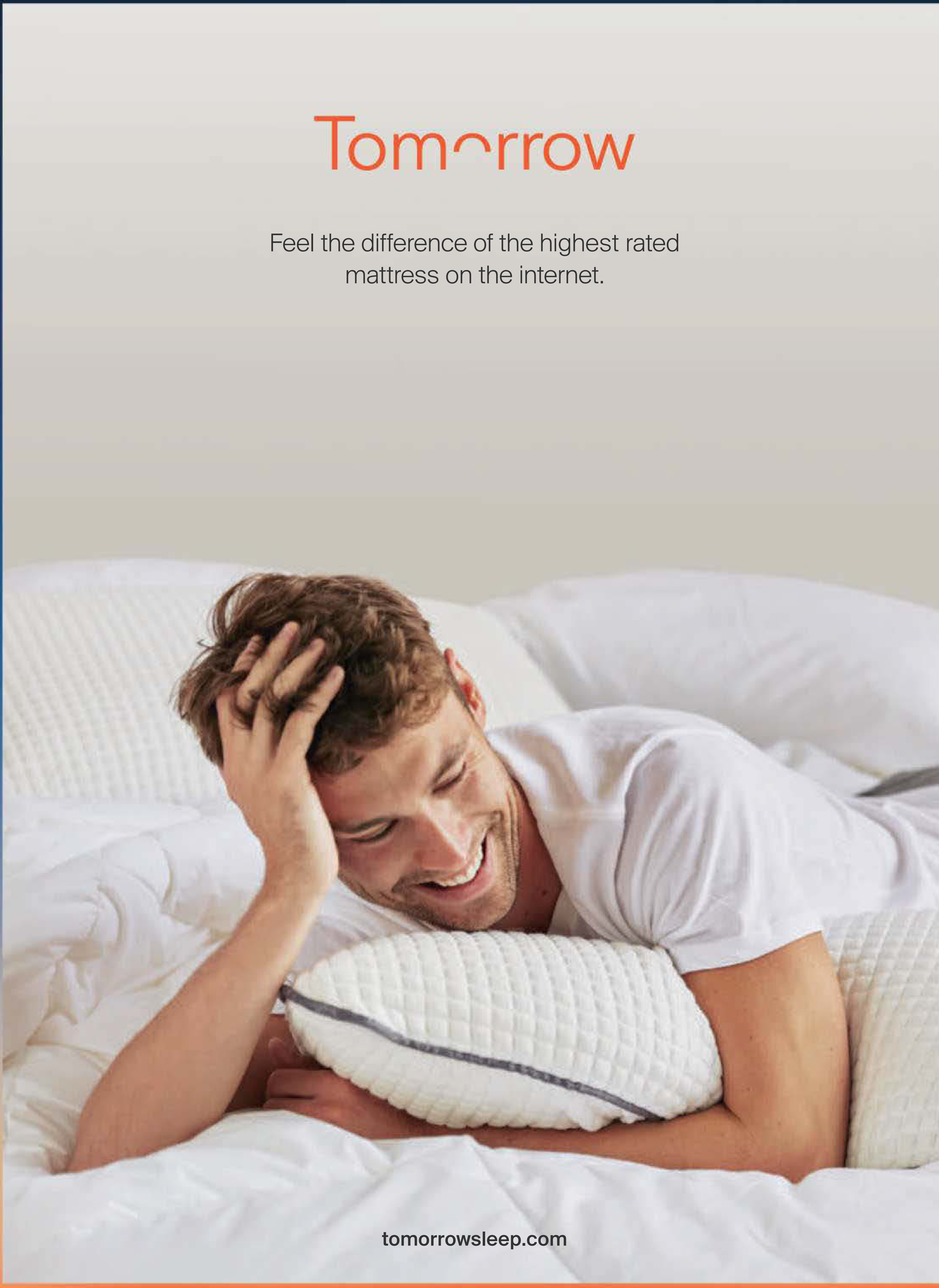
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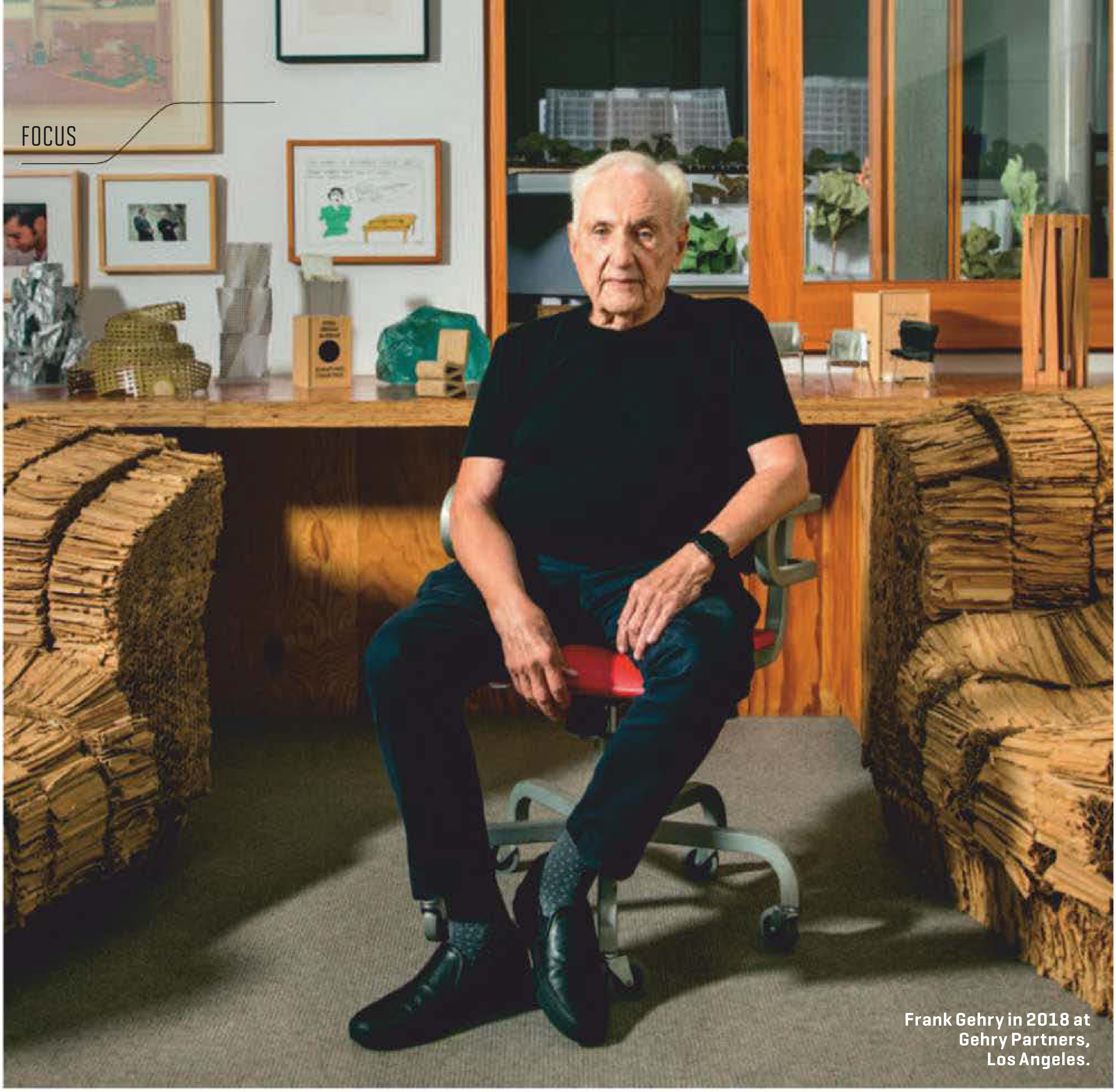

Frank Gehry in 2018 at Gehry Partners, Los Angeles.

FRANK GEHRY

The award-winning architect tells *Fortune* how he got started.

Interview by Dinah Eng

Frank Owen Gehry, 89, has become one of the world's leading architects, known for postmodern designs like the Walt Disney Concert Hall in Los Angeles, the Guggenheim Museum in Bilbao, Spain, and the Louis Vuitton Foundation in Paris. His Los Angeles firm Gehry Partners has 160 employees, but he still personally oversees every project.

VENTURE **I WAS BORN** Frank Owen Goldberg in Toronto, where my family had a hardware store. My grandfather was president of a synagogue and used to read the Talmud to me. The Talmud is all about curiosity. It starts with the word "why." I used to listen to the men sit and talk, challenging beliefs and ideas.

When my father had a heart attack, he lost his business, and in 1947, we emigrated to California, following his brother to Los Angeles. My father ended up working in a liquor store, four blocks from where we lived in a two-room apartment in downtown L.A.

We were poor, and at 17, I got a job as a truck driver and took night classes at Los Angeles City College. I loved woodworking, and after taking a class in architectural drawing, I was hooked and enrolled at the University of Southern California. Back in the '50s, anti-Semitism was in the air. USC was filled with it. Teachers said I should change my name if I wanted to succeed. In 1954, when my then wife, Anita, got pregnant with our ▷▷

PHOTOGRAPH BY **MICHAEL LEWIS**

Gehry's Walt Disney Concert Hall in downtown L.A. opened in 2003.

▷▷ first child, I agreed to change my surname to Gehry.

After USC, I got drafted into the U.S. Army and, when I came back, went to the Harvard Graduate School of Design for city planning. But I didn't finish because it was boring. I came back to L.A. to work for an architectural firm, then decided to start my own office in 1962.

I had a friend who wanted to build a six-unit apartment house, so we built it together. We pooled savings and bought the land for about $5,000, which was a lot for us. He had a connection to Kay Jewelers, and I designed a couple of stores and a warehouse for them. So slowly, Frank Gehry and Associates got started.

I didn't go out with any intention to attract any particular kind of job. I'd done art installations at the Los Angeles County Museum of Art for artist friends of mine and became part of the group meeting with investors when the city got ready to build the Museum of Contemporary Art. I did the Temporary Contemporary design, when MOCA didn't open in time for the 1984 Olympic Games.

Working internationally requires understanding cultural differences. You have to want to understand the differences and make it part of your work program. I spent time studying and talking with Basque families, the Basque Minister for Culture [and Language Policy] and others to understand their culture before designing the Guggenheim Museum Bilbao.

In the early days, they hire you because they know you're struggling, and they think they can get you cheap. In the later days, when you have a name, they just want your name.

Now I work for people who make a lot of money from my buildings. But even back in the beginning, if a client's wishes were totally counter to my feelings about the work, I wouldn't take the job. If you do the best work with good people, the money comes. Today, my second wife, Berta, is CFO of the company and guides the ship financially.

Right now, I love designing concert halls. I just did one pro bono for the West-Eastern Divan Orchestra, which brings together Israeli, Palestinian, and other Arab musicians to play and talk to each other through music. Of all the awards I've received, the most meaningful was getting a doctorate in music from the Juilliard School. I don't play a note, but I got it for making buildings for music.

The number of people practicing architecture as an art has dwindled. A lot of buildings are really just commercial models that, with very little effort, could become special. I believe it's possible to create designs that are not faceless or aggressive but are reasonable containers to live in and play in, that bring something uplifting and communal to people. ■

FRANK GEHRY'S BEST ADVICE

FOUNDER OF FRANK GEHRY AND ASSOCIATES AND GEHRY PARTNERS

TREAT ALL JOBS EQUALLY: "With every project, no matter how small, act as if it's the most important one. Make sure it's technically and economically viable because you'll be judged on the smallest things."

TEST EVERYTHING: "I don't have expectations when I take on a project. I test ideas endlessly and ask why. I build 20 to 30 models for every project because you have to give the job its due. You don't just do the first idea that comes to you, which is easy. It's not fair to do anything less than your best."

© SHUTTERSTOCK

THE BEST SMALL AND MEDIUM COMPANIES TO WORK FOR

The 30 million small and medium enterprises in the U.S. are responsible for nearly two-thirds of all new private sector jobs. Great Place to Work compiled this year's list of the country's top small and medium workplaces by analyzing feedback from more than 158,000 employees. For the complete list of 150 companies, visit Fortune.com. By Radhika Marya

TOP FIVE SMALL COMPANIES

01

HUGHES MARINO

Commercial Real Estate

HQ .... San Diego
U.S. EMPLOYEES 102

"The culture is like none other," an employee says. "Everyone is extremely polite, helpful, outgoing, caring, and has a great work ethic."

02

YOU NEED A BUDGET

Information Technology

HQ .... Lehi, Utah
U.S. EMPLOYEES 61

"YNAB is the most welcoming, kind, supportive place I know," one worker says. "Every day, I start work knowing I'm making a difference in customers' lives, but also that my work is appreciated and necessary to the future of the company, even as a part-time employee."

03

FRONT

Information Technology

HQ .... San Francisco
U.S. EMPLOYEES 81

According to one employee: "No matter where you are in the hierarchy of the company, your opinion is heard, respected, and responded to."

04

ORGANIFI

Retail

HQ .... San Diego
U.S. EMPLOYEES 65

Workers appreciate being in the loop. As one says, "The transparency that the company provides is unique."

05

EDUCE GROUP

Professional Services

HQ .... Bethesda, Md.
U.S. EMPLOYEES ... Confidential

Staff members enjoy "the culture, which revolves around our people." One says, "We celebrate wins together."

TOP FIVE MEDIUM COMPANIES

01

INTUITIVE RESEARCH AND TECHNOLOGY

Engineering

HQ .... Huntsville, Ala.
U.S. EMPLOYEES 378

"They treat employees like equals," a staffer says, pointing out that regardless of rank, higher-ups "will say hi to you and stop to have a conversation." The worker continues, "Doesn't matter how busy they are, they *always* find time for their employees."

02

THE TRADE DESK

Information Technology

HQ .... Ventura, Calif.
U.S. EMPLOYEES 612

"Everyone is extremely helpful," a staffer says. "Management takes time to hear the employees out and takes their recommendations and suggestions seriously."

03

PEOPLETEC

Professional Services

HQ .... Huntsville, Ala.
U.S. EMPLOYEES 323

Staff members appreciate the energy corporate leadership invests in listening to concerns, calling the time spent talking to individuals "unique."

04

ASANA

Information Technology

HQ .... San Francisco
U.S. EMPLOYEES 350

"Everyone has a voice and is encouraged to exercise that right," an employee observes.

05

WEST MONROE PARTNERS

Professional Services

HQ .... Chicago
U.S. EMPLOYEES 985

Staffers believe that company leadership lives by a "people first" philosophy. "They actually mean that," one worker says.

ILLUSTRATIONS BY JONATHAN CALUGI

Teams with Purpose Protect Mission-Critical Systems

An empowering culture that values teamwork and cutting-edge technology is helping the IT management and security firm **Tanium** attract the best and the brightest in its industry.

FORTUNE 100 BEST MEDIUM WORKPLACES 2018

GIVING COMPANIES AND GOVERNMENT agencies the tools they need to protect their enterprise systems is mission-critical to Tanium, an 11-year-old cyber- and IT-security firm based in Emeryville, Calif. Tanium acts like the central nervous system for its customers, arming them with the power to secure, control, and manage millions of devices in a matter of seconds, building business resilience against technology disruptions that come their way.

What sets Tanium apart from other companies is the shared purpose that motivates employees to work together to solve its customers' most challenging problems. You'll never hear a Tanium employee say, "It's not my job," or "There's nothing we can do," says CEO and cofounder Orion Hindawi. Such unwavering dedication helps explain why the company retains nearly all of its customers, which include close to half of the *Fortune* 100.

By trusting and empowering its employees to do the right thing, Tanium continues its rapid growth while keeping its culture strong. "People come to work at Tanium and stay here because they are inspired by our mission and want to be part of our culture where teamwork, integrity, and an unstoppable spirit make up the core values," says Bina Chaurasia, chief people officer.

To underscore the importance of those values, cofounder and executive chairman David Hindawi meets with every final candidate to ensure that each newcomer is a good cultural fit. And once those folks are hired, it's important to Tanium that employees are not just getting the job done, but that they're performing in accordance with the values. Every employee is empowered to act like an owner and is given an equity stake in the company—a differentiator that Tanium believes is critical to the sustainable growth and long-term resilience of the business.

Orion Hindawi sees the link between Tanium's technical innovation and rapid growth, and its people. "Working at Tanium," he says, "means being part of an enterprise that's creating a technology that is completely revolutionary and of paramount importance to society today. It also means being part of building a company where everyone can do the best work of their lives." In the end, that's good for Tanium employees—and customers. ■

THE BEST WORKPLACES IN AGING SERVICES

The median age of the U.S. population is increasing at an unprecedented rate, making the need for good senior services all the more important. *FORTUNE* and research partner Great Place to Work came together to determine the first-ever Best Workplaces in Aging Services list by analyzing survey results from more than 162,000 U.S. employees. The list separates rankings according to the senior housing and at-home-care segments of the industry. To read the full list, which consists of 50 workplaces in aging services, visit Fortune.com. By Radhika Marya

SENIOR HOUSING

01
GURWIN JEWISH NURSING & REHABILITATION CENTER
HQ .... Commack, N.Y.
U.S. EMPLOYEES 936

02
VAN DYK HEALTH CARE
HQ .... Hawthorne, N.J.
U.S. EMPLOYEES .... Confidential

03
SENIOR STAR
HQ .... Tulsa
U.S. EMPLOYEES 1,280

04
SEABROOK RETIREMENT COMMUNITY
HQ .... Baltimore
U.S. EMPLOYEES 540

05
EMBRACE LIVING COMMUNITIES
HQ .... Oak Brook, Ill.
U.S. EMPLOYEES 146

06
MERRILL GARDENS
HQ .... Seattle
U.S. EMPLOYEES 1,892

07
SUNRISE SENIOR LIVING
HQ .... McLean, Va.
U.S. EMPLOYEES .... Confidential

08
RAYA'S PARADISE
HQ .... West Hollywood, Calif.
U.S. EMPLOYEES 65

09
POMPERAUG WOODS
HQ .... Southbury, Conn.
U.S. EMPLOYEES 163

10
VI
HQ .... Chicago
U.S. EMPLOYEES 3,000

AT-HOME CARE

01
EAGLE CREEK THERAPY SERVICES
HQ .... Dallas/Fort Worth Metroplex
U.S. EMPLOYEES 89

02
CARE INDEED
HQ .... Menlo Park, Calif.
U.S. EMPLOYEES 385

03
CHERISHED COMPANIONS HOME CARE
HQ .... Chagrin Falls, Ohio
U.S. EMPLOYEES 208

04
24HR HOMECARE
HQ .... El Segundo, Calif.
U.S. EMPLOYEES .... Confidential

05
GREAT LAKES CARING HOME HEALTH AND HOSPICE
HQ .... Jackson, Mich.
U.S. EMPLOYEES 2,302

06
CARE TO STAY HOME
HQ .... Santa Ana, Calif.
U.S. EMPLOYEES 170

07
CONSTELLATION HEALTH SERVICES
HQ .... Norwalk, Conn.
U.S. EMPLOYEES 454

08
GRANDCARE HEALTH SERVICES
HQ .... Pasadena, Calif.
U.S. EMPLOYEES 249

09
COMPASSCARE
HQ .... Stamford, Conn.
U.S. EMPLOYEES 53

10
ALACARE HOME HEALTH AND HOSPICE
HQ .... Birmingham, Ala.
U.S. EMPLOYEES .... Confidential

ILLUSTRATIONS BY JONATHAN CALUGI

The Engagement Equation

With a focus on enriching the lives of both employees and residents, **Vi** is building award-winning communities with real staying power.

FORTUNE BEST WORKPLACES FOR AGING SERVICES 2018

RESIDENTS ENJOYING A GAME OF BOCCE AT VI AT BENTLEY VILLAGE IN NAPLES, FLA.

WHEN RANDY RICHARDSON, PRESIDENT OF Vi, started running the portfolio of luxury retirement communities in 2000, he visited each one and asked two questions of every employee he met: Why did you come to work for this company, and what do you like best about your job?

"Almost universally, coast to coast, no matter the position, the first answer was that we had a reputation for being a high-quality organization, and they were proud to be associated with the company," says Richardson, adding that answers to the second question were almost universal too. "They said, 'I feel like I'm making a difference in someone's life.'"

The ability to attract and maintain engaged staff (the average employee's length of service is nearly six years) is the reason Vi (short for *vitae*) is included on *Fortune*'s list of Best Workplaces for Aging Services and has won *Chief Learning Officer* magazine's LearningElite award for eight years running. Recently, Vi was also ranked No. 1 on *Elearning!* magazine's Learning! 100 list.

"Those are nice things to show off, but at the end of the day, it really is about resident and employee satisfaction and how that drives your business," says Richardson. "They go hand in hand. Moving the needle on employee engagement has a direct correlation with resident satisfaction."

In an industry with an annual turnover rate of close to 50%, Vi keeps its rate at less than half that by hiring and training the best leaders possible. "The No. 1 reason a person leaves their job is due to their manager," says Richardson. "We focus on developing our management-level personnel so that they have the skill set to create this environment of engagement with the people who are doing the work every day and have the highest interface with the residents."

Other reasons for Vi's success: a holistic approach to wellness focused on the physical, spiritual, and vocational; exceptional fine dining thanks to well-trained chefs who cook meals one plate at a time; and a full-continuum program of quality care, including assisted-living, skilled nursing, and memory care.

TOP-NOTCH SERVICE AT THE BISTRO CAFE AT VI AT PALO ALTO, CALIF.

"If residents do need higher levels of care, we already have a long-standing relationship with them," says Richardson. "It takes a lot of fear out of the experience. It's not fun getting old and losing your independence from a physical point of view, but because our people know them and vice versa, we can provide a higher level of dignity and service to them."

And that's a practice that never gets old. ■

Vi® | *Redefining* SENIOR LIVING

The Power of Human Connection

This operator is transforming from a senior living provider to a human connection company.

"We believe in the power of human connection to transform lives."

TOM GRAPE
Chairman and CEO
Benchmark

WITH A DEEP COMMITMENT TO HUMAN CONNECTION, Benchmark not only keeps residents connected to what matters most but also cultivates a workforce culture of trust, respect, and support. "We believe in the power of human connection to transform lives," says Chairman and Chief Executive Officer Tom Grape.

For instance, if associates experience financial setbacks, they can apply for help from the Benchmark One Company Fund (OCF)—a nonprofit set up to grant funds to cover unforeseen expenses due to death, illness, disaster, and more. OCF has distributed $1.6 million to nearly 1,000 eligible Benchmark associates in the past decade, including $332,000 in 2017 alone. Raising funds is one way the company's residents and associates come together, enabling them to connect with one another.

Benchmark University also offers programs to help associates bolster their careers and connect with the rapidly changing aging services landscape.

The culture of connection plays a key role in Benchmark's success and has been a driving factor in building a more inclusive workplace, says Senior Vice President of Human Capital Veronica Barber. For instance, there's an effort to hire from a diverse applicant base—including individuals over 50.

And despite aging services having a high turnover rate, Benchmark is experiencing a surge in overall number of applicants, returning associates, and retention, including a 10% reduction in turnover this year. "When associates are fulfilled, they stay longer, and when they feel empowered, they can be fully present to care for our residents, families, and one another," Barber says.

Residents of the company's 58 communities benefit from the lower turnover. "What delights our customers most is not the beautiful buildings, great amenities, and wonderful activities," says Grape. "It's when our residents and their families experience a real connection with our associates and with the passions in their lives."

For now, the company is aimed at transforming from a senior living company to a "human connection" organization. To achieve that, it will fully implement its recently refreshed mission, vision, and values and focus its more than 6,300 associates on deeply understanding people, meeting them where they are, and connecting them to what's meaningful and possible at every stage of life. ■

BENCHMARK
Connecting to what matters


SUPERMICRO
25 Years
OF GROWTH & INNOVATION
FIRST-TO-MARKET
Technologies
RESOURCE-SAVING
Computing
Supermicro celebrates 25 years of industry leading growth and Green Computing innovation by delivering highest quality, First-To-Market server and storage technologies. These resource-saving computing offerings can help us to preserve our precious Earth for an even brighter future.
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XEON
PLATINUM
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Intel® Xeon® Scalable processors
SUPERMICRO
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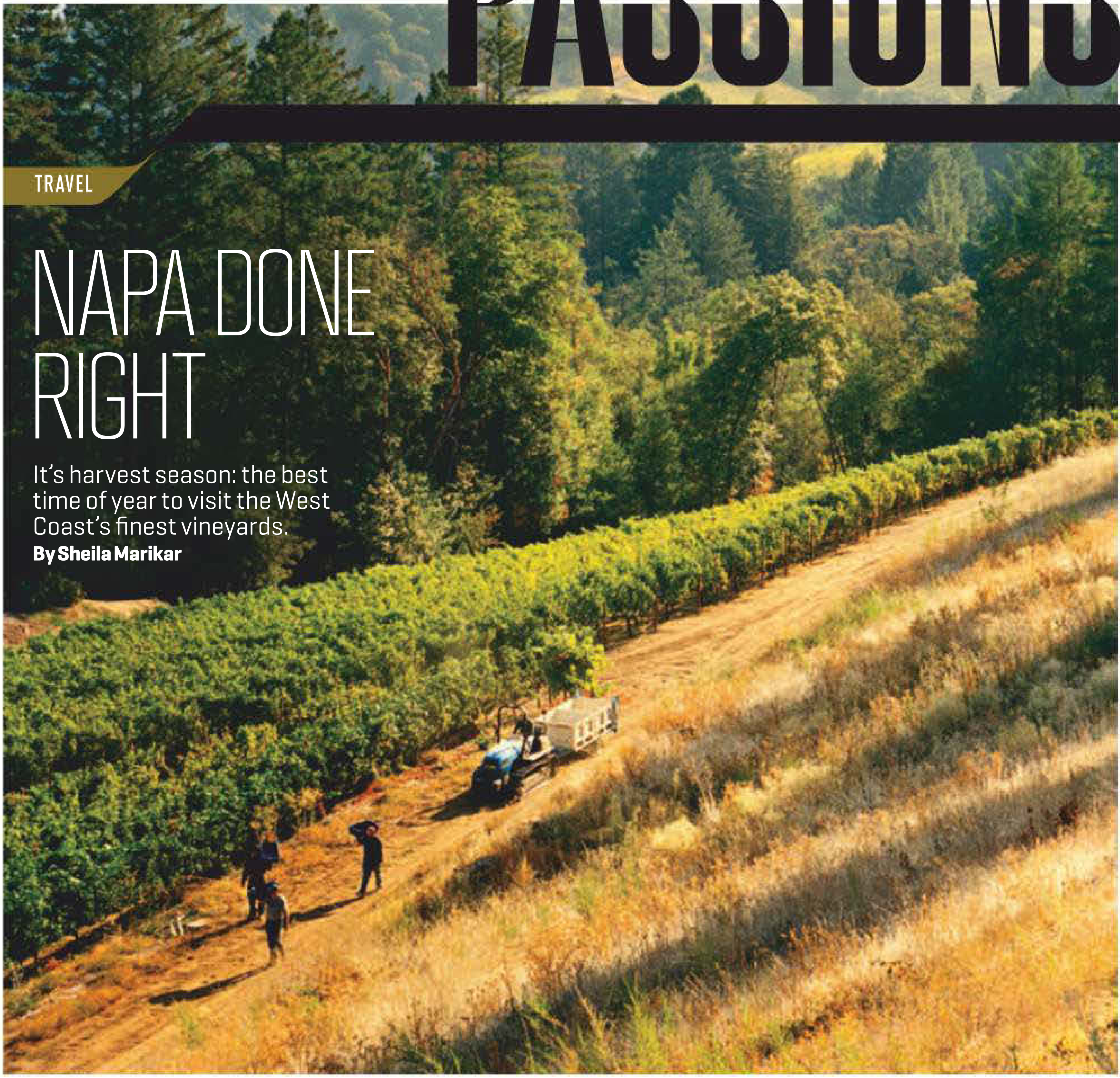
PASSIONS



TRAVEL

NAPA DONE RIGHT

It's harvest season: the best time of year to visit the West Coast's finest vineyards.

By Sheila Marikar

AUTUMN USHERS NAPA VALLEY into harvest season, one of the best times to visit the nation's premier wine region. Though last year's wildfires ravaged parts of the California valley, rebuilding has been quick, and there have been a spate of new openings, like the Ink House, an ultra-exclusive, four-room boutique hotel in St. Helena. The colonial-style mansion's wide, wraparound veranda offers a vista of vineyards and the rolling hills beyond; inside, modern accents (a chandelier of brass vines) spice up the homey atmosphere.

One of the perks of staying at the Ink House: unfettered access to Brian Woolery, the property's chef—his scrambled eggs defy gravity—and all-knowing concierge. Here's what he recommends. ▷▷

Darioush's 22-acre Sage vineyard atop Mount Veeder.

© FREDERIC LAGRANGE

The bar at the Charter Oak.

Darioush's Cabernet Sauvignon grapes.

Best new restaurants: The Charter Oak, the casual St. Helena restaurant started by three-Michelin-star chef Christopher Kostow and Meadowood's Nathaniel Dorn, is phenomenal. The atmosphere, the food, the cocktail program, the wine program—everything about it is the epitome of what a great place to eat should be. In downtown Napa, there's the Mexican restaurant Gran Eléctrica (the original is in Brooklyn). There's an amazing bar with a range of tequilas and mezcals. It's a fresh twist on Napa Valley dining that isn't your typical farm-to-table approach.

Hottest wineries: The proprietor of Sinegal Estate in St. Helena may be an heir to Costco, but you would never know it from his winery. Sinegal has a private tasting lounge that's filled with modern art and a gorgeous estate surrounded by gardens. Its reserve red is absolutely delicious. Aonair is also in St. Helena, and the tasting experience overlooks its stunning vineyards. Family owned and off the beaten path, it is technically part of Conn Valley. Try its Mountains Reserve red blend.

Sober escape: Check out the Culinary Institute of America in St. Helena, where you can take a half-day cooking class with some of the best chefs in the country. Nearby, there's Health Spa Napa Valley—it has an outdoor pool and Jacuzzi as well as a full menu of massages, facials, and other treatments. It's an ideal way to relax and get a break from tastings. Our guests get complimentary passes.

Locals' secret: Lunch at Rutherford Grill. Sit at the bar and be amazed by how many winemakers you'll see and hear meeting their colleagues and friends, bringing fresh barrel samples, and talking about them. The food is also excellent—the steak enchilada with butternut squash is unexpectedly delicious.

Things to avoid: Not knowing how far places are from one another, a lot of people think Napa and Sonoma are a quick drive apart. But on most days, it takes at least an hour to get from one to the other. Consider focusing on one appellation—St. Helena one day, Howell Mountain another—with one or two preplanned tastings. Leave time for yourself to take locals up on their recommendations—if you're getting along really well with the tasting-room manager at, say, Darioush, he's going to recommend other places you might like.

THE $10,000 DAY

We asked Woolery to plan us a special, singular day in Napa Valley: You'll arrive in the valley via private jet or helicopter to Napa County Airport. We'll pick you up in the house car, a Bentley, and check you in at the Ink House (which will be all yours for the night), before whisking you off to the Meadowood Spa for some post-travel pampering. You'll meet with a wellness therapist, who will oversee your treatments, and enjoy a 90-minute culinary experience in your personal spa suite. After the spa you'll do a private tasting at Promontory, an exclusive winery in the heart of Oakville that's famous for its Bordeaux-style Cabernet. Back at the Ink House, *Top Chef* alum Casey Thompson will prepare a gourmet dinner to round out the day.

FROM TOP: KELLY PULEIO/THE CHARTER OAK; FREDERIC LAGRANGE; ILLUSTRATION BY MARTIN LAKSMAN

Creating a Family Culture in a Corporate World

Eureka Casino Resort's employees are more than just staff—they're owners, too.

WANT YOUR EMPLOYEES TO TRULY CARE about their work? Sell them the company. In 2015, Nevada-based Eureka Casino Resort did just that, making the rare move of transferring ownership from the Lee family—who started the casino in 1997—to their staff, via an employee stock-ownership plan (ESOP).

Andre Carrier, Chief Operating Officer, says Eureka's employees have always been a dedicated group, but making them owners means they're invested in the company's growth in a way that employees at other businesses may not be. "When people come to work at Eureka, they are saying, 'I don't want things to happen to me, I want to make things happen,'" he says. "There's an urgency to be effective."

This is because Eureka employees own more than just shares in the company; they own the connection between their decisions and actions and the impact those behaviors have on the business. This results in candid and passionate contributions from all employees in everything from menu choices and prices to casino promotions and paint colors.

This growth-focused culture has been a key driver of Eureka's success since the beginning, and it has helped the company earn a spot on this year's Best Medium Workplaces list. "What brings us gratification is getting better," says Carrier. "In fact, continuous improvement is one of our core values."

MARCELLA BURTOFT, GUEST ROOM ATTENDANT, HAS WORKED WITH EUREKA SINCE 2010.

Another factor contributing to the company's culture: fostering an environment where the entire staff feels as though they are part of the family. These family-centric values and the desire to improve have only become more pronounced since the launch of the ESOP.

ANGIE LUCERO, TABLE GAMES DEALER, HAS BEEN WITH EUREKA SINCE 2006.

Gregory T.H. Lee, the company's Chairman and Chief Executive Officer, recognizes these changes too. What was once a small family business that Lee cofounded with his mother and father is now a much larger family business that includes his entire staff. "There's tremendous pride," he says. "The employees know that they're a part of the Eureka family. We all share core values, we're all investors, and we all define success in the same way.

"Family businesses are, in many ways, about legacy," says Lee. "By passing ownership to the men and women I grew the business with, I am assured we will both stay a family and be a strong and growing business for years to come." ■

AEP'S NEW BREAKTHROUGH OVERHEAD LINE DESIGN (BOLD) IS A HIGHLY EFFICIENT, COMPACT TRANSMISSION TECHNOLOGY WITH A SMALLER ENVIRONMENTAL FOOTPRINT.

THE ERA OF ABUNDANCE

▶ Energy is plentiful again—and benefits are widely shared.

THE 21ST CENTURY DIDN'T START OUT AS A NEW golden age for American energy. In the early 2000s, concerns about diminishing oil reserves and dependence on natural gas imports seemed like intractable realities. But a technology-driven renaissance has transformed the landscape by cracking open latent sources, from shale to sunshine. The benefits include more than a million new jobs, lower energy bills, smaller environmental footprints, and less waste.

"We literally have gone from the era of scarcity to the era of abundance," says Barry Worthington, executive director of the United States Energy Association.

In September, the U.S. became the world's largest oil producer, according to the U.S. Energy Information Administration. Between 2007 and 2017, hydraulic fracturing boosted shale gas production by a factor of 17. Power from renewable sources, led by hydropower and wind, doubled that same decade to 17%.

Today the average American household spends less on electricity than it did in 2011. Greenhouse-gas emissions from electricity producers fell by about 25% between 2005 and 2016, according to the Environmental Protection Agency.

Being a global energy leader makes America stronger economically and geopolitically, Worthington says. As consumers depend less on energy imports, tens of millions of dollars get plowed back into the American economy every day.

"Keeping that money here—rather than sending it to Saudi Arabia, Venezuela, or wherever it might go—is a huge contribution to the broader economic structure of the United States," Worthington says.

American Electric Power (AEP), a utility based in Columbus, Ohio, is playing its part, with the nation's largest transmission system and 5.4 million regulated customers in 11 states. AEP generated 70% of its power from coal in 2005, but now less than half comes from coal. Over that period, renewables swelled from 4% of AEP's power-generating mix to 14%. In the future, AEP plans to have more renewable generation capacity in its portfolio than coal.

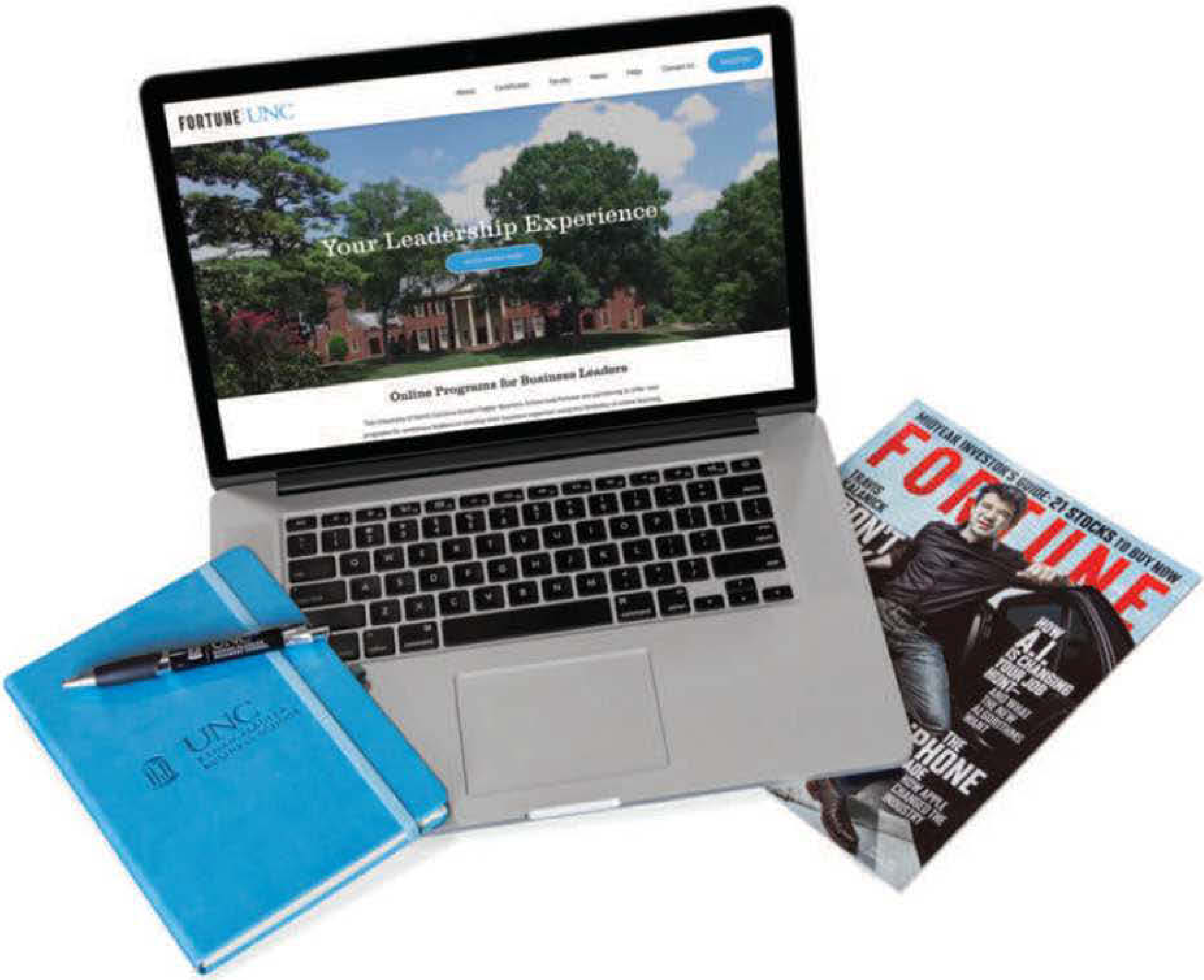
Technology has a role in energy abundance, too. Big-data analytics allow AEP to depend less on large, centralized power plants and instead optimize the grid through more diverse supplies, says chairman and CEO Nick Akins. AEP's \$10 million pilot program to develop up to 375 electric vehicle (EV) charging stations in Ohio could shed light on how to incentivize and scale up EV infrastructure elsewhere.

"We're on the precipice of a major change in the way we deliver and use energy in this country because we now have so many resource options available," Akins says. "It's going to benefit all Americans but also benefit other parts of the world."

USEA
United States Energy Association

The era of abundance is just beginning, and tracking its benefits across the globe will likely be a long-term project.

EMPOWERING
THE FUTURE
The future is never far away. It's around every corner, waiting for us to make it our own. Together with customers and communities, we're finding newer, smarter ways to energize businesses, communities, people. The future. We're empowering it.
AMERICAN ELECTRIC POWER®
BOUNDLESS ENERGY™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Online Programs for Business Leaders
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UNC

50

WHAT IF I'D BOUGHT AMAZON AT $20? What if I'd been Employee No. 5 at Netflix? These, of course, are the what-ifs on which we build our fantasies. But they're also backward-looking versions of the question that preoccupies every investor and executive: How do I identify companies that are poised for sustained, strong growth? To answer that question, *Fortune* teamed up in 2017 with the Boston Consulting Group (BCG) to devise the Future 50, which weighs dozens of factors to assess companies' long-term potential. Last year's picks, we're happy to say, handily outperformed the stock market. This year, we've expanded the index beyond the U.S.—where growing middle-class populations are creating intriguing new what-ifs.

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A Global Hunt for the Next Decade's Champions

TO FIND THE FUTURE 50, WE SCOUR TODAY'S DATA TO IDENTIFY TOMORROW'S TOP PERFORMERS. AFTER A PROMISING DEBUT, WE'VE EXPANDED OUR SEARCH TO COVER THE WORLD. BY MARTIN REEVES

IT'S A DISCLAIMER FAMILIAR TO ANY INVESTOR, but it's perhaps truer now than ever: Past performance is no guarantee of future success. Technological changes have accelerated the rate of competition: New challengers are rising faster than ever, and incumbent leaders are falling just as fast. At BCG, our research shows that for large companies, there is now less correlation than there used to be between past and future financial and competitive performance over multiple years.

The tools business leaders use, however, have not yet caught up to this reality. CEOs may pride themselves on being "forward-looking" (and the very best ones are called "visionaries"), yet the metrics commonly used to judge the state of a business (for example, profitability, revenue growth, and stock performance) are inherently retrospective. In other words, CEOs are looking into the proverbial rearview mirror when they really need binoculars.

That's why last year BCG and *Fortune* created the Future 50. Our index is forward-looking, in the sense that it aims to measure vitality—a company's capacity to reinvent its business and sustain revenue growth. Over long periods, the majority of shareholder returns of high performers are driven by such growth. However, consistently delivering growth is especially challenging for larger companies, which can no longer rely on startup-like momentum to sustain their performance. Our goal is to create a new tool for managers to measure and shape growth potential.

Signs of future strength

The Future 50 are the exceptions—the established public companies with the best long-term growth outlook. Our index is based on two pillars: a "top-down" market view of growth potential, and a "bottom-up" assessment of a firm's capacity to deliver growth. (See below for details on our methodology.)

To assess capacity, we focused on four dimensions: strategy, technology and investments, people, and structure. We identified dozens of theories that predict long-term performance, based on research and academic study. Then we tested them, leveraging a wide range of financial and nonfinancial data. In the nonfinancial realm, we used natural language processing algorithms to parse companies' annual reports and SEC filings, searching for indicators of a firm's strategic thinking on dimensions such as long-term focus; a broader sense of purpose beyond financial returns; and "biological thinking"—for example, embracing complexity and being adaptive. Finally, we used a machine-learning model to test the predictive power of these factors, retaining only those with a demonstrated impact on long-term growth.

Vitality operates over long periods and

THE FUTURE 50 METHODOLOGY

To identify the Future 50, BCG examined 1,100 publicly traded companies with at least $20 billion in market value or $10 billion in revenue in the 12 months through the end of 2017. A company's final score represents its outperformance across the following metrics when compared with peers of a similar size. (See Fortune.com for more details.)

50% of a company's score is based on **market potential**—defined as its expected future growth as determined by financial markets. This is assessed by calculating the present value of its growth opportunities, which represents the proportion of its market value that is not attributable to the earnings stream from its existing business model.

The other 50% is based on a company's **capacity to deliver** against this potential. This score comprises 17 factors, selected for their ability to predict growth over the following five years. These factors fall into four categories:

- **Strategy:** Our A.I. algorithm relies on natural language processing to detect a company's strate-

THE FUTURE 50

may not be reflected in short-term performance. That said, early results are encouraging: Since their selection last October, the 2017 Future 50 have achieved average revenue growth of 18% and total shareholder returns of 35%—outperforming both the overall market and growth-focused stock indexes. (See the chart at right.)

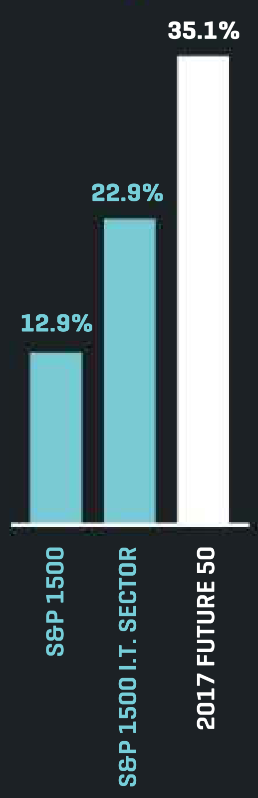
Global patterns of vitality

Our 2017 ranking assessed only U.S. companies. This year we expanded our scope to include the largest public companies worldwide. We found a bipolar landscape. The vast majority of this year's Future 50 are headquartered in two countries: 42% each in Greater China (including Hong Kong) and the U.S.

This distribution may seem extreme, but it is in line with growth trends. Of the fastest-growing large companies over the five years through 2017, 54% were based in China, and 28% in the U.S. Growth-focused investment follows a similar pattern: In the first half of 2018, approximately 80% of venture capital funding went to those two countries, according to Crunchbase.

Vitality is also unevenly distributed by sector. In the U.S. and other developed markets, the vast majority of vital companies are tech players. But in China and other emerging markets, the picture is more varied, thanks in part to rising consumer demand from the growing middle class. While digital leaders such as Alibaba, Baidu, and Tencent rise to the top, there are also three Chinese automakers among our top 50, along with a consumer-oriented Indian bank and a Thai convenience-store operator.

2017 FUTURE 50: 1-YEAR TOTAL SHAREHOLDER RETURN



SOURCE: S&P GLOBAL

With high potential, high risk

The very attributes that make high growth possible often also increase risk. One cautionary example: While last year's Future 50 companies are outperforming in the aggregate, three—LendingClub, Gogo, and Macom Technology Solutions—have lost half their market value since publication.

Many high-growth companies are led by founder-CEOs, who face the challenge of preserving culture and momentum while transitioning in the leadership role. Tech giants face trust issues, as users become increasingly sensitive to the social and political implications of digital products and increasing market power. And macro concerns, such as trade disputes, fears of a slowdown, and the impact of government influence on the economy, are more salient than ever. (Such concerns have impacted the share prices of many companies on this year's list, especially in China.)

To calibrate these risks, we have stratified our ranking. We classified four companies—Samsung Biologics, Tesla, Facebook, and JD.com—in a "higher uncertainty zone": Though they score well in our vitality analysis, each faces circumstances that elevate the risk that their growth could derail.

The Future 50 can't predict success with certainty, of course. Evolving markets, new competitors, and external forces always have the potential to disrupt trajectories. But we believe this index provides a useful set of binoculars through which to recognize growth potential in volatile times.

Martin Reeves is a senior partner at management consulting firm BCG and the director of the BCG Henderson Institute.

gic orientation from its SEC filings and annual reports. We assess the clarity of a company's strategy from earnings calls. We also assess a company's commitment to sustainability from its governance rating by Arabesque, a data-analytics firm.

Technology and investments: A company's capital expenditures and R&D (as a percentage of sales) measure its investment in the future. Technology advantage is assessed through the growth in a company's patent portfolio and that portfolio's digital intensity (share in computing and electronic communication). To account for external innovation, a company's portfolio of startup investments is compared with the best-performing global venture capital funds.

People: We assess the age and tenure of a company's executives and directors, as well as the share of managers and employees who are female. The value of consistent, focused management is assessed via leadership stability and smaller board size.

Structure: A company's age and (revenue-based) size are correlated with vitality loss. But three-year and six-month sales growth can be predictive of future growth as signs of revitalization.

This Workday Never Stops

RAPID-FIRE PRODUCT REINVENTION, INTENSIVE RESEARCH, AND NEAR-ZERO DOWNTIME HAVE TURNED WORKDAY INTO AN OFFICE-SOFTWARE JUGGERNAUT. HERE'S WHY IT'S NO. 1 ON OUR FUTURE 50.

BY ADAM LASHINSKY

THINGS ARE GETTING a little crazy at the Pleasanton, Calif., headquarters of software maker Workday. It's only the second week of October, but already employees are transforming the cubicles inside their otherwise charmless suburban office park into festive and elaborate Halloween displays.

This is a source of great pride for Aneel Bhusri, Workday's cofounder and CEO, who humblebrags that the decorations are part of a companywide office contest. Bhusri is a straitlaced guy, but he's been known to step into a costume himself. He

BONUS HUNTERS Staff at Workday's headquarters in Pleasanton, Calif. If the company hits its high customer-satisfaction marks, every employee gets a stock grant.

PHOTOGRAPH BY **BRAD WENNER**

and cofounder David Duffield once led an all-hands meeting in cow and monkey onesies in honor of Irish retailer Primark, a newly signed Workday customer that sells the garments. “Happy employees make for happy customers,” Bhusri says.

If Workday can give itself over to a little frivolity, that’s because its products are serious stuff. Just 13 years old, Workday makes software that runs critical operations for half of the *Fortune* 50 and more than 35% of the *Fortune* 500. It specializes in systems for human resources and accounting departments, and in its short life, it has earned a reputation for ease of use and reliability that has kept clients loyal.

For Bhusri and Duffield, the company’s chairman, Workday is a second act. The two also worked together at PeopleSoft, which made similar products an enterprise-technology generation ago before being bought by Oracle in a bitterly contested $10.3 billion takeover. Today Workday is a leader in “cloud” software, programs sold as subscriptions and managed remotely. The company built its wares specifically for online distribution. It prides itself on outspending competitors on R&D, on having happy customers, and on rapid expansion. It isn’t profitable, but it produces half-a-billion dollars in annual cash flow and is growing like a startup. Wall Street expects revenue in the current fiscal year of $2.8 billion, a nearly 30% year-over-year growth rate.

This combination of hard and soft metrics—financial growth, heavy product investment, and a future-oriented (even fun-having) workforce—has landed Workday atop this year’s *Fortune* Future 50, a quantitative analysis of large publicly traded companies assessed by management consultancy BCG to have their best years ahead of them.

50
THE FUTURE 50

23%

Year-to-date gain for Workday’s stock (through Oct. 15). The S&P 500 rose about 3% over the same stretch

MORE THAN
35%

Share of the *Fortune* 500 that runs Workday software

30%

Year-over-year growth in subscription revenue, through the most recent quarter

PETROS DERMETZIS, Workday’s chief product officer, has a PopSockets grip on his phone with an illustration of Theódoros Kolokotrónis, a famously helmeted Greek general who defeated the Ottoman army to win Greece’s independence in the 19th century. “I try to copy him,” says Dermetzis, who was raised in Greece by a Greek father and an English mother, married a Spaniard, and has worked in locales as diverse as Japan, Spain, and Atlanta. He’s been associated with Duffield and Bhusri for 23 years, since before PeopleSoft bought his startup.

Like other software companies, Workday touts itself as a one-stop shop for corporate users. Its first product was for HR departments. Where Workday separates itself from the pack is in its weekly online updates, twice-yearly major product re-dos (both unusually frequent for enterprise software), and near-zero downtime. Dermetzis calls this ability to serve customers “unheard-of” and boasts that “Salesforce

THE FUTURE 50

is the only company that comes close." (Salesforce, for what it's worth, was the top Future 50 company last year.)

Workday claims its company's whole tech-oriented ethos is future-looking. "Companies are running their operations by looking in the rearview mirror with stale data," says Dermetzis, a wiry and voluble man who gesticulates impressively while he talks. "These are technological crimes that society has accepted." With Workday's speedily updated programs, Dermetzis says, customers always have a clear real-time view of their operations, starting with how their people are performing but extending to their financial performance and other nuts-and-bolts areas.

Bhusri, the CEO, attributes Workday's technological success to the company's "tinkering mentality." When Apple released the iPad in 2010, for example, Workday turned loose a small team of recent college graduates to create an iPad version of their product. "Our people are well versed in Hadoop and Spark," he says, name-checking two programming tools popular with DIY problem-solvers.

Workday knows its limitations too—and it's willing to stretch itself financially to address them. In 2016, the company released a financial planning product for businesses. It didn't catch on. So this June, to fill that hole in its lineup, Workday paid $1.55 billion to buy Adaptive Insights, a younger company that was about to go public.

The acquisition, Workday's largest, could be costly in nonfinancial ways too. Veteran enterprise-software analyst Patrick Walravens of JMP Securities praises Workday for strong leadership, a large market opportunity, and an "enviable competitive position." Still, he expects Workday will have challenges integrating Adaptive's product into its own, "while at the same time satisfying the needs of Adaptive's 4,000 customers, the vast majority of which run" on systems sold by Workday competitors Oracle and Microsoft.

To maintain momentum to hurdle such obstacles, Workday counts on motivating employees, who in turn are incentivized to please customers. One of the three metrics that determine the size of an annual, all-employee stock grant is hitting 95% customer satisfaction. (The other two involve revenue growth and product milestones.)

One way Workday satisfies customers is by spending lavishly to develop products. Its annual R&D expenditure, at 31% of revenues, bests peers Salesforce and Adobe by that measure. "We are going after a bigger market than they are," explains Robynne Sisco, the company's copresident and chief financial officer. "And our products are more complicated."

Sisco did stints at GE, Ford, Visa, Oracle, Verisign, and VMWare before joining Workday in 2012. Today she plays a lead role in pushing Workday's newest line, its offering for running a company's financial management systems (think accounting, reporting, and the like). She notes that Workday has about 2,300 customers, almost all of whom use its HR software. But far fewer (and only eight *Fortune* 500 companies) deploy its "financials" product.

Bhusri says it has been a "huge undertaking" to make this critical software "cloud ready" but notes the line is growing 50% annually. "I would like that to be higher," he says. "But I'll take it." And if the right customers sign up, he won't be shy about dressing up in costume to celebrate.

31%

Share of revenue that Workday spends on research & development

SECOND ACT CEO Aneel Bhusri launched Workday after selling PeopleSoft, a company with a very similar core business.

COURTESY OF WORKDAY

The Future 50

Some are mining narrowly defined niches to produce phenomenal growth. Others are migrating into multiple industries with viral speed. Still others are inventing new business models as they go. But each of these companies won its spot on the Future 50 by demonstrating both steady execution and forward-looking strategic nimbleness.

01

WORKDAY

U.S. [WDAY, $124]

6.6
5.2 1.4

THIRTY-ONE CENTS out of every dollar in revenue. That's how much enterprise software-maker Workday spends on research and development every year. That investment feeds an unusually rapid cycle of product updates and improvements, which, in turn, has built a loyal customer base that includes more than 35% of the *Fortune* 500. Shareholders have had reason to stay loyal, too, to the tune of annualized returns of 27% over the past three years. For more about what makes Workday run, see executive editor Adam Lashinsky's feature on page 66.

Market value: **$27.0 billion**

02

WEIBO

CHINA [WB, $57]

5.4
4.0 1.4

NOT LONG AGO, China's answer to Twitter was struggling: The microblog platform had lost ground to Tencent's messaging service, WeChat, and China's censors had begun forcing the closure of user accounts. But Weibo has shrugged off tough times to become a powerful outlet, not just for short posts but for long-form content such as news reports, film reviews, and videos. Second-quarter revenue grew 68%, and the platform clocked 431 million monthly active users, up 19% year over year—all generating troves of data that Weibo is now monetizing.

Market value: **$12.6 billion**

03

SERVICENOW

U.S. [NOW, $172]

5.3
4.0 1.3

SIX YEARS AGO, ServiceNow's market share in IT service management stood at 10%. By last year, the cloud-based platform, which helps IT teams run an organization's technology infrastructure, had leaped to 40%. ServiceNow claims 42% of the 2,000 largest global companies among its customer base; better yet, it has a 97% retention rate. While this growth has come without much profit—think of it as an IT Amazon—sales have risen almost 700% over the past five years, and the company aims to hit $4 billion in revenue, a 130% jump from today's mark, by 2020.

Market value: **$30.6 billion**

04

CTRIP.COM INTERNATIONAL

CHINA [CTRP, $34]

5.3
3.9 1.4

AS CHINA'S middle class grows, outbound tourism is expected to surge. Ctrip, China's leading online travel agent, has already faced down stiff competition to become the dominant platform for China's hundreds of millions of domestic tourists; it's on target to see international travel deliver 40% to 50% of its revenue within a few years. Net revenue for the second quarter increased 13% year over year, to $1.1 billion. Ctrip's biggest new challenge: doing battle with Chinese tech giants like Meituan and Tencent eager for a piece of the lucrative market.

Market value: **$18.5 billion**

05

VIPSHOP HOLDINGS

CHINA [VIPS, $5]

4.8
3.4 1.4

E-COMMERCE IS booming in all segments in China, including fashion—the niche that Vipshop specializes in. The online store runs discount promotions on brand-name clothing. Product revenue surged from roughly $3 billion in 2014 to $10 billion in 2017. Its active customer base grew 6% in Q2 to 29.8 million, a rise Vipshop attributes in part to new partnerships with the larger Tencent and JD.com. Such deals could help Vipshop personalize customer experiences through data-sharing arrangements and introduce social elements to its online shopping.

Market value: **$3.3 billion**

COMPANY CAPACITY SCORE
MARKET POTENTIAL SCORE
X.X OVERALL SCORE
X.X X.X

THE FUTURE 50

06

NAVER
SOUTH KOREA [$124]

4.7
3.3 1.4

THE KOREAN tech giant established an early lead in its home market for search and other Internet services. Since 2013, its share price has more than doubled, and Naver is poised to extend its reach in cloud services and payment processing, analysts say. LINE, a subsidiary that makes a popular chat app, recently capitalized on a hot trend, introducing a rewards-points-like cryptocurrency called Link that people can use to buy and sell game-related content. Facebook's struggles, meanwhile, create an opening for Naver to capture more chat market share.

Market value: **$17.8 billion**

07

VERTEX PHARMACEUTICALS
U.S. [VRTX, $176]

4.6
3.2 1.4

VERTEX GOT its start making a hepatitis C drug, but it has more recently homed in on medicine that treats symptoms of cystic fibrosis, a genetic disease that afflicts 75,000 people worldwide. Its two best-selling drugs, Orkambi and Kalydeco, account for 87% of its $2.5 billion in revenue. And in February, Vertex received approval of a third CF drug, Symdeko, which earned $186 million in its first quarter on the market—more than twice what analysts expected. The success of the drugs has helped Vertex more than double its revenue in three years.

Market value: **$45.1 billion**

$90 BILLION

Average market capitalization of the 50 companies on the list, as of Oct. 10, 2018

08

NETFLIX
U.S. [NFLX, $326]

4.5
2.9 1.6

YOU CAN'T spell FAANG without the "N" in Netflix, and the streaming service's stock has outperformed nearly every other name in the acronym [except Amazon] over the past three years, rising 200%. There are plenty of indications that success will continue, with analysts predicting 25% annual revenue growth over the next few years. While it's facing more pressure from traditional entertainment providers that are developing their own channels—Disney will launch a streaming service in 2019, for example—Netflix has made big strides in growth abroad. Over the past year, while domestic memberships jumped 11%, subscriber ranks internationally grew 40%, and international revenues now roughly equal those generated by Netflix's domestic streaming viewership.

Market value: **$141.9 billion**

09

S.F. HOLDING
CHINA [$6]

4.2
2.8 1.4

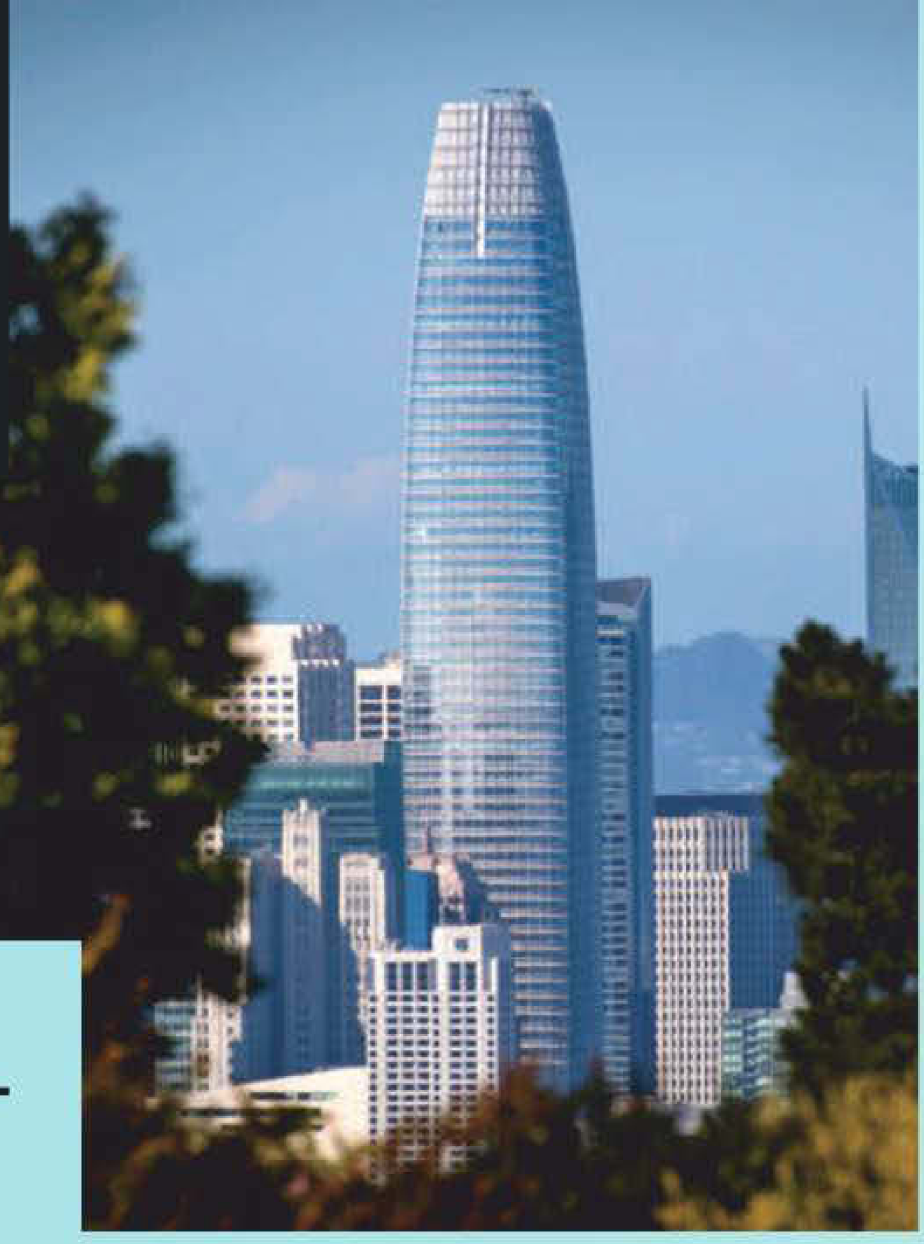
CHINA'S DELIVERY firms have surged thanks to the nation's e-commerce boom. But S.F. Express, a subsidiary of S.F. Holding, has emerged on top. Group revenues in the first half of this year rose 32.2%, and analysts predict 20% future annual growth. The premium courier service distinguishes itself by retaining complete control over its delivery network rather than adopting a franchise model. That network includes a fleet of aircraft, and S.F. Express is investing in drones, too, nabbing China's first government-issued drone delivery license this year.

Market value: **$26.2 billion**

BLOCKBUSTER Jeffrey Wright in a scene from *Hold the Dark*, one of more than 80 feature films that Netflix plans to release in 2018.

50

THE FUTURE 50



LEADERSHIP STRUCTURE
The new Salesforce Tower, San Francisco's tallest building, has become a metaphor for the company's rapid rise.

▲

10

SALESFORCE

U.S. [CRM, $138]

4.1
2.5 1.6

THE LONGTIME LEADER in the enterprise cloud space—and the top scorer in last year's Future 50—took another significant leap forward this May with its $6.5 billion acquisition of MuleSoft, an application integration platform. Tech strategists surmise that Salesforce will use MuleSoft tools, which tout many global brands as customers, to more easily integrate other services provided by cofounder Marc Benioff's company. All four of Salesforce's core cloud product offerings continue to see growth, and BCG estimates that the company will increase revenue as much as 23% annually in the near term. Profits remain slender, amounting to about 6% of Salesforce's $12 billion in sales over the last 12 months. But the company is successfully increasing its cash flow, which jumped 38% in the second quarter of 2018.

Market value: **$104.3 billion**

11

NVIDIA

U.S. [*NVDA, $246*]

4.0
2.8 1.2

NVIDIA'S PRODUCTS are at the forefront of a number of attractive trends, including artificial intelligence, virtual reality, and autonomous vehicles. But it's most highly linked to the gaming sector, which accounts for 57% of revenues. The excitement around these technologies has helped shareholder returns reach an annualized 134% over the past three years. Not all of the company's revenue streams are so glamorous: Nvidia also gets 20% of sales from data centers, creating a stable floor if economic downturns crimp its other businesses.

Market value: **$149.4 billion**

12

NETEASE

CHINA [NTES, $211]

4.0
3.4 0.6

NETEASE WAS founded in 1997 as an Internet services company, but today gaming accounts for nearly two-thirds of its $8.3 billion in revenue. China's government has recently clamped down on the gaming industry, spooking investors and sending Netease's shares down 44% this year. But many see current government opposition as a recalibration of standards, and they expect the industry to recover. Netease's net revenue still grew 22% year over year in the second quarter, and it has a slew of top-end games lined up for release when approvals resume.

Market value: **$27.6 billion**

13

SUNAC CHINA HOLDINGS

CHINA [HK: 1918; $3]

3.9
2.7 1.2

IN MARCH, chairman Sun Hongbin admitted that Sunac's investment in entertainment conglomerate LeEco had been a dud, and declared the company would stick to what it knows: property. Sunac is China's fourth-largest developer by sales, which rose 76% in the first half of this year over the same period in 2017. It builds both residential and commercial projects and specializes in integrations of the two. And it sits on a massive land bank—155.9 million square meters as of June—that includes a large stock of salable land in major cities to fuel future growth.

Market value: **$12.1 billion**

14

ALIBABA GROUP HOLDING

CHINA [BABA, $138]

3.8
2.3 1.5

DURING ITS Singles' Day promotion last year, Alibaba sold $25 billion worth of goods—up 39% from the year before. [Compare that with the "record breaking" $6.6 billion sold in the U.S. on Cyber Monday of 2017.] Not content to dominate the world's largest e-commerce market, Alibaba has expanded aggressively outside China and in other sectors, including cloud computing and food delivery; revenue in fiscal 2018 rose 58% over the previous year. Concerns over the retirement of founder and chairman Jack Ma have dissipated; the juggernaut is poised to succeed without him.

Market value: **$355.7 billion**

COMPANY CAPACITY SCORE
MARKET POTENTIAL SCORE
X.X OVERALL SCORE
X.X X.X

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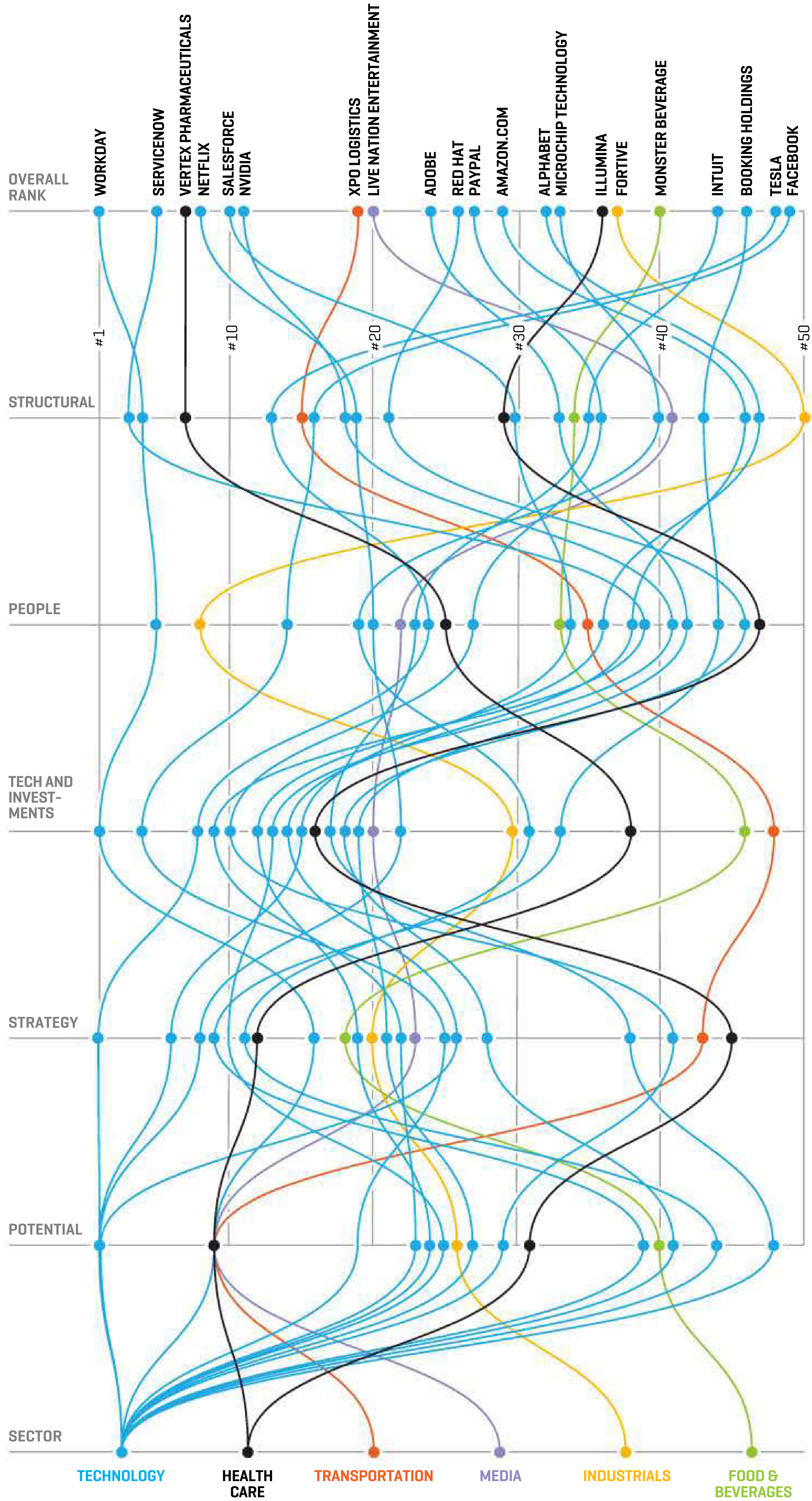
TECH IN THE DRIVER'S SEAT IN THE U.S.

THE MAJORITY OF U.S. companies on this list fall in the technology category. That group is broad enough to include software innovators (Workday, Intuit), a travel specialist (Booking Holdings), and a mass entertainer (Netflix). But their high scores reflect a shared strength: a deep commitment to research. (See the Technology and Investments line.)



15

BAIDU

CHINA (BIDU, $194)

3.8

2.3 1.5

RUMORS THAT Google plans to reenter China don't seem to have disrupted China's paramount search engine. Baidu has flourished in Google's eight-year absence, gaining invaluable expertise in navigating China's heavily politicized cyberspace. It has also boosted ad sales with help from non-search products, like its video and news feed services. Revenue from ads grew 25% year over year in the second quarter, bringing in $3.18 billion. And Baidu aims to become a leader in autonomous driving and A.I., building on its background in intelligent-algorithm design.

Market value: **$68.0 billion**

ROBO-ACQUIRER An M&A spree helped XPO Logistics become a supply-chain giant; tech like this drone is cementing its dominance.

16

TENCENT HOLDINGS

CHINA (TCEHY, $35)

3.7
2.2 1.5

TENCENT'S messaging app, WeChat, recorded 1 billion monthly active users earlier this year—a sign of how indispensable it has become in connecting friends, linking consumers with businesses, and facilitating China's $12 trillion in annual mobile payments. Still, Tencent's core revenue stream is gaming, which accounts for up to two-thirds of the company's $35 billion income. As Chinese government regulations have restricted that industry, Tencent has begun pivoting: In a recent restructuring, it has shifted its focus toward the industrial Internet.

Market value: **$345.6 billion**

17

CELLTRION

SOUTH KOREA ($251)

3.6
2.2 1.4

CELLTRION specializes in "biosimilars"—cheaper generic versions of the pricey "biologic" drugs that are among Big Pharma's bestsellers. Wall Street analysts project that the firm could achieve up to 25% future annual growth, with sales in multiple markets. U.S. regulators approved this country's first biosimilar in 2015. Since then, Celltrion and its partners have won a thumbs-up from an FDA advisory panel for copies of Johnson & Johnson's anti-inflammatory treatment Remicade and, in early October, for Roche's blockbuster cancer drug Rituxan.

Market value: **$31.4 billion**

18

JIANGSU HENGRUI MEDICINE

CHINA ($8)

3.4
2.1 1.3

OVER THE past year, Hengrui, China's largest pharma company, has received half-a-dozen approvals from the FDA, giving global sales at the generic- and innovative-drugs manufacturer a boost—and increasing confidence at home, where drug-contamination scares have left patients skeptical about the industry. Revenue in the first half of 2018 grew 22%, to $1.12 billion. Hengrui is also China's market leader in oncological treatments, where demand is growing fast as the population grays. Its new-drug pipeline should help growth average 26% over the next two years.

Market value: **$30.9 billion**

▲

19

XPO LOGISTICS

U.S. (XPO, $102)

3.4
2.0 1.4

XPO LOGISTICS, which specializes in trucking and other supply-chain services, has grown from $177 million in sales in 2011 to $17 billion today, thanks largely to an incredible run of acquisitions. After a pause of a couple of years, it's shopping again. In August, XPO said it had its eye on a dozen other companies and is prepared to spend up to $8 billion. But XPO also has opportunities for organic growth. In April, it launched XPO Direct, which allows retailers to rent space from XPO in areas where the stores don't have warehouses. This enables retailers to better fulfill the e-commerce promises they've made in their efforts to fend off Amazon. It's a move that could eventually make XPO an Amazon competitor; Deutsche Bank expects XPO Direct to reach $1 billion in revenue within a few years.

Market value: **$13.0 billion**

COMPANY CAPACITY SCORE
MARKET POTENTIAL SCORE
X.X — OVERALL SCORE
X.X X.X

COURTESY OF XPO LOGISTICS

![THE FUTURE 50]

10%

Share of all large global companies that belong to the technology sector

44%

Share of 2018 Future 50 companies that belong to the technology sector

9

Number of Future 50 tech companies with a market capitalization of $100 billion or greater

20

LIVE NATION ENTERTAINMENT

U.S. [LYV, $50]

1.9 | 1.4 | 3.3

INVESTORS IN this leader in concert promotions and ticket sales got a boost in July when news circulated about a potential acquisition by Sirius XM, reportedly backed by Liberty Media (which owns 34% of Live Nation). Instead, Sirius purchased streaming service Pandora, and its CEO said that Live Nation is "not on my mind right now." Whether or not a buyout happens, there are plenty of reasons to be bullish about a company that has delivered a 26% annual shareholder return over the past three years. It's growing its international presence—attendance at its concerts overseas has risen 58% in the past two years, and revenue per fan at its European festivals grew 12% this last quarter. And with its control of Ticketmaster, Live Nation has a big moat against competitors in the U.S.

Market value: **$10.4 billion**

21

AAC TECHNOLOGIES HOLDINGS

CHINA [AACAY, $9]

2.6 | 0.6 | 3.2

YOU MIGHT NOT have heard *of* AAC, but you've almost certainly heard *from* it. AAC is one of the most advanced manufacturers of miniature acoustic components, like the tiny speakers that sit inside iPhone handsets. The behind-the-scenes supplier holds over 2,500 patents, not just in acoustics but in haptics (touch-sensing tech), optics, and other miniaturized tech. A trough in the smartphone market this year has pushed AAC's first-half revenues down 2.5% and its share price even lower, dropping 40% in 2018, but it's well poised to capitalize on the next up cycle.

Market value: **$11.8 billion**

22

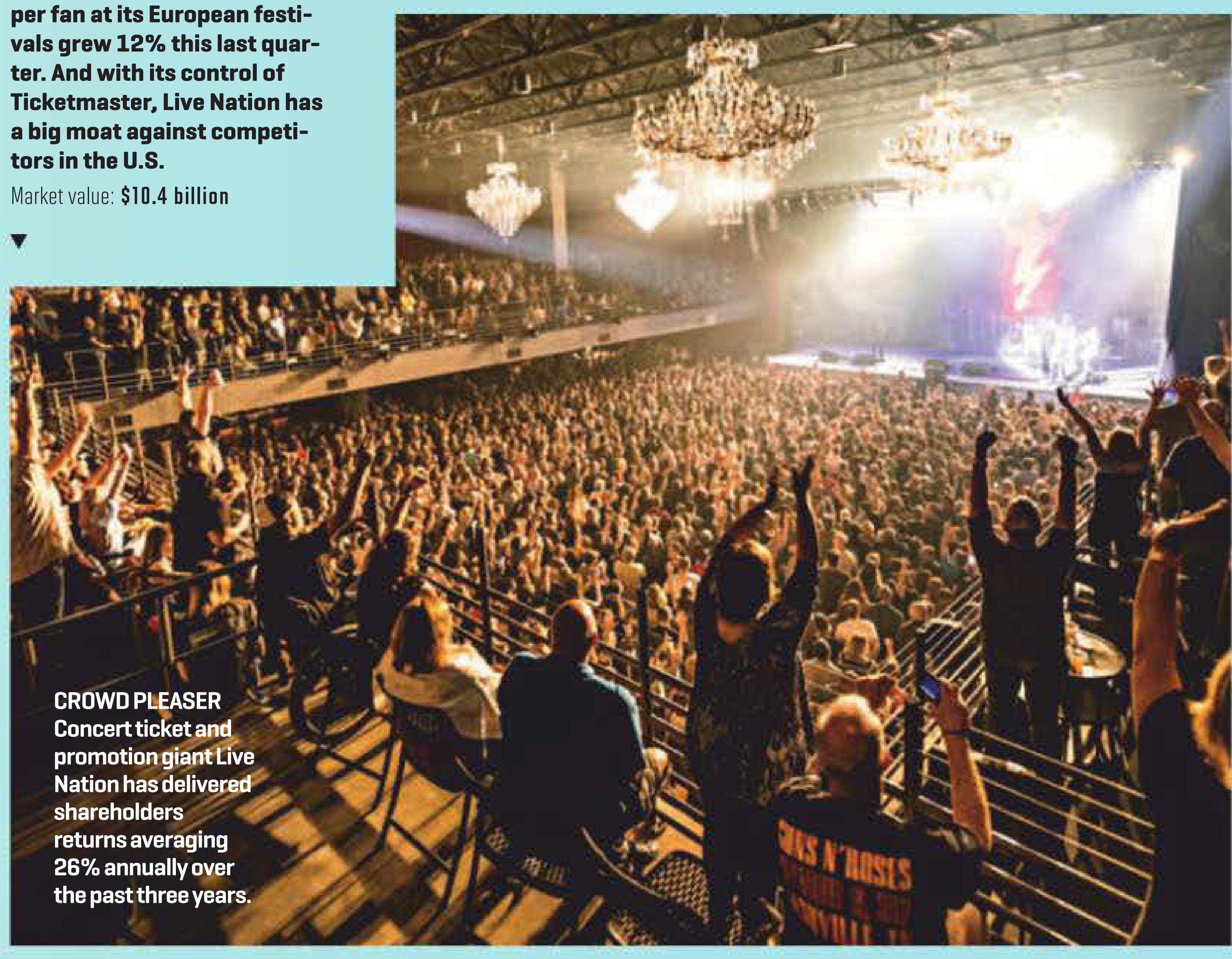
YAHOO JAPAN

JAPAN [YAHOY, $7]

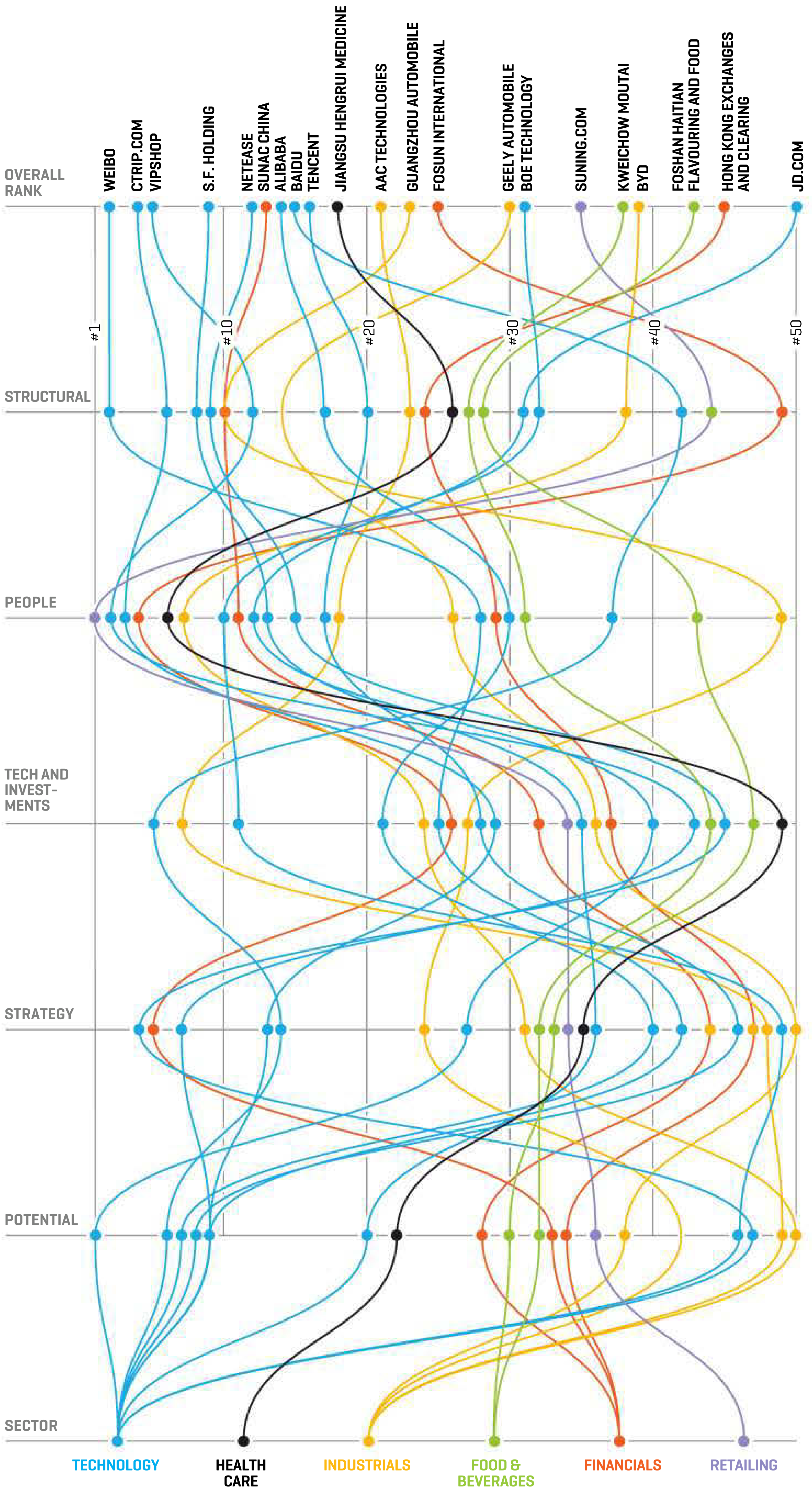
2.5 | 0.7 | 3.2

SPAWNED AS a joint venture between Yahoo and telecom conglomerate SoftBank in 1996, Yahoo Japan owns a market leading Internet portal in its home country. Its stock has slumped this year—a result of Altaba, the successor to the U.S. version of Yahoo, deciding to offload its equity stake. Despite these headwinds, Yahoo Japan's aggressive investment in e-commerce—including bolstering digital payments, turning office supplies vendor Askul into a subsidiary, and offering shopping discounts to fend off rivals like Amazon and Rakuten—suggests signs of a renewal.

Market value: **$17.6 billion**



CROWD PLEASER Concert ticket and promotion giant Live Nation has delivered shareholders returns averaging 26% annually over the past three years.



CHINA'S CONSUMERS MAKE AN IMPACT

THE BIG THREE of Chinese tech—Alibaba, Baidu, and Tencent—hold prominent places on this year's list. But the presence of food and beverage companies (Kweichow Moutai, Foshan Haitian), automakers like Geely and GAC, and travel giant Ctrip reflects the rapid rise and goods-consuming potential of China's growing middle class.

23

GUANGZHOU AUTOMOBILE GROUP (GAC) CHINA (GNZUF, $1)

2.3	0.8	3.1

GAC'S SHARE PRICE slumped a steep 42% this year as investors reacted to international trade tensions and a decline in Chinese auto demand. But growth at the state-owned Chinese automaker reaccelerated in August, and longer-term trends are promising. GAC is lining up to release new models of its Trumpchi brand. (The word means "legend" in Chinese; there's no connection to the U.S. President.) Back home, GAC has expanded production capacity for its joint venture with Toyota, while channeling sizable R&D bets into electric vehicles and autonomous cars.

Market value: **$14.4 billion**

VIRTUAL DA VINCI A researcher at Adobe, the maker of Photoshop, experiments with an augmented reality visor.

▲

24

ADOBE

U.S. [ADBE, $238]

3.1
1.9 1.2

ADOBE'S EPIC transition to a cloud-based, subscription business model continues to pay off, with the Photoshop-maker's stock having risen 65% in the past year. Now the company is on to its next big bet to satisfy Wall Street's appetite for growth: applying data crunching and analytical tools to marketing. In September, Adobe said it would buy marketing specialist Marketo for $4.75 billion; in June, it completed its $1.68 billion acquisition of Magento Commerce, which it plans to fold into its digital analytics business. It's a multibillion-dollar plan to become a giant in a fast-growing, potentially lucrative field—though it's one in which it faces stiff competition from established tech giants like Oracle, SAP, and fellow Future 50 member Salesforce.

Market value: **$116.1 billion**

25

FOSUN INTERNATIONAL

CHINA [FOSUF, $2]

3.1
2.0 1.1

FOSUN FOCUSES its international investments on health, happiness, and wealth. Within that spectrum, its interests run the gamut from a stake in Cirque du Soleil to full ownership of an English Premier League soccer club (the Wolverhampton Wanderers). Fosun also owns package holiday operator Club Med, an entity it may soon offer in an IPO listed in Hong Kong. Profits were up 17% in the first half of 2018, capping a sixth consecutive year of earnings growth. Fosun has also committed to significant deleveraging, opening space for future expansion.

Market value: **$13.9 billion**

26

RED HAT

U.S. [RHT, $118]

3.1
2.2 0.9

THE COMPANY that popularized open-source software for servers has long rewarded investors, with total shareholder returns averaging 29% annually over the past three years. Red Hat hit a speed bump during the second quarter, missing its expected revenue marks and spooking the markets; the company attributed the decline to an anomaly having to do with a past change in its contract model. But revenues still grew by 14% year over year, and among the top 25 customers that renewed, the average contract was at 115% of its previous value.

Market value: **$20.7 billion**

27

PAYPAL

U.S. [PYPL, $75]

3.0
1.9 1.1

PAYPAL HAS soared since its spinoff from eBay in 2015. Propelled by a wider e-commerce boom, the payment company's share price has more than doubled since the parting. Today the business boasts 250 million customers. Features such as One Touch, a tool that saves customers the hassle of reentering information when making a purchase on a new merchant's website or app, have greased the gears. The future looks bright too. Its Venmo app has become synonymous with millennial money-sending. It's literally a verb: "I'll Venmo you." (Go ahead and Google it.)

Market value: **$89.3 billion**

COMPANY CAPACITY SCORE
MARKET POTENTIAL SCORE
X.X OVERALL SCORE
X.X X.X

ORGANIC GROWTH
Amazon's acquisition of Whole Foods gave its e-commerce a brick-and-mortar anchor.

28

DASSAULT SYSTÈMES

FRANCE [DASTY, $131]

2.0 | 1.0 | **3.0**

DASSAULT Systèmes has become one of Europe's leading software companies, thanks in part to its 3DExperience platform and "digital twin" software. Manufacturers on big complex products—naval ships, automobiles, airplanes, oil rigs, even mining equipment—need the software to experiment with designs and modifications before the final construction process. Analysts expect growth of 8% to 13% a year for Dassault as it woos designers beyond autos and aerospace in new arenas like life sciences and consumer packaged goods.

Market value: **$33.6 billion**

▲

29

AMAZON.COM

U.S. [AMZN, $1,755]

1.4 | 1.6 | **3.0**

JEFF BEZOS'S Amazon has become one of the most powerful companies of the modern era. Its stock has risen more than 85% over the past year, in anticipation of more of the same: With forays into cloud computing, streaming video, and high-end grocery stores (through its blockbuster 2017 purchase of Whole Foods), there doesn't seem to be a business that Bezos is afraid of entering. Amazon has come under fire for its labor practices, and some investors want the company to improve its overall profitability. Its recent move to raise its minimum wage for low-ranking workers, to $15 an hour, could address the former criticism while making it more challenging to address the latter.

Market value: **$856.1 billion**

30

GEELY AUTOMOBILE HOLDINGS

CHINA [GELYF, $2]

1.9 | 1.0 | **2.9**

THIS YEAR Geely became the third-ranked carmaker in China, outsold only by Volkswagen and General Motors. Sales at the Chinese automaker, which also owns the Volvo brand, soared 30% in the first half of the year. The company is well positioned to take advantage of the sector's shift to low-emission "new energy" vehicles, notably through its car-sharing brand, Lynk & Co, which will launch in Europe next year, and its ownership of the London EV Company. Geely is also reportedly in talks with Toyota to license that company's hybrid engine technology.

Market value: **$15.8 billion**

31

BOE TECHNOLOGY GROUP

CHINA [$0.43]

2.2 | 0.7 | **2.9**

CHINA'S LARGEST manufacturer of LCD screens is adding huge capacity to its production of flexible OLEDs—the sort that can be used in foldable phones, wearable tech, laptops, and even interactive dashboards in cars. BOE is building two new OLED factories, due to come online by 2020. Its earnings slipped in the second quarter, but LCD pricing appears to have bottomed out and income is expected to rebound. To guard against future troughs, BOE has begun diversifying into health care—leveraging its expertise in A.I., sensors, and screen tech.

Market value: **$15.1 billion**

50 THE FUTURE 50

39%

Google's share of the U.S. digital advertising market, according to eMarketer

24.7 MILLION

Passenger cars sold in China in 2017—42% more than were sold in the U.S. that year

483

Physical stores in the Whole Foods network. Many now do double-duty as Amazon distribution points

COMPANY CAPACITY SCORE | MARKET POTENTIAL SCORE | OVERALL SCORE

X.X | X.X | X.X

32

ALPHABET

U.S. [GOOGL, $1,092]

1.6 1.3 **2.9**

THE CORE GOOGLE search product remains the driver of Alphabet's business, thanks to its incredibly lucrative online advertising franchise. But other businesses are emerging as potential blockbusters: Google's Waymo self-driving car division is on the rise, its cloud-computing platform recently had its first $1 billion quarter, and analysts believe YouTube's video service could generate up to $20 billion in revenue this year. The multibillion-dollar question: Whether discomfort with Google's market power could create more tension with regulators.

Market value: **$756.0 billion**

33

MICROCHIP TECHNOLOGY

U.S. [MCHP, $66]

2.0 0.8 **2.8**

WHEN THIS Arizona-based microelectronics maker went public in 1993, it was a penny stock. Twenty-five years later, the company's shares trade at $66. The world's seemingly bottomless appetite for computer chips has kept the business growing at a healthy clip, leading to nearly $4 billion in sales in its last fiscal year. Microchip Technology, known for its tiny, computer-like, microcontroller circuits, continues to expand by making big acquisitions, most recently picking up Microsemi, a California manufacturer, for $10 billion.

Market value: **$15.7 billion**

34

TOKYO ELECTRON

JAPAN [TOELY, $32]

2.0 0.8 **2.8**

IT MAY NOT BE a household name in computer chips like Intel or AMD, but Tokyo Electron, which had $10.6 billion in sales in its most recent fiscal year, plays a crucial role in the semiconductor industry. Besides selling the equipment used to manufacture chips, Tokyo Electron also makes machines used to produce high-quality flat-panel display screens for personal computers and LCD televisions. Though it's vulnerable to overall slowdowns in the semiconductor industry, Tokyo Electron's exposure to the screen industry offers it a separate source of growth.

Market value: **$21.4 billion**

35

SUNING.COM

CHINA [$2]

1.7 1.1 **2.8**

SUNING IS A ROLE MODEL for traditional retailers seeking to adapt smoothly to e-commerce. The electronics retailer has become a "clicks and mortar" powerhouse, exploring new retail formats such as "unmanned stores," and over 40% of its sales are now online. Suning has used its network of some 4,000 stores and over 6 million square meters of warehousing to facilitate deliveries of online orders; that same network is the foundation of a fast-growing third-party logistics service. Sales for Suning as a whole rose 32% year over year in the first half of 2018.

Market value: **$17.1 billion**

SNACKBOT Electronics retailer Suning uses autonomous robots to deliver parcels—and in some cities, drinks and food.

© IMAGINECHINA

STILL LIFE WITH SORGHUM **Kweichow Moutai distillery workers processing grains that will be used to make *baijiu* liquor.**

36

ILLUMINA

U.S. [ILMN, $305]

2.7
1.6 1.1

GENETIC TESTING is having a heyday as the process of sequencing genomes becomes cheaper and more ubiquitous. Illumina has capitalized with its testing expertise. It partners with consumer-focused DNA testing services like 23andMe, and with pharma giants like Bristol-Myers Squibb who seek its help with drug development. Last year, the FDA approved Illumina's companion diagnostic for Amgen's Vectibix, a drug for metastatic colorectal cancer. In the past 12 months, Illumina has provided a 60% return to shareholders; over the past five years, that figure is 306%.

Market value: **$44.8 billion**

37

FORTIVE

U.S. [FTV, $80]

2.7
1.5 1.2

IN THE TWO YEARS since Fortive separated from parent company Danaher, its stock has popped 60%. The conglomerate has two broad divisions. One focuses on instruments that measure and monitor, like gas detectors and electricians' tools. The other sells equipment, services, and software to the transportation and auto repair industries. Fortive recently acquired Accruent, a software provider that helps businesses manage real estate and facilities—and whose subscription business model is the kind Wall Street prizes for its predictability.

Market value: **$26.8 billion**

▲

38

KWEICHOW MOUTAI

CHINA [$97]

2.7
1.6 1.1

***BAIJIU* IS China's native liquor. A clear, colorless spirit made from sorghum wheat, it's used for toasts at banquets, offered as a gift to guests, or simply knocked back over dinner. Kweichow Moutai produces China's most illustrious *baijiu*, taking its name from the village that is home to its distillery. Moutai's stock took a dive in 2013 following President Xi Jinping's crackdown on lavish government spending. But the company rebounded because Moutai *baijiu* is as much a cultural product as a physical one. Kweichow Moutai has seen heady growth in more recent years. In 2017, Moutai overtook Diageo to become the world's most valuable liquor company. Its market cap has ballooned 67% since then, and revenues for the first half of 2018 rocketed 38% year over year, to $4.86 billion.**

Market value: **$121.7 billion**

39

BYD COMPANY

CHINA [BYDDY, $13]

2.6
2.0 0.6

BYD IS an acronym for "Build Your Dreams." Its own dream began with rechargeable batteries, which BYD made for smartphone makers. That led to bigger batteries—powerful enough to be used in cars. In 2008, Warren Buffett's Berkshire Hathaway took an 8.25% stake in BYD: That stake is now worth roughly $1.5 billion, and BYD has become the world's top seller of electric vehicles themselves, shipping 108,000 units last year. BYD plans to sell batteries to other EV makers before the year is out, and is partnering with Baidu to build autonomous vehicles.

Market value: **$17.9 billion**

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COMPANY CAPACITY SCORE — MARKET POTENTIAL SCORE
X.X X.X — X.X — OVERALL SCORE

50

THE FUTURE 50

190
MILLION

The number of people in India without bank accounts—a potential customer base for Kotak Mahindra

$122
BILLION

The market capitalization of China's Kweichow Moutai, the world's most valuable liquor company

7
OUT OF 10

Share of the Thai convenience store market held by CP All, comprising 10,268 7-Eleven franchises

40

MONSTER BEVERAGE

U.S. [MNST, $54]

2.6
1.6 1.0

MONSTER HAS grown sales by 13% over the past six months, and sales outside the U.S. are up more than 18% year over year as the energy-drink maker begins to enjoy international expansion in the wake of a distribution deal with Coca-Cola in 2015. The beverage sector is traditionally a difficult one for sustained growth, but Monster's energy drinks are seen as a lifestyle brand among many young shoppers. The company has also been aggressive about innovating with new products; it plans to introduce new beverages in China and India by early next year.

Market value: **$29.8 billion**

41

CP ALL

THAILAND [BKK: CPALL; $2]

2.5
1.5 1.0

YOU CAN BARELY walk a block in Bangkok without coming upon a 7-Eleven (on some blocks, you'll find more than one), which helps explain the strong results of its $15 billion franchise operator, CP All. The gleaming convenience stores have become as indispensable as they are ubiquitous (market share in the country is about 70%). Beyond snack foods (chilli-squid-flavored Lay's chips, for example) and Slurpees (Thai style, of course), stores offer bill payment for cell phones and utility services, and will soon launch banking. Annualized total shareholder return for the company was 16% over the three years through Sept. 10, and analysts forecast (coincidentally) 7% to 11% annual future growth for the chain, which is trying to achieve the same omnipresence outside the Thai capital.

Market value: **$18.8 billion**

42

KOTAK MAHINDRA BANK

INDIA [NSE: KOTAKBANK; $15]

2.5
1.1 1.4

FOUNDED IN 1985, this Mumbai bank almost doubled its customer base—from 8 million to 14.5 million—between March 2017 and this summer. The growth spurt was ignited by Kotak Mahindra's 2017 launch of 811, an effort at inclusive banking, that offers all Indians a digital bank account in less than five minutes. It's cheap, too, with zero charges for digital transactions. The relatively small bank ($3.9 billion in 2017 net revenue) is now building out its branch network to physically be where its new customers are. Analysts project it's on track for 25% annual growth.

Market value: **$29.2 billion**

LUCKY NUMBERS
CP All has turned its more than 10,000 7-Eleven convenience stores into a $15 billion business.

HANNAH REYES MORALES—BLOOMBERG VIA GETTY IMAGES

COMPANY CAPACITY SCORE
MARKET POTENTIAL SCORE
X.X OVERALL SCORE
X.X X.X

MOBILITY AND THE RISE OF THE MODERN WORKPLACE

Organizations are gaining benefits from the connected workspace—including increased speed to market, greater productivity, and higher employee satisfaction.

ORGANIZATIONS ACROSS EVERY business sector are confronting the mandate to go digital. It's occurring at a fast pace and involves a number of innovations, from the Internet of Things (IoT) and cloud services to artificial intelligence (AI) and robotics. The connected workspace capitalizes on these technologies—accelerating time to market, expanding corporate end-user capabilities, and improving business processes (supply chain, marketing, customer service, etc.). These advances revolve around a mobile-first strategy that enables end users to have instant, secure access to productivity apps and data.

Digital adoption and the careful orchestration of technologies are key to building the 21st-century corporation. Lenovo, in partnership with technology provider CDW, is building those innovative solutions that support the connected workspace. For example, today's workforce demands customized end-user experiences to support diverse and unique work styles. It requires an approach that will enable new levels of mobility, allowing end users to deploy mobile apps to be even more creative and productive—anywhere, anytime, and on any device.

In the "always on, always connected" workspace, employees can gather, monitor, track, and analyze vast amounts of data using the remote IoT sensors and AI embedded in Lenovo end-user devices. It's an example of a smart office, which allows end users to freely collaborate and create their own personalized workflows. That same level of versatility extends to IT operations and the data center.

"Our entire portfolio of servers, storage, software-defined infrastructure, networking, and services provides the data center support to power the Lenovo devices you use every day," says Tom Butler, director, WW Commercial Portfolio and Product Management at Lenovo.

In fact, due to increased connectivity, companies are changing how they store, access, and secure data, and they're looking for more powerful solutions to help them reach their goals. Lenovo's ThinkSystem and ThinkAgile solutions enable organizations to meet that constant demand, ensuring that every device on the network has instant access and high availability.

In partnership with CDW, Lenovo is using innovative IT to support organization mobility and transform the modern workplace. In health-care, that means wireless connectivity and a range of devices for in-hospital diagnostics, remote care monitoring, and secure access to patient data. In manufacturing, that model consists of using IoT intelligence to inform production processes on a global scale.

"More than ever, employees want flexibility," says Butler. The connected workspace ensures not only that businesses gain a competitive edge but also that end users have seamless access to all of the productivity apps they need on whatever device they choose. "To support that choice, we continuously invest and innovate with our industry-leading ThinkPads, ThinkCentres, and ThinkStations, all backed up by our award-winning data center portfolio to provide end-to-end solutions for the modern workforce," he says.

Lenovo

CDW PEOPLE WHO GET IT

SECRET SAUCE Foshan Haitian dominates the Chinese market for condiments like soy sauce, oyster sauce, and vinegar.

THE FUTURE 50

$695 BILLION

Projected value of travel booked online worldwide in 2018, according to eMarketer—a 10.4% increase from 2017

43

FOSHAN HAITIAN FLAVOURING & FOOD

CHINA [$11]

2.5
1.4 1.1

SO LONG AS there's Chinese food, it seems, there will be soy sauce. That explains the growth trajectory of Foshan Haitian, which makes and sells a smorgasbord of condiments vital to Chinese cuisine—including oyster sauce and vinegar as well as soy sauce. It's the leading brand in the market, and sales to the catering industry contribute the majority of FH's revenues. As China's growing middle class opts to eat out more often, the shift away from home cooking should have a positive impact on FH's income. Soybeans were one of the earliest victims of the China-U.S. trade war, and FH's costs may swell in the short term. Revenue for the second quarter, meanwhile, were down 14% from the previous quarter. But analysts project future annual growth of up to 17% for the soy sauce giant.

Market value: **$29.5 billion**

44

INTUIT

U.S. [INTU, $204]

2.5
1.9 0.6

FEW COMPANIES have reinvented themselves as successfully, or as often. Intuit, the maker of tax and small-business software, has adapted and improved its product line to transition from the DOS epoch of the 1980s, through the Windows decades, and again for today's open-platform mobile era. Its secret, revealed by *Fortune* in the 2017 Future 50 issue, is a "change before it's needed" culture of continuous innovation. A pending turnover of the CEO role, from 11-year veteran Brad Smith to Sasan Goodarzi, hasn't fazed investors: Intuit shares are up 28% for the year.

Market value: **$52.9 billion**

45

HONG KONG EXCHANGES AND CLEARING

CHINA [$26]

2.4
1.4 1.0

A SLEW OF Chinese IPOs has been good news for the operator of Hong Kong's bourse. The exchange revamped its regulations this year to attract more companies from mainland China. Companies can now register dual-class shares in Hong Kong, allowing executives to raise money without diluting ownership—incentives that enticed big names such as Xiaomi and Meituan. Hong Kong's "stock connect" arrangements, which open mainland China's markets to foreign investors, are also driving growth. Revenue hit a record $1 billion in the six months through June.

Market value: **$33.2 billion**

46

BOOKING HOLDINGS

U.S. [BKNG, $1,789]

2.4
1.4 1.0

BOOKING HOLDINGS, previously known as the Priceline Group, is the second-largest online travel agency in the world, and its execution and advantages in scale and efficiency make it a formidable challenger and a Wall Street favorite. Booking has steadily gained international market share, with 8% to 11% growth projected annually, and its share price has nearly doubled in the past five years. The next challenge for the owner of brands like Kayak and OpenTable: balancing growth goals and profit margins, which have been squeezed by high advertising costs.

Market value: **$84.9 billion**

COMPANY CAPACITY SCORE — MARKET POTENTIAL SCORE
X.X — OVERALL SCORE
X.X X.X

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Holiday Retirement Is Making Work More Meaningful

This provider of senior living communities is cultivating a workplace built on caring and an enthusiasm for meaningful living.

FORTUNE BEST WORKPLACES FOR AGING SERVICES 2018

FOR THE PAST TWO YEARS, Holiday Retirement has been busy reinventing itself. The 47-year-old company, which is the country's largest provider of independent senior living communities, recently brought in a new CEO, moved from Oregon to Florida, and revamped its management model. This month, it won a place on *Fortune*'s inaugural list of Best Workplaces for Aging Services.

That's good news both for residents of the company's 262 retirement communities and its nearly 9,000 employees.

"We have a big, audacious goal," says Lilly Donohue, who became CEO in 2016. "We want to be known as the happiest place for elders to call home."

To meet that goal, Donohue says Holiday also has to make itself the happiest place for employees to work. "You have to engage employees," she says, noting that housekeepers, servers, executive chefs, and resident experience coordinators are among those most directly affecting residents' lives. "We know a highly engaged workforce drives customer satisfaction, which impacts our financial performance to create significant opportunities and innovation."

Under the customer-centered business model, Holiday's corporate offices function as a support center. To that end, the company has been redirecting resources to its communities and removing barriers to communication between top leadership and employees. One result has been a flood of new ideas, ranging from a speed-dating initiative being launched for residents in West Covina, Calif., to incentives for hourly employees who provide tours for potential residents in the Corvallis, Ore., community.

Technology is playing a big part in the transformation. The company has embraced a cloud infrastructure to seamlessly provide business information to and from its communities, thus reducing costs and improving reliability. Residents, too, are benefiting: Each is provided with a mobile device that can connect them to emergency services in a matter of seconds, no matter where they are.

By attracting employees who are the best and brightest, Donohue hopes to fuel a culture change in the senior services sector. "This hasn't always been a sexy sector," she says, adding that Holiday is committed to becoming a fun, interesting, and rewarding place to work. It also offers significant opportunities for advancement.

The Best Workplaces award is an important step toward changing the conversation about aging. But Donohue says it is the employees who deserve the credit. "They are the ones creating the great place," she says. "I am the cheerleader."

"We have a big, audacious goal. We want to be known as the happiest place for elders to call home."

LILLY DONOHUE
CEO
Holiday Retirement

HIGH REWARDS, REAL RISKS

THE COMPANIES featured here have great forward-looking DNA, by the metrics of the Future 50. But each of the four faces legal actions or tensions with regulators that threaten to hamstring its progress. Sometimes those problems are a consequence of their own breakneck success; other times they're the result of allegations against their leaders. Not coincidentally, all four have seen their shares tumble this year—creating opportunities for risk-takers.

47

SAMSUNG BIOLOGICS

SOUTH KOREA [$428]

THIS BIOTECH manufacturer, a publicly listed joint venture of two companies affiliated with the Samsung conglomerate, brought in only $400 million in revenue in 2017. But through partnerships with Biogen and AstraZeneca, it holds a stake in the world's largest pipeline for biosimilar generic drugs—a pipeline that analysts believe can generate annual revenue growth of 40% to 60% for years to come. In July, South Korean regulators ruled that the company violated accounting standards in structuring one of its partnerships and referred the case to prosecutors. In a statement, the company said its actions were legal.

Future 50 Score: **6.3**
Market value: **$28.3 billion**

48

TESLA

U.S. [TSLA, $257]

ONE OFTEN-CITED statistic encapsulates the potential of this electric-car pioneer: On multiple occasions over the past two years, Tesla, which delivered about 100,000 vehicles in 2017, enjoyed a higher market value than General Motors, which sold 9.6 million that year. In the most recent quarter, Tesla's mid-price Model 3 ranked for the first time among the five top-selling sedans in the U.S.—a milestone in founder and CEO Elon Musk's quest to make electric vehicles ubiquitous and affordable. The question is whether Musk can steer Tesla in a straight line. This fall, the SEC sued him for misleading investors in a Twitter post about taking the company private (one of numerous impolitic Musk tweets). In a settlement, Musk gave up Tesla's chairmanship. Production problems and executive turnover, meanwhile, have fueled doubts about Tesla's stability.

Future 50 Score: **5.5**
Market value: **$43.8 billion**

▼

TOO FAST, TOO FURIOUS Cofounder and CEO Elon Musk has turned Tesla into one of the world's most promising companies—but his public behavior has exacerbated doubts about its future.

49

FACEBOOK

U.S. [FB, $151]

FACEBOOK HAS upended the media industry, rewritten the rules of advertising, and changed the way many of its 1.47 billion daily active users relate to friends and family. Even as growth slackens for Facebook's core product, Wall Street believes its other units—including photo hub Instagram and the WhatsApp messaging service—can fuel revenue increases of 20% to 30% a year. Still, Facebook's vast reach has magnified scrutiny of its flaws, including shaky protections for user data and a troubling role in spreading fake news. Fears of user backlash and tighter regulation have helped send its shares down 30% since July.

Future 50 Score: **4.7**
Market value: **$437.1 billion**

50

JD.COM

CHINA [JD, $23]

ALIBABA GETS most of the attention in conversations about e-commerce in China, but JD.com has been a potent No. 2. The company has become a $64 billion juggernaut, thanks to an emphasis on "high touch" relationships with its sellers and a concerted effort to reach neglected consumers in China's rural areas and so-called lower-tier cities. Founder and CEO Richard Liu has been the driving force behind its success, but he now faces uncomfortable scrutiny; prosecutors in Minnesota are reviewing allegations that Liu raped a college student during a visit to Minneapolis in August. (Liu's attorneys say he is innocent.) F

Future 50 Score: **3.6**
Market value: **$32.8 billion**

T. FALLON—BLOOMBERG VIA GETTY IMAGES

CREATING A BETTER WORLD THROUGH BUSINESS

CECP is a CEO led coalition that believes that a company's social strategy — how it engages with key stakeholders including employees, communities, investors, and customers —determines company success.

Founded in 1999 by actor and philanthropist Paul Newman and other business leaders to create a better world through business, CECP has grown to a movement of more than 200 of the world's largest companies that represent $7 trillion in revenues, $18.6 billion in societal investment, 13 million employees, and $15 trillion in assets under management.

CECP helps companies transform their social strategy by providing customized connections and networking, counsel and support, benchmarking and trends, and awareness building and recognition.

Learn more about the movement at **cecp.co**

NRG Energy values being a good neighbor to the communities where we operate. Here, Mauricio Gutierrez, President and CEO, NRG Energy volunteers with local causes.

Tim Hockey, President and CEO of TD Ameritrade, works alongside employees to transform lives at a Habitat for Humanity build.

More than 75% of WellCare associates volunteered to support their communities in 2017.
Here Ken Burdick, CEO, lends a hand at Feeding Tampa Bay Mobile Pantry.

CECP is pleased to welcome 36 new corporations to the CEO Force For Good over the last year:

- 21st Century Fox
- AmerisourceBergen Corporation
- Blackbaud, Inc.
- BlackRock Financial Management Inc.
- Brookfield Asset Management Inc.
- BrownFlynn
- CarMax Business Services, LLC
- Catalent
- CIT Group Inc.
- Cognizant Technology Solutions Corporation
- Comcast NBCUniversal
- EILEEN FISHER, Inc.
- Equinix, Inc.
- Genworth Financial, Inc.
- Heidrick & Struggles International, Inc.
- Herman Miller, Inc.
- Hermes Investment Management
- Hyatt Corporation
- IKEA Group
- International Paper Company
- Kohl's Corporation
- L'Oréal SA
- Mars, Inc.
- NRG Energy, Inc
- Pinnacle Foods, Inc.
- Regeneron Pharmaceuticals
- RHR International LLP
- SAP AG
- Sidley Austin LLP
- TD Ameritrade Holding Corporation
- The Hershey Company
- The NASDAQ Stock Market
- WellCare
- Workday
- Wynn Resorts Ltd

CECP
THE CEO FORCE FOR GOOD

A Mission for Service and a Passion for Care

Legend Senior Living® remains true to its core values by supporting employees and enhancing quality of life for residents and their families.

LEGEND SENIOR LIVING TAKES PRIDE IN ITS commitment to providing top service and the finest care. The family-owned business, based in Wichita, Kans., operates 40 residences in the U.S., offering independent living, assisted living/personal care, and memory care services.

Tim Buchanan, founder and CEO of Legend, pioneered the concept of assisted living nearly 30 years ago, with the goal of improving quality of life for residents and their families, as well as for employees. Today, the company remains true to that original calling, putting core values such as servanthood, teamwork, stewardship, and caring front and center each day. "It is fulfilling knowing the hard work associates do is changing the lives of other human beings and their families," says Buchanan.

Legend recognizes that while working in an assisted living residence is rewarding, it can also be stressful and physically demanding. To that end, in 2013, the company committed hundreds of thousands of dollars to new training, development, and stress-reduction programs for employees. Active, encouraging experiences and personal connections are built into associates' daily rhythm. Legend has also gone to great lengths to provide a safe work environment for employees. In 2014, it created SafetyWorx™, a program based on 58 safety procedures and reporting metrics.

Both initiatives contributed to the program winning the 2015 Argentum Best of the Best Award, a national industry award that recognizes excellence in senior living.

Legend's concern for its employees also extends beyond the workplace. Recognizing that serving seniors is a 24/7 business, the company's culture encourages a healthy work-life balance. Flexibility in scheduling makes it easier for associates to pick up their children and attend school events or family functions, and the company also provides generous paid time off, offering extended time away to allow employees to visit their families in other countries.

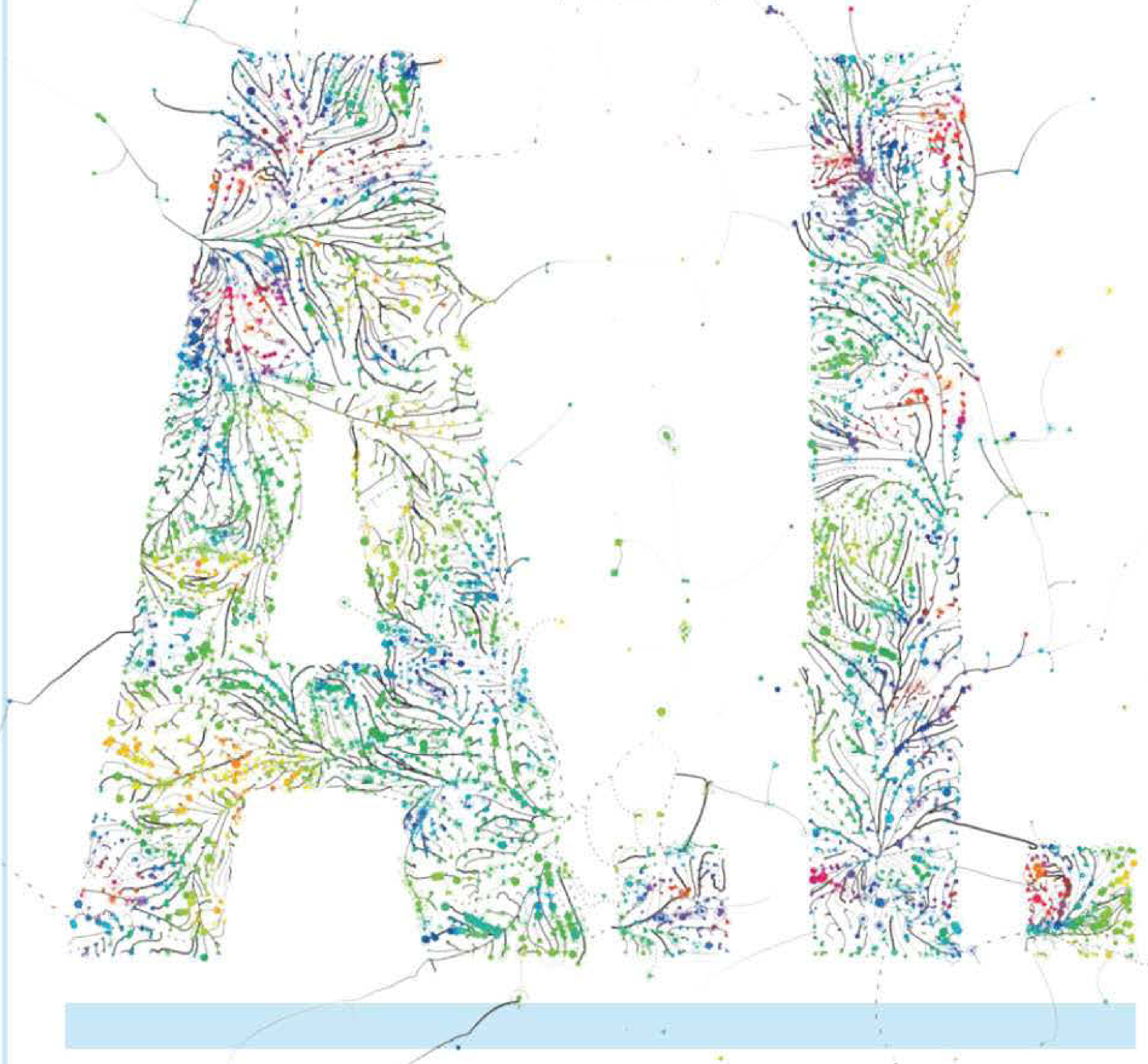
And Legend's employees reflect its magnanimity. After Hurricane Irma, when the company donated tens of thousands of dollars to stock refrigerators with goods and help with flood expenses, workers chipped in thousands of their own dollars as well. "We really are excited to see the Legend culture and spirit of our associates in action," says Buchanan. "Fostering a culture of generosity has added richness to the lives of both the givers and recipients." ■

"Fostering a culture of generosity has added richness to the lives of both the givers and recipients."

TIM BUCHANAN
FOUNDER & CEO, Legend Senior Living

MATT BUCHANAN, EXECUTIVE VICE PRESIDENT

FORTUNE



MAYBE WE FEAR IT. Maybe we hope for too much from it. Whatever our motivation, most of us—as business leaders or consumers—have yet to grapple with what artificial intelligence can do. When consultancy Pegasystems recently asked Americans whether they believed they had interacted with A.I., only one in three said yes; in fact, almost 85% had done so. As that figure suggests, A.I. is beginning to touch ever more facets of our lives, and we owe it to ourselves to start thinking in a clear-eyed way about its perils and potential.

In this special package, Kai-Fu Lee, the venture capitalist and former head of Google China, describes the "Four Waves" of advances that are enabling A.I.'s rise (page 92). *Fortune*'s staff offers a whirlwind tour of the ways A.I. is already changing the business world (page 96). And in "It Might Get Loud" (page 112), we explore how A.I. could turn voice-recognition into a dominant way of interacting with technology. Could Alexa or Siri discuss these stories with you in depth? Not yet... but wait till next year. —*Matt Heimer*

THE FOUR WAVES OF A.I.

BY KAI-FU LEE

▲ PHOTOGRAPH BY REED YOUNG

T

THE TERM "ARTIFICIAL INTELLIGENCE" was coined in 1956, at a historic conference at Dartmouth, but it has been only in the past 10 years, for the most part, that we've seen the first truly substantive glimpses of its power and application. A.I., as it's now universally called, is the pursuit of performing tasks usually reserved for human cognition: recognizing patterns, predicting outcomes clouded by uncertainty, and making complex decisions. A.I. algorithms can perceive and interpret the world around us—and some even say they'll soon be capable of emotion, compassion, and creativity—though the original dream of matching overall "human intelligence" is still very far away.

What changed everything a decade or so ago was an approach called "deep learning"—an architecture inspired by the human brain, with neurons and connections. As the name suggests, deep-learning networks can be thousands of layers deep and have up to billions of parameters. Unlike the human brain, however, such networks are "trained" on huge amounts of labeled data; then they use what they've "learned" to mathematically pick out and recognize incredibly subtle patterns within other mountains of data. A data input to the network can be anything digital—say, an image, or a sound segment, or a credit card purchase. The output, meanwhile, is a decision or prediction related to whatever question might be asked: *Whose face is in the image? What words were spoken in the sound segment? Is the purchase fraudulent?*

This technological breakthrough was paralleled with an explosion in data—the vast majority of it coming from the Internet—which captured human activities, intentions, and inclinations. While a human brain tends to focus on the most obvious correlations between the input data and the outcomes, a deep-learning algorithm trained on an ocean of information will discover connections between obscure features of the data that are so subtle or complex we humans cannot even describe them logically. When you combine hundreds or thousands of them together, they naturally outstrip the performance of even the most experienced humans. A.I. algorithms now beat humans in speech recognition, face recognition, the games of chess and Go, reading MRIs for certain cancers, and any quantitative field—whether it's deciding what loans to approve or detecting credit card fraud.

Such algorithms don't operate in a vacuum. To perform their analyses, they require huge sets of data to train on and vast computational power to process it all. Today's A.I. also functions only in clearly defined single domains. It's not capable of generalized intelligence or common sense—AlphaGo, for example, which beat the world's masters in the ancient game of Go, does not play chess; algorithms trained to determine loan underwriting, likewise, cannot do asset allocation.

With deep learning and the data explosion as catalysts, A.I. has moved from the era of discovery to the era of implementation. For now, at least, the center of gravity has shifted from elite research laboratories to real-world applications. In essence, deep learning and big data have boosted A.I. onto a new plateau. Companies and governments are now exploring that plateau, looking for ways to apply present artificial intelligence capabilities to their activities, to squeeze every last drop of productivity out of this groundbreaking technology (see our next story). This is why China, with its immense market, data, and tenacious entrepreneurs, has suddenly become an A.I. superpower.

What makes the technology more powerful still is that it can be applied to a nearly infinite number of domains. The closest parallel we've seen up until now may well be electricity. The current era of A.I. implementation can be compared with the era in which humans learned to apply electricity to all the tasks in their life: lighting a room, cooking food, powering a train, and so on. Likewise, today we're seeing the application of A.I. in everything from diagnosing cancer to the autonomous robots scurrying about in corporate warehouses.

FROM WEB-LINKED TO AUTONOMOUS

A.I. APPLICATIONS can be categorized into four waves, which are happening simultaneously, but with different starting points and velocity:

The first stage is "Internet A.I." Powered by the huge amount of data flowing through the web, Internet A.I. leverages the fact that users automatically label data as we browse: buying vs. not buying, clicking vs. not clicking. These cascades of labeled data build a detailed profile of our personalities, habits, demands, and desires: the perfect recipe for more tailored content to keep us on a given platform, or to maximize revenue or profit.

The second wave is "business A.I." Here, algorithms can be trained on proprietary data sets ranging from customer purchases to machine maintenance records to complex business processes—and ultimately lead managers to improved decision-making. An algorithm, for example, might study many thousands of bank loans and repayment rates, and learn if one type of borrower is a hidden risk for default or, alternatively, a surprisingly good, but overlooked, lending prospect. Medical researchers, similarly, can use deep-learning algorithms to digest enormous quantities of data on patient diagnoses, genomic profiles, resultant therapies, and subsequent health outcomes and perhaps discover a worthy personalized treatment protocol that would have otherwise been missed. By scouting out hidden correlations that escape our linear cause-and-effect logic, business A.I. can outperform even the most veteran of experts.

The third wave of artificial intelligence—call it "perception A.I."— gets an upgrade with eyes, ears, and myriad other senses, collecting new data that was never before captured, and using it to create new applications. As sensors and smart devices proliferate through our homes and cities, we are on the verge of entering a trillion-sensor economy. This includes speech interfaces (from Alexa and Siri to future supersmart assistants that remember everything for you) as well as computer-vision applications—from face recognition to manufacturing quality inspection.

The fourth wave is the most monumental but also the most difficult: "autonomous A.I." Integrating all previous waves, autonomous A.I. gives machines the ability to sense and respond to the world around them, to move intuitively, and to manipulate objects as easily as a human can. Included in this wave are autonomous vehicles that can "see" the environment around them: recognizing patterns in the camera's pixels (red octagons, for instance); figuring out what they correlate to (stop signs); and then using that information to make decisions (applying pressure to the brake in order to slowly stop the vehicle). In the area of robotics, such advanced A.I. algorithms will be applied to industrial applications (automated assembly lines and warehouses), commercial tasks (dishwashing and fruit-harvesting robots), and eventually consumer ones too.

THE CHANGES YET TO COME

BECAUSE A.I. CAN BE PROGRAMMED to maximize profitability or replace human labor, it adds immediate value to the economy. A.I. is fast, accurate, works around-the-clock, doesn't complain, and can be applied to many tasks, with substantial economic benefit. How substantial? PwC estimates that the technology will contribute about $16 trillion to worldwide GDP by 2030.

But that gift doesn't come without challenges to humanity. The first and foremost is job displacement: Since A.I. can perform single tasks with superhuman accuracy—and most human jobs are single-task—it follows that many routine jobs will be replaced by this next-generation tech. That includes both white-collar and blue-collar jobs. A.I. also faces questions with security, privacy, data bias, and monopoly maintenance. All are significant issues with no known solution, so governments and corporations should start working on them now.

But one concern we don't have to face quite yet is the one that may be most common these days, cast in the image of science-fiction movies—that machines will achieve true human-level (or even superhuman-level) intelligence, making them capable presumably of threatening mankind.

We're nowhere near that. Today's A.I. isn't "general artificial intelligence" (the human kind, that is), but rather narrow—limited to a single domain. General A.I. requires advanced capabilities like reasoning, conceptual learning, common sense, planning, cross-domain thinking, creativity, and even self-awareness and emotions, which remain beyond our reach. There are no known engineering paths to evolve toward the general capabilities above.

How far are we from general A.I.? I don't think we even know enough to estimate. We would need dozens of big breakthroughs to get there, when the field of A.I. has seen only one true breakthrough in 60 years. That said, narrow A.I. will bring about a technology revolution the magnitude of the Industrial Revolution or larger—and one that's happening much faster. It's incumbent upon us to understand its monumental impact, widespread benefits, and serious challenges. F

This essay is adapted from Lee's new book, AI Superpowers: China, Silicon Valley, and the New World Order *(Houghton Mifflin Harcourt). He is the chairman and CEO of Sinovation Ventures and the former president of Google China.*

▶ Artificial intelligence is already changing the way we work.

▲ PHOTOGRAPHS BY
THE VOORHES

25 WAYS A.I. IS CHANGING BUSINESS

IT'S TIME TO GET REAL ABOUT A.I.'S FUTURE, a subject in desperate need of discipline. The technology's mind-blowing possibilities have apparently inebriated various seers, who take two routes to fantasyland: propagating boldly precise forecasts of jobs to be spawned and destroyed years hence, or spinning tales of A.I. transforming our world into a heaven (or hell). Instead, we wanted to confront the realities of how A.I. is changing business—minus the melodrama.

On the chief source of A.I.-induced anxiety—employment effects—the reality is that no one knows or can know what's ahead, not even approximately. The reason is that we can never foresee human ingenuity, all the ways in which millions of motivated entrepreneurs and managers worldwide will apply rapidly improving technology. Postmaster General Arthur Summerfield predicted confidently in 1959 that mail would soon be delivered by packing letters into guided missiles, the wonder tech of the day. A growing economy meant more letters, and the future for postal workers seemed bright. It was, for a while. The possibility that mail would cease to be written on paper never occurred to Summerfield, though the necessary technologies for email, texting, and the cell network existed in rudimentary form or were being developed. We risk missing the boat in the same way with A.I.

The second reality to remember is that A.I.'s eventual uses will be determined largely by market forces. Earnest discussions of how A.I. can be directed to make the world a utopia miss that point. They recall RCA chief David Sarnoff's long-ago prediction that the coming of color TV would enable people to see fine art in their homes. That sounded wonderful, but nobody wanted it for such high-minded uses. A.I. will be used by companies and consumers for countless practical purposes, most of them modest, and the cumulative effect can't be foreseen. As we try to guess A.I.'s future, the key will be to think like self-interested people (including both good and bad guys) in the real world.

No bad guys here, though. These 25 examples of A.I. at work are beneficial, even inspiring—and they're real. —*Geoff Colvin*

GETTING US ALL TO SPEAK THE SAME LANGUAGE

EVER SINCE THE GOLDEN age of the original *Doctor Who* and *Star Trek*, science fiction has highlighted devices that can automatically translate languages so that humans can talk to aliens without needing to study far-out dialects. It turns out that companies here on Earth, like **Google,** are using artificial intelligence technologies to create devices that can translate conversations from one language to another. While Google's recently released Pixel Buds is a promising start, consider the ways businesses could use the technology when it works seamlessly. American executives could call up their Portuguese-speaking counterparts and brainstorm global partnerships on the fly. Businesses with international offices could more effectively communicate with employees, who could work in tandem with colleagues in other countries who don't speak the same language. Salespeople could scout for potential leads in new regions and make cold calls that could bring about their next game-changing deal. Although many companies have instituted an English-only policy as a way to keep employees speaking the same lingo, on-the-fly translation technology lets non-U.S. employees speak their mother tongues and retain aspects of their cultures—a benefit in this era of globalization.
—Jonathan Vanian

+

34%

PERCENTAGE OF PEOPLE WHO BELIEVED THEY HAD INTERACTED WITH A.I., ACCORDING TO A STUDY BY PEGASYSTEMS. (PERCENTAGE WHO ACTUALLY HAD: 84%)

READING YOUR MIND

MOVE OVER, ALEXA. Voice control is cool—see our feature on the topic on page 112—but consulting Alexa, Siri, or Cortana can be awkward and disruptive in public. Enter AlterEgo—a noninvasive, wearable device created by MIT researchers that knows what you're going to say before you even open your mouth. The device can answer many queries within seconds, send private messages, and internally record streams of information to access at a later time—all without any observable external actions. AlterEgo doesn't really read minds, although it may sound that way. Instead, the device effortlessly facilitates private human-machine communication by interpreting electrical impulses in the jaw that are triggered when words or phrases are internally vocalized. Although university-based researchers are still in the process of collecting data and training the system, AlterEgo might also eventually serve as a platform for communication between users in high-noise environments, such as the flight deck of an aircraft or a factory floor, as well as a mode of communication for those with speech impediments. And while AlterEgo could radically speed up the process of writing, planning, and communicating, for now, humans would still be the ones stuck actually reading all those emails. *—Carson Kessler*

HIRING SMARTER

THE HIRING PROCESS IS fraught with challenges. Humans may be subtly or unconsciously swayed by a last name, a college, even the font size of a résumé. Now some companies are seeing if A.I. can help.

Applicants at **Vodafone, Nielsen,** and **Unilever,** for example, play a smartphone game designed by A.I. start-up **Pymetrics** that measures cognitive and emotional traits with an algorithm designed to avoid racial, gender, or other bias. Unilever then asks top candidates selected by the software to record a video on **HireVue,** answering questions about how they would handle various situations encountered on the job. Another algorithm sifts the best candidates by reviewing not just what the individuals said but also how quickly they responded and what emotional cues they revealed in their facial expressions. Those candidates who pass the early tests are rewarded with regular job interviews with a live person.

Unilever says that since it instituted the system it's getting a higher rate of acceptances when it offers a job, and has increased applicant numbers across several diversity measures, including race, ethnicity, and socioeconomic status—and that it's drawing from a more diverse pool at three times as many colleges and universities. *—Aaron Pressman*

20%

PERCENTAGE OF PEOPLE WHO WANT THEIR VOICE ASSISTANTS TO HELP THEM BE "FUNNIER OR MORE ATTRACTIVE," ACCORDING TO A STUDY BY COMPUTERLOVE IN THE U.K.

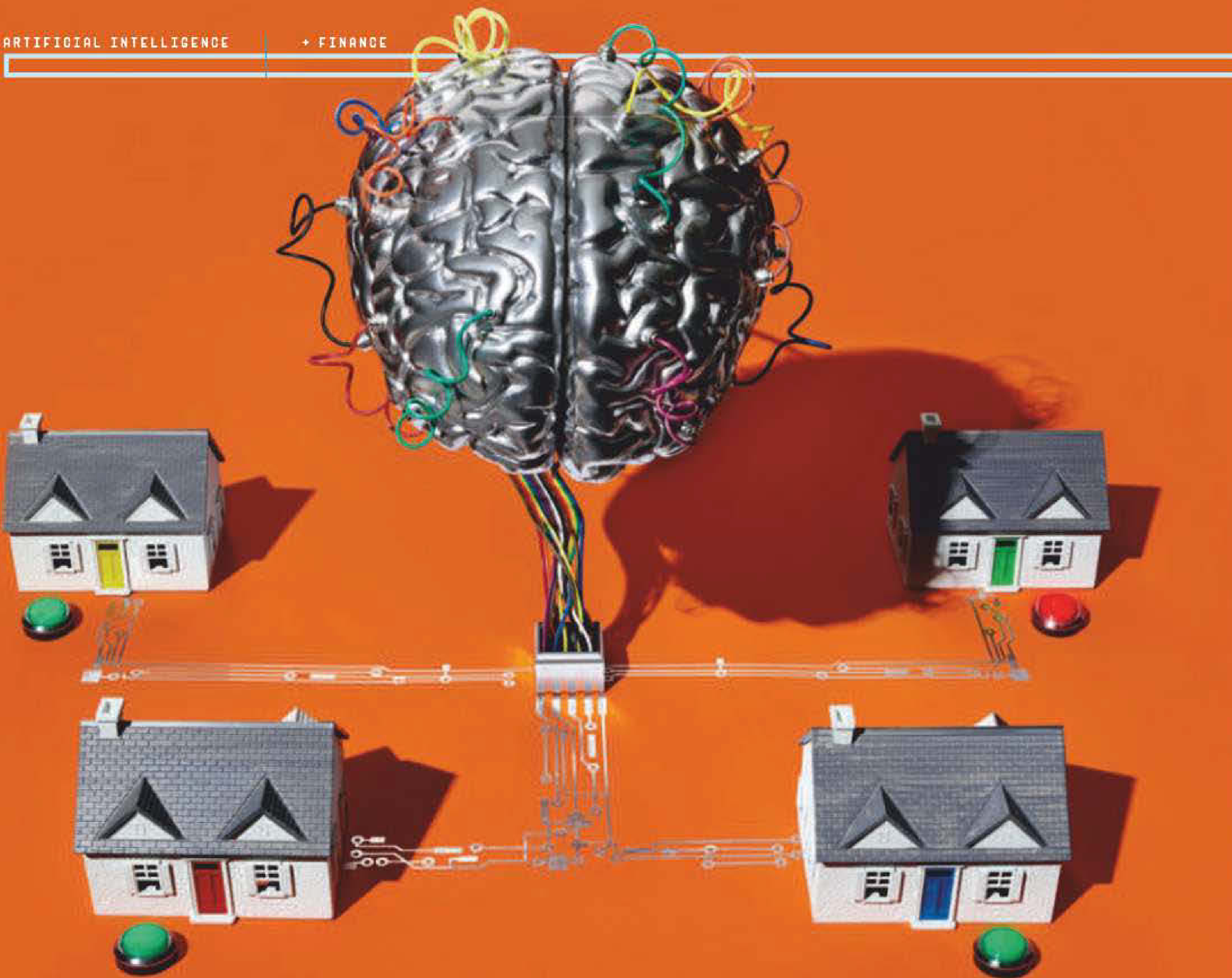
BUILDING THE ULTIMATE MANAGER

JUDGMENT OF HUMAN behavior was once reserved for, well, humans. But increasingly, algorithms are the ones evaluating and drawing conclusions on our actions and even intentions. That's especially true in the workplace, where HR departments are turning to A.I. for more scalable (and hopefully, more reliable) insights into possible attrition risks, attributes of high performers, and what makes teams tick. Boston-based **Humanyze** is experimenting with smart ID badges that track how employees interact with each other throughout the day, enabling employers to look for patterns to figure out how work actually gets done.

Textio, a Seattle startup, uses A.I. to help companies craft the right recruiting ads (the "augmented writing platform" is particularly effective at surfacing language that will attract more diverse candidates). Big companies are getting in on H-less HR too: **Intel** is looking at using artificial intelligence to power a new internal tool that would match employees to other opportunities within the company, all in the name of retention.

These new capabilities could help companies attract and retain the talent they need (and cut down on onboarding and recruiting costs by automating these processes). One possible downside? They also risk alienating the very people they claim to serve—employees might not like the increasingly intrusive workplace of tomorrow. *—Michal Lev-Ram*

ILLUSTRATIONS BY **ANDREA MANZATI**



MEET YOUR NEW ROBOT MORTGAGE LENDER

ONE THEORY HAS ARISEN in the decade since the subprime mortgage crisis: Machines may be better than humans at giving out home loans. A new Fannie Mae survey of mortgage lenders found that 40% of mortgage banks have deployed A.I.—using it to automate the document-heavy application process, detect fraud, and predict a borrower's likelihood of default. San Francisco–based **Blend,** for one, provides its online mortgage-application software to 114 lenders, including lending giant **Wells Fargo,** shaving at least a week off the approval process. Could it have prevented the mortgage meltdown? Maybe not entirely, but it might have lessened the severity as machines flagged warning signs sooner. "Bad decisions around data can be found instantaneously and can be fixed," says Blend CEO and cofounder Nima Ghamsari. While banks are not yet relying on A.I. for approval decisions, lending executives are already observing a secondary benefit of the robotic process: making home loans accessible to a broader swath of America. Consumers in what Blend defines as its lowest income bracket—a demographic that historically has shied away from applying in person—are three times as likely as other groups to fill out the company's mobile application. Says Mary Mack, Wells Fargo's consumer banking head: "It takes the fear out." *—Jen Wieczner*

+

72%

PERCENTAGE OF PEOPLE WHO ARE AFRAID OF ROBOTS TAKING OVER THEIR TASKS, ACCORDING TO PEW RESEARCH

A NEW EDGE FOR PRO INVESTORS...

IN THE WORLD OF FINANCE, there's been such an explosion of data collected over the past decade that even those twentysomething analysts working around the clock don't stand a chance of being able to process it all. But machines might. **Bloomberg, FactSet Research Systems,** and **Thomson Reuters** have all developed an array of data-science tools and techniques—including machine learning, deep learning, and natural language processing (NLP)—to quickly unearth valuable insights for thousands of financial professionals.

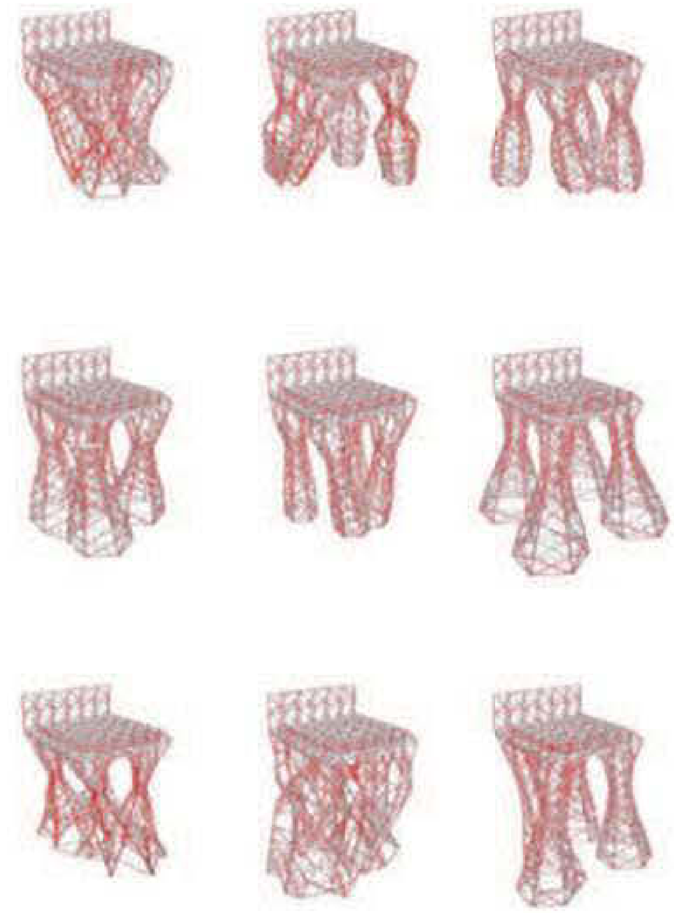
Bloomberg was a pioneer of sentiment analysis (an example of NLP), which it began developing around a decade ago, in which machine-learning techniques are used to flag a news story or tweet as being relevant to a stock and assign a sentiment score. A.I. is also spreading to wealth management. Investment groups have more than quadrupled their number of "alternative data" analysts over the past five years, as asset managers scramble to unlock the potential of trading signals contained in website scrapes, language analysis, credit card purchases, and satellite data. Firms reported to be using A.I. for investment research include **BlackRock, Fidelity, Invesco, Schroders,** and **T. Rowe Price.** BlackRock, the world's largest asset manager, has been a forerunner in adopting A.I. and is setting up a BlackRock Lab for Artificial Intelligence. *—Scott DeCarlo*

...AND FOR THE AMATEURS TOO

"ROBO-ADVISER" SERvices, offered by startups including **Betterment** and **Robinhood** and traditional discount brokerages like **Charles Schwab,** are already using A.I. to serve the investing masses. Their low-fee investment tools rely on algorithms to determine how your assets should be split among stocks, bonds, and other assets, based on your needs and your stomach for risk. Their A.I. can automatically rebalance your portfolio; it can also nudge a (non-robotic) adviser to call you when the algorithms predict you need help with tax strategy or estate planning.

The next frontier: A.I. smart enough to help savers make good decisions about long-term, buy-and-hold investments. **Bank of America Merrill Lynch** and **Morgan Stanley** are among the bigger players in an emerging discipline known (awkwardly) as quantamental analysis. They aim to combine the quantitative processing for which basic A.I. is best suited (basically, the capacity to spot patterns in gargantuan loads of data) with additional algorithms trained in the sophisticated analysis associated with supersmart humans—assessing, say, the growth potential of an industry or the strategic acumen of a company's management. Machine learning could eventually enable a quantamental system to learn from its mistakes. The ultimate goal: Warren Buffett–like stock-picking wisdom at low prices—and perhaps a name catchier than "quantamental." *—Matt Heimer*

+ MANUFACTURING

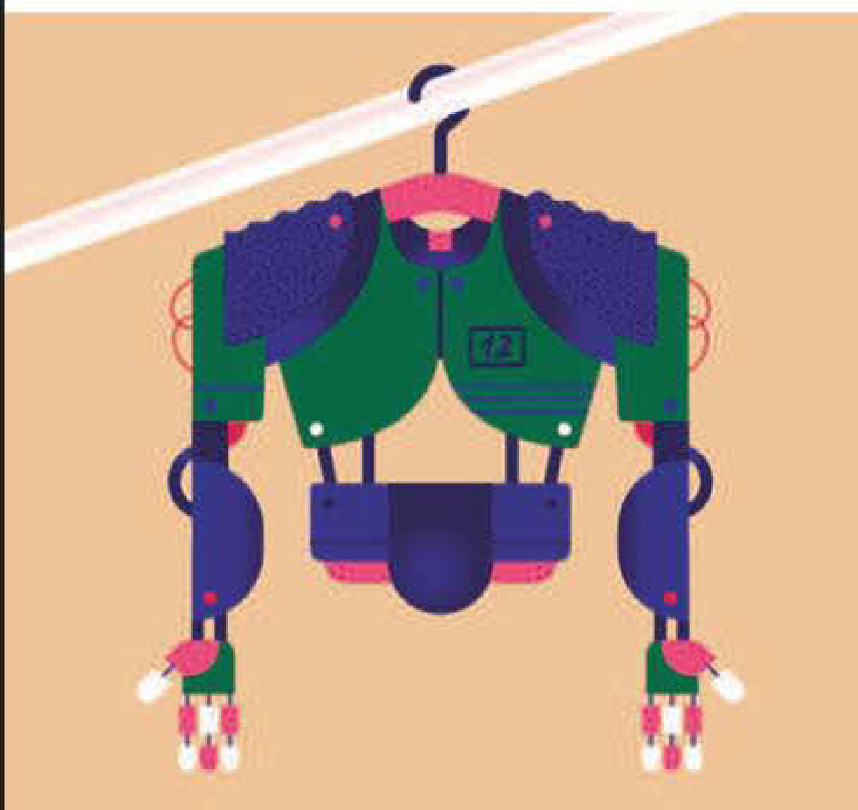


RENDERING: COURTESY OF AUTODESK

DESIGNING MORE EFFICIENTLY

SURE, COMPUTER ALGORITHMS ARE TAKING over tech and science and medicine ... but the creatives are still safe, right? Not exactly. A new program from software developer **Autodesk** called Dreamcatcher (rendering above) can use A.I. techniques to assist human designers as they go about their creative tasks. Already in use by companies including **Airbus, Under Armour,** and **Stanley Black & Decker,** the software is an example of the burgeoning field of generative design. A designer inputs requirements, limitations, and other qualities into the program—even the total cost of materials. The software then produces hundreds or even thousands of options. As the human designer winnows the choices, the software susses out preferences and helps iterate even better options. Airplane manufacturer Airbus used the software to redesign an interior partition in the A320 and came up with a design that was 66 pounds, or 45%, lighter than the previous setup. *—A.P.*

MELDING HUMANS AND ROBOTS



▲ **ROBOTS HAVE BEEN ON THE ASSEMBLY LINE doing all kinds of manufacturing for decades. Lately, a new feature is being added to the automated work machines: humans. Dubbed "cobots," short for collaborative robots, the new setups range from robotic helpers that can hand the correct part to a human worker to an almost Ironman-like robotic exoskeleton suit that a person wears to gain added strength and A.I. software guidance. BMW has a cobot nicknamed Miss Charlotte that is helping assemble doors at its Spartanburg, S.C., plant. Mercedes-Benz is turning to cobot technology to help personalize each car that the luxury-automaker assembles in some of its most expensive categories. Replacing larger automated systems, humans with more nimble cobot helpers can be quicker at choosing from among the huge variety of parts needed to customize S-Class sedans, for example. MIT professor Julie Shaw is working on software algorithms developed with machine learning that will teach cobots how and when to communicate by reading signals from the humans around them. Some researchers have even looked at connecting cobots to human brain-wave readouts. Mind-reading assistive robots? Now *that's* collaboration. —*A.P.***

POWERING CLEAN ENERGY

IF WIND ENERGY IS TO BE decisively cheaper than fossil-fuel power, the process of transforming wind into electricity must get more efficient. Machine-learning technology developed at **Siemens** is helping. Researchers realized that huge wind turbines could use data on weather and component vibration to fine-tune themselves continually, for example, by adjusting the angles of rotor blades. But "you cannot analytically calculate this," says researcher Volkmar Sterzing.

That's the right kind of problem for A.I. and machine learning. Sensors were already generating the needed parameters, but "previously, these were used only for remote maintenance and service diagnostics," says Sterzing. "Now they are also helping wind turbines generate more electricity." The technology can even adjust turbines to the unpredictable airflows coming through the turbines in front of them.

Deploying this A.I. broadly is now an opportunity for **SiemensGamesa Renewable Energy,** an independent company formed last year by combining Siemens's wind operations with the wind power business of Spain's Gamesa. —*G.C.*

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48%

PERCENTAGE OF PEOPLE WHO FOUND CHATBOTS PRETENDING TO BE HUMAN "CREEPY," ACCORDING TO MINDSHARE

KEEPING AN EYE ON THE MORTALS

HUMANS ARE NOT GREAT at knowing their own limits—they eat too much, sleep too little, and overestimate what can be achieved in a period of time. That may seem a matter of little consequence when it comes to, say, Thanksgiving dinner, but in certain professions—like long-haul trucking and heavy-equipment operation—such fallibility can be dangerous and catastrophically costly.

That's why companies are increasingly using A.I., guardian angel–like, to safeguard employees in high-risk jobs. Systems, trained on hundreds of hours of employee sensor data, monitor conditions—like an operator's heart rate, body temperature, and indicators of fatigue level or nervousness—in real time and signal when that individual needs to rest or take a break, explains Mike Flannagan, an SVP at business software firm **SAP.** [SAP has a Connected Worker Safety product that does this.]

As for the rest of us? We can expect to see this type of technology soon in our own garages, where automakers are dreaming up ways for our cars to keep an eye on us. While the tech is currently limited to a coffee cup icon that flashes on the dash in a few models, Nils Lenke, head of innovation management for automotive at **Nuance Communications,** an A.I. firm that works with most of the major carmakers, says fatigue-detecting voice and facial recognition technology will soon be standard in new vehicles. —*Erika Fry*

ORIGINAL PHOTO, MAP: MIKE HALL—GETTY IMAGES

MAKING WEAPONS THAT PICK THEIR TARGETS

ONCE THE STUFF OF APOCALYPTIC SCI-FI tales, killer robots capable of choosing and taking out our nation's enemies are now within reach—if companies and the Pentagon decide to go that far. Defense officials have so far stopped short of developing Lethal Autonomous Weapons Systems (the government's official term), which could theoretically strike without a human order as easily as Facebook can tag friends in your photos without your say-so.

But the A.I.-driven technology that could form the basis for such attacks is well underway. Project Maven, the Pentagon's most high-profile A.I. initiative, aims to use machine-learning algorithms to identify terrorist targets from drone footage, assisting military efforts to combat ISIS (more than 20 tech and defense contractors are reportedly involved, though they have not all been publicly named). Although supporting war efforts is nothing new for the defense industry, the Pentagon has increasingly looked to Silicon Valley for expertise in A.I. and facial recognition. That growing relationship has recently sparked controversy, with **Google** announcing this summer that it would withdraw from Project Maven after several employees quit in protest. Going forward, companies' only barrier to winning lucrative new A.I. defense contracts may be their own unwillingness. —*J.W.*

AVERTING THREATS

THE FAILURE TO prevent attacks in cyberspace and IRL (in real life) is an expensive line item—the average cost of an individual data breach was nearly $4 million in 2017. But the surge in attacks of late has an upside: It means there's also more data to mine. Machine-learning techniques have been used to detect patterns and filter emails for decades, but newer systems from vendors like **Barracuda Networks** can use A.I. to actually learn the unique communication patterns of particular companies and their execs in an effort to pinpoint potential phishing scams and other hacking attempts. In the world of physical security, A.I. is even being used in security cameras to "see" and try to stop threats. New cameras from startup **Athena Security** can identify when a gun is pulled and even automatically alert the police. In short: The more data we have, the more we can use A.I. to fight crime. —*M.L.*

EMBEZZLERS, BEWARE!

HOW DO YOU catch a financial criminal? Instead of bulking up compliance staff to sift through thousands of transactions in search of suspicious activity, banks across the globe like **HSBC** and **Danske Bank** are increasingly turning to A.I. to flag financial scams, money laundering, and fraud. (This push has gained even more momentum recently as several banks were hit with huge fines for failing to detect illegal funds flowing through their accounts.) HSBC partnered with A.I. startup **Ayasdi** to automate some of its compliance. In its 12-week pilot with HSBC, Ayasdi's A.I. technology achieved a 20% reduction in false positives (transactions that looked suspicious but were legit), while retaining the same number of suspicious-activity reports as human review. —*C.K.*

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2022

YEAR IN WHICH A.I. WILL BE BETTER THAN HUMANS AT FOLDING LAUNDRY, ACCORDING TO RESEARCHERS AT OXFORD AND YALE

DRIVING SO YOU DON'T HAVE TO

"THE MACHINE KNOWS WHERE IT'S GOING!" CRIED Michael Scott, protagonist of NBC's *The Office*, before launching a Ford Taurus rental car into a lake near Scranton, Pa. Getting an autonomous vehicle to drive safely under idealized road conditions has technically been possible for a while now, but for the real world, the cars are going to have to learn to drive a little bit more like us. That's where **Comma.ai,** a startup founded by notorious iPhone hacker George Hotz, comes in. Rather than teaching its computer systems what a tree or a stop sign looks like, Comma.ai's Openpilot technology analyzes the patterns of everyday drivers to train its self-driving models. The company is pulling in millions of miles of driving data from a dashcam app called Chffr and a plug-in module called Panda, then aggregating that data to create an autonomous system that mimics human drivers. The company—whose technology currently works with select **Honda, Toyota,** and **Hyundai** vehicles—is styling itself as the Android to Tesla's Autopilot iPhone, an open-source system that is pegging its success to the notion that users will make it better. Let's just hope Michael Scott isn't one of them. —*Daniel Bentley*

YOUR NEW TRAVEL COMPANION

EYJAFJALLAJÖKULL, it turns out, has stayed with us long after the ash faded away. The Icelandic volcano that erupted in 2010 affected millions of fliers and, in doing so, ushered in a new era in travel communications. With information flow capabilities strained, airlines discovered social media as an effective, real-time way to reach passengers. "Once that happened," says Rob Harles, **Accenture Interactive's** head of social media and emerging channels, that mode of communication "was an unstoppable force." Since then, however, the number of travelers has ballooned, with 1.25 billion arrivals in 2016, an increase of 30%. Human-powered social media interaction on that scale is "impossible," Harles says.

Enter the customer service chatbot that's able to answer travelers' basic questions: Is my flight delayed? When is my hotel checkout? **Booking.com,** for instance, has a bot that the company claims can solve 60% of customer queries automatically. The next stage of this technology is for bots to understand the nature of your trip—business or pleasure?—and to make recommendations based on your preferences throughout your journey, ranging from suggesting a flight upgrade to reserving a table at the best vegan café in, say, Pittsburgh. So what's currently known as a chatbot may soon resemble a full-blown automated concierge. —*Claire Zillman*

UPGRADING THE CALL CENTER

"CAN I HELP YOU?" By 2020, **IBM** estimates that 85% of customer service interactions will be handled without a human agent. Machine learning and natural language processing make it possible for chatbots, enhanced phone support, and self-service interfaces to perform most of the functions of human representatives.

As for the 2.7 million Americans who are employed as customer service representatives? Some may be redeployed to tasks that bots can't do (like dealing with truly irate customers). Companies relying on this technology say it can help eliminate human error, drastically increase speed in data retrieval, and remove bias from customer service interactions.

And don't think this ends with bots. Swiss investment bank **UBS** recently teamed up with New Zealand A.I. expert **FaceMe** to digitally clone chief economist Daniel Kalt to interact with clients just as he would in the flesh. The bank said the avatar, built using IBM Watson A.I. technology and trained by the real Kalt, is part of its exploration to provide a "mix of human and digital touch." —*McKenna Moore*

16%

PERCENTAGE OF WOMEN WHO SAID THEY WOULD FEEL COMFORTABLE RIDING IN A DRIVERLESS CAR, VS. 38% FOR MEN, ACCORDING TO A REUTERS/IPSOS POLL


BANFF, ALBERTA
EDC
TAKE ON THE WORLD
COOL WEATHER.
HOT OPPORTUNITIES.
CANADA IS OPEN
FOR BUSINESS.
Our winters may be cold, but our economy is heating up. Thankfully, Export Development Canada offers flexible financing options to global companies and a network of credible Canadian suppliers to help you seize every business opportunity our country has to offer.
We're ready. Are you?
LEARN MORE canada.ca/open-for-business
THE WORLD WORKS IN CANADA.
invest CANADA
DESTINATION CANADA
Canada

MONEYBALL 2.0

WHEN NHL SCOUTS looked at Sean Durzi (above) in 2017, they decided to pass on the 19-year-old defenseman. Just one year later, Durzi went second round to the Toronto Maple Leafs. The difference was powerful new A.I. software by Montreal-based startup **Sportlogiq** that parsed terabytes of data to uncover his powerful playmaking ability—call it Moneyball 2.0. Sportlogiq is just one of several companies using A.I. to help teams spot the next star. "It's all about identifying talent in hidden pockets and finding that diamond in the rough," says Cam Potter, cofounder of **Brooklyn Dynamics**, an Australian data-analytics company that has worked with several Major League Baseball teams and even developed a machine-learning A.I. system for the 2017 Tour de France that collected real-time data points and spit out race predictions.

Brooklyn Dynamics is developing an app that will soon allow time-crunched scouts and coaches to run machine-learning analytics on both prospects and current players, creating a centralized database that can be accessed by college and pro teams around the world. "It's a unique tool to add to the recruiter's repertoire," Potter says. "Other members of the organization can then look at [the stats] and join in on the draft discussion to eventually decide who's going to bring value to the club." —*C.K.*

CHANGING HOW YOU SHOP

BRICK-AND-MORTAR stores have a new calling: They're perfect A.I. data collection labs. **Home Depot** is using data from millions of transactions to figure out what else you—the DIY-er grappling with, say, a big kitchen renovation—might need and provide detailed home project guides as well as hyper-targeted cross-selling. **Sephora** has used A.I.-powered facial recognition by **ModiFace** (recently bought by **L'Oréal**) to help shoppers select that exact right makeup shade: The software analyzes millions of other past users to better predict what will look good on you. And MIT-spinoff **Celect** uses machine learning to forecast how shoppers behave, determine what kinds of promotions work better in what part of the store, and figure out where products should be placed for optimal results.

As for that price check in aisle 10? **Walmart,** for one, has tested robots at 50 stores that scan shelves for out-of-stock items, products placed back in the wrong spot by customers, and incorrect prices —all time-consuming and cumbersome jobs for humans. Though retailers are tight-lipped about in-store tech, companies like **Navii** and **Simbe** that make A.I.-powered robots are attracting attention and investors, according to CB Insights. —*Phil Wahba*

WILL THIS AD MAKE YOU SMILE?

MARKETERS DON'T ALWAYS hit the mark—we're looking at you and that Kendall Jenner spot, Pepsi—but increasingly, they're leaning on artificial intelligence to make those misfires less likely. Emotion A.I. firm **Affectiva** says a quarter of *Fortune* 500 companies use its tech in their creative development processes, testing the reaction to potential ads in A.I.-enhanced survey research. Affectiva's system, which has been trained on images of 7 million faces (and 3.8 billion facial frames) from 87 countries, decodes the facial expressions of individuals—the tech identifies 20 specific ones as well as eight emotions, including "disgust"—moment by moment as they watch ads.

Media research giant **Kantar Millward Brown,** which has deployed Affectiva's product since 2011 (30,000 ads' worth) found **Nike's** lauded Colin Kaepernick ad scored smiles at key points. "We were really able to pinpoint the fact that it was Kaepernick's message about sacrifice and dreams that triggered the positive response," says Graham Page, the firm's managing director. They also found that viewers responded positively, and with surprise, to women players featured in World Cup ads.

Page noted that beyond helping clients sharpen their campaigns, Kantar has gained broad insights that benefit all clients. Ads that viewers describe as "progressive," with protagonists featured in modern roles (rather than traditional ones) are 25% more effective, according to the firm. —*E.F.*

DURZI: DAVID KIROUAC—ICON SPORTSWIRE VIA GETTY IMAGES

GROWING YOUR NEXT MEAL

ON THE SURFACE, FARMING SEEMS LIKE a simple endeavor: Pop seeds in the ground, water, harvest, repeat. But in reality, how food is grown is built on a series of intricate equations. "A lot of the data we deal with in agriculture is very complex," says Nate Storey, the cofounder and chief science officer of **Plenty,** an indoor vertical-farming enterprise. Environmental factors (airflow, carbon dioxide, light, and humidity, to name a few), the genetics of the plant, and the things we do to it, like fertilizing and watering, are all interacting variables. Now Plenty and a number of other startups are using A.I. to help manage the complex decisions that go into farming. For example, Plenty and its indoor-ag rivals **Bowery** and **Gotham Greens** are all building systems that collect and analyze data sets of images that can help identify whether a plant has an issue, like nitrogen or iron deficiency or a pest problem, through machine learning and then preemptively treat it. "The software can learn what the problems are and do it in an automated fashion at a large scale that we couldn't individually do," Storey says. —*Beth Kowitt*

MAKING HEALTH CARE HUMAN AGAIN

BY ERIC TOPOL

THE CURRENT U.S. HEALTH CARE PICTURE is pretty bleak: more than 12 million serious diagnostic errors each year, a third of the $3.6 trillion spent attributed to waste, reduction in life expectancy for what will be three years in a row (which is unprecedented), and peak levels of physician burnout, depression, and suicide. That's all happening at a time when there is more medical data per individual than ever, imagined with wearable sensor physiology, scan anatomy (above), DNA sequencing, gut microbiome biology, just to name a few layers. Enter deep-learning A.I., with neural networks that will impact every type of clinician, from helping to accurately read scans, slides, skin lesions, eyegrounds, and more, to health systems, promoting the use of remote monitoring that ultimately obviates the need for regular hospital rooms, and at the consumer level, by providing a virtual medical coach to better manage or even prevent diseases. It's still early in the integration of A.I. into medical practice, with far more hype than validation. But it's our best shot to deal with all of the formidable challenges: to use the wealth of data to reduce errors and waste, and the gift of time to markedly improve the clinician-patient relationship.

Eric Topol, MD, is the founder and director of the Scripps Research Translational Institute and author of the forthcoming book Deep Medicine.

7%

PERCENTAGE OF HR EMPLOYEES WHO THINK "A ROBOT COULD DO THEIR JOB," ACCORDING TO A STUDY BY IDEALL

OUTSMARTING YOUR DOCTOR

IN JUST THE PAST few years, there have emerged credible if still-in-the-works A.I.-powered technologies that can read radiology scans (like **Imagen**), identify tumors and track the spread of cancer (**Arterys**), detect eye conditions using retinal imaging (**Google's DeepMind**), flag dangerously abnormal potassium levels via a "bloodless blood test" (**Mayo Clinic Ventures** and **AliveCor**), and otherwise assist with the tricky business of diagnosing, or even predicting, disease. Historically, diagnostic error rates have been put at 5% to 20%, though the rate is higher for some conditions, while the health care system is strained by doctor shortage and burnout—some things A.I. may be able to treat. —*E.F.*

BRAIN: SPL/SCIENCE SOURCE

WHEN CULTURE IS A COMPETITIVE WEAPON

Sage Intacct is creating a workplace that embraces disruption and drives innovation.

ATLANTA CONVENTION & VISITORS BUREAU IS ONE OF THOUSANDS OF BUSINESSES THRIVING WITH SAGE INTACCT'S CLOUD ACCOUNTING SOFTWARE.

IN TODAY'S WORLD OF ONGOING DISRUPTION, BUSINESSES MUST continually transform to stay competitive. This means building a company culture that can both adapt to change and embrace innovation. Nobody understands this better than Sage Intacct, a cloud accounting software company.

Since Sage acquired Intacct last year, the organization has continued to grow as a robust yet nimble financial management powerhouse. With a fierce commitment to product innovation and customer service, Sage Intacct has established itself as a leader in helping finance professionals increase efficiency and drive growth for their organizations. "The combination of innovative software and great service is really what the industry originally thought we should be doing in this business model," says Rob Reid, managing director and executive vice president of the company.

And while Sage Intacct is riding on several waves of success, it's certainly not resting on its laurels. "We've got this culture where we're attacking the status quo," says Reid, who argues that if they don't shake up the status quo, the competition will.

By encouraging and facilitating new ideas and open-mindedness, Sage Intacct is fostering a work environment that embraces digital disruption and drives innovation. "Our culture is a competitive weapon," says Reid. Others seem to agree, as industry accolades including a 4.7 rating on Glassdoor and near perfect customer satisfaction score (98/100) on G2 Crowd can attest.

A key to Sage Intacct's high level of success is its commitment to developing exceptional leadership. By regularly soliciting feedback from employees, partners, vendors, and customers, the company is able to glean insights to help improve products and optimize processes that deliver outstanding results for its customers.

FORTUNE 100 BEST MEDIUM WORKPLACES 2018

This commitment to innovation has become even more pronounced since the merger, which can largely be credited to the complementary blending of the two company cultures. For instance, both companies have a tradition of giving back to the communities in which they work and live. "We feel it's our responsibility to make the world a better place and to do it not only from our business but to provide resources to other worthy causes," says Reid.

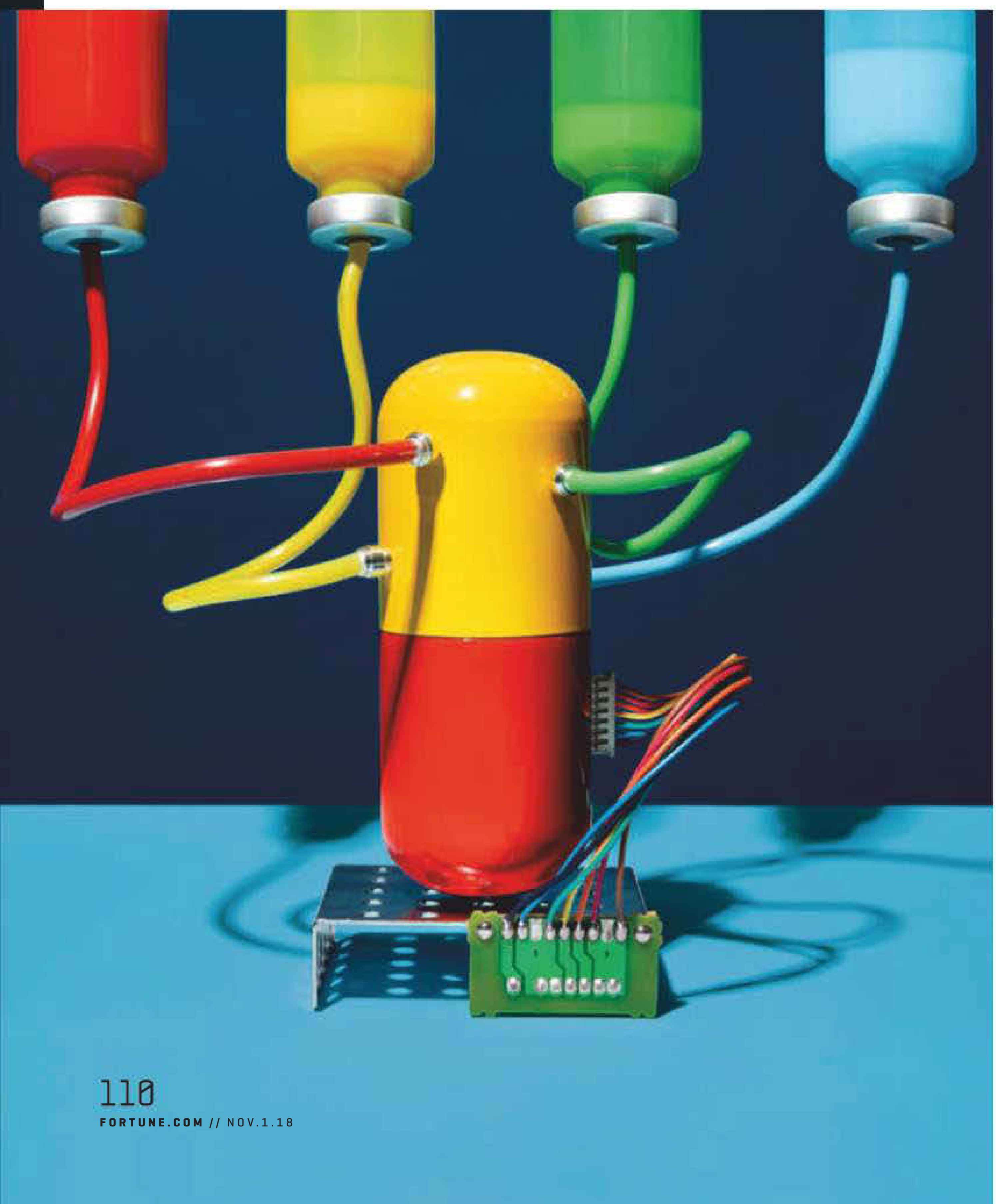
One of the ways that Sage Intacct delivers on this commitment is by giving its employees paid days off for volunteer activities. Some employees have been highly creative in making these efforts even more productive. For example, recently an employee hosted a birthday party for her three-year-old and asked those invited to forgo presents and instead bring groceries and other provisions for those in need. The guests were so generous that they overwhelmed the local food bank with multiple vans overflowing with donated items, ultimately resulting in 10,000 meals.

It's this type of generosity and commitment to community that has helped define Sage Intacct's culture and set it up for long-term success.

sage Intacct

REINVENTING DRUG R&D

THE MEDICINE BUSINESS IS FILLED WITH TWISTS OF FATE. A drug may appear safe for humans in early studies with small groups of patients only to crash and burn in spectacularly expensive fashion in a large-scale clinical trial. In fact, return on investment for the largest biopharmaceutical companies in the U.S. fell to a dismal 3.2% in 2017, according to Deloitte. Which is why American companies like **BERG** and **Roivant Sciences** and U.K.-based **Exscientia** want to harness the power of A.I. to better deploy resources. BERG has partnered with major drugmakers like **AstraZeneca** and **Sanofi Pasteur** to use clinical data fed through an algorithm to identify promising biological targets for drugs and molecules that may be able to treat diseases like Parkinson's. Sanofi is also analyzing huge amounts of data to gain a deeper understanding of why certain flu vaccines are effective for some people but not for others (a critical public health question considering last year's devastating flu season). A.I. as a central medicine-making tool is still in its early stages. But the promise is clear: Being able to funnel pharma R&D efforts to the most promising targets can avoid a huge waste of time and money and, hopefully one day, lead to a more streamlined drug development process that benefits companies and patients alike. —*Sy Mukherjee*



REVERSING DISEASE

AMERICA'S HEALTH care system has been criticized for favoring triage over cheaper, proactive approaches—and businesses pay the price in lost productivity and skyrocketing health care costs. **Virta Health** CEO Sami Inkinen is taking a different tack, using A.I. to prevent patients at risk for diabetes from developing the full-blown disease and, in early trials, even reversing Type 2 diabetes through its purely digital platform. Virta aims to shift customers' lifestyles by connecting them with coaches who give them personalized recommendations on diet and other factors. It also provides digitally connected tools to measure blood sugar, ketones, blood pressure, and weight. Using a patient's anticipated blood sugar and weight improvement, clinicians can prioritize patients in their hourly workflow. Virta is not alone: **IBM's Watson Health** unit and medtech giant **Medtronic** are collaborating on an app called Sugar.IQ that offers similar tools. —*S.M.*

STYLING BY MEGUMI EMOTO—ANDERSON HOPKINS

AMAZON, APPLE, and GOOGLE are investing billions to make VOICE RECOGNITION the main way we communicate

IT MIGHT GET LOUD

with the Internet. It will be the biggest technology shift since Steve Jobs launched the iPhone. **By Brian Dumaine**

▲ PHOTOGRAPH BY **SAM KAPLAN**

FOUR SHORT YEARS AGO, Amazon was merely a ferociously successful online retailer and the dominant provider of online web hosting for companies. It also sold its own line of consumer electronics devices, including the Kindle e-reader, a bold but understandably complimentary outgrowth of its pioneering role as a next-generation bookseller. Today, thanks to the ubiquitous Amazon Echo smart speaker and its Alexa voice-recognition engine, Amazon has sparked nothing less than the biggest shift in personal computing and communications since Steve Jobs unveiled the iPhone.

It all seemed like such a novelty at first. In November 2014, Amazon debuted the Echo, a high-tech genie that uses artificial intelligence to listen to human queries, scan millions of words in an Internet-connected database, and provide answers from the profound to the mundane. Now, sales of some 47 million Echo devices later, Amazon responds to consumers in 80 countries, from Albania to Zambia, fielding an average of 130 million questions each day. Alexa, named for the ancient Egyptian library in Alexandria, can take musical requests, supply weather reports and sports scores, and remotely adjust a user's thermostat. It can tell jokes; respond to trivia questions; and perform prosaic, even sophomoric, tricks. (Ask Alexa for a fart, if you must.)

Amazon didn't invent voice-recognition technology, which has been around for decades. It wasn't even the first tech giant to offer a mainstream voice application. Apple's Siri and Google's Assistant predated Alexa by a few years, and Microsoft introduced Cortana around the same time as Alexa's launch. But with the widespread success of the Echo, Amazon has touched off a fevered race to dominate the market for "smart" home devices by potentially making those objects as important as personal computers or even smartphones. Just as Google's search algorithm revolutionized the consumption of information and upended the advertising industry, A.I.-driven voice computing promises a similar transformation. "We wanted to remove friction for our customers," says Rohit Prasad, Amazon's head scientist for Alexa, "and the most natural means was voice. It's not merely a search engine with a bunch of results that says, 'Choose one.' It tells you the answer."

The powerful combination of A.I. with a new, voice-driven user experience makes this competition bigger than simply a battle for the hottest gadget offering come Christmastime—though it is that too. Google, Apple, Facebook, Microsoft, and others are all pouring money into competing products. In fact,

POPE: HEINZ-DIETER FALKENSTEIN—GETTY IMAGES; EDISON: BETTMANN/GETTY IMAGES; AUDREY: COURTESY OF NOKIA BELL LABS; TELEPHONE: SHEILA TERRY—SCIENCE SOURCE

Talking Head

1000 A.D.
Pope Sylvester II invents a talking head that (legend has it) could answer yes or no questions.

Voice Machines

1876 Alexander Graham Bell introduces the **telephone.**

1877 Thomas Edison (above) invents the phonograph, the first device to record and play back voice.

I Hear You

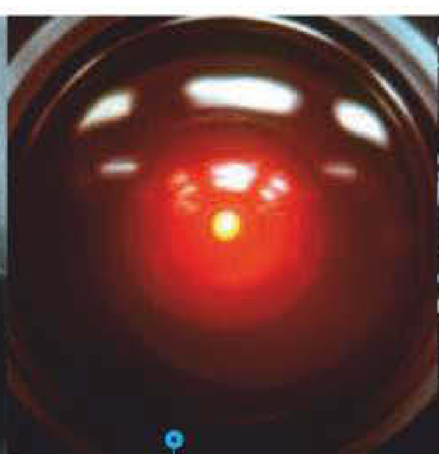
1952 Bell Labs creates **Audrey** (Automatic Digit Recognition), a device that can recognize the spoken digits one through nine.

Gene Munster of the investment firm Loup Ventures estimates that the tech giants are spending a combined 10% of their annual research-and-development budgets, more than $5 billion in total, on voice recognition. He calls the advent of voice technology a "monumental change" for computing, predicting that voice commands, not keyboards or phone screens, are fast becoming "the most common way we interact with the Internet."

With the stakes so high, it's no surprise the competition is fierce. Amazon holds an early lead, with 42% of the global market for connected speakers, according to research firm Canalys. Google is making itself heard too. Its Echo look-alike line of Google Home devices powered by its Google Assistant has a 34% share and recently has been outselling Amazon. The pricey and later-to-the-game Apple HomePod is a distant third. And in October, Facebook unveiled its line of Portal audio and video devices, which do some but not all of the voice-recognition tasks of its mega-cap competitors—and, notably, is powered by Alexa.

The current market for connected speakers and similar gadgets is big and growing—but not necessarily the most dramatic voice-related opportunity for the tech titans. Global Market Insights, a research firm, pegs global 2017 smart-speaker sales at $4.5 billion, a number it projects will grow to $30 billion by 2024. The hardware revenues, however, are largely beside the point. Amazon, for example, has sold the Echo at breakeven or less. Last holiday season it offered the bare-bones Echo Dot for $29, which ABI Research reckons is less than the cost of the device's parts. Instead, each major player has a strategy that in some way feeds its larger goal of locking in customers to its other goods and services. Amazon, for one, uses the Echo line to increase the value of its Amazon Prime subscription service. Google hopes voice searches will eventually boost the already massive trove of data that feeds its advertising franchise. With Siri, Apple sees a way to tie together its phones, computers, TV controllers, and even the software that automakers are tying into their onboard systems.

It's too soon to predict a winner, what with all the investment and fast-moving innovations. But it's safe to say the industry has coalesced around the notion that voice technology, enhanced by recent advancements


Add One Plus One

1962 IBM unveils its **Shoebox** at the World's Fair in Seattle. The machine can do simple math calculations via voice commands—though one has to speak slowly, with long pauses.

Hi, Dave ...

1968 **HAL 9000,** a talking computer, takes over a spaceship in the movie *2001: A Space Odyssey* and terrorizes an astronaut named Dave.

As Smart as a Toddler

1971 The Defense Department starts funding voice-recognition programs. One, Carnegie Mellon's **Harpy** system, can understand 1,011 words, the vocabulary of a typical 3-year-old.

Julie, Can You Sing?

1987 Texas Instruments creates a chip for a doll that can answer a set of simple questions. Worlds of Wonder, a toy company started by ex-Atari employees, markets it as "Julie."

I Can Hear You Now

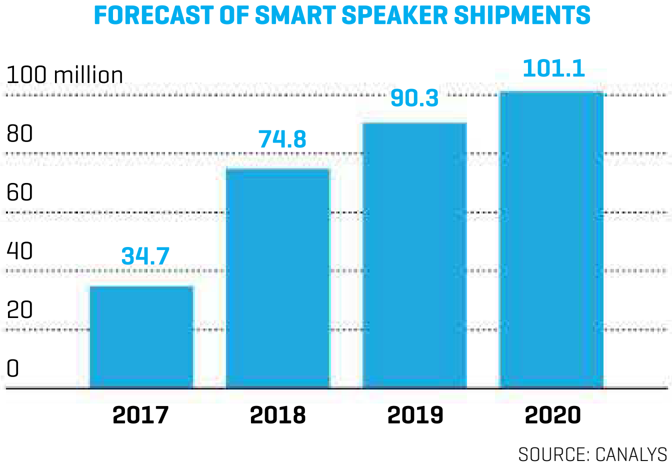
1997 PC app Dragon NaturallySpeaking is able to process simple speech without the speaker having to pause awkwardly between each word.

Voice Assistant Launches

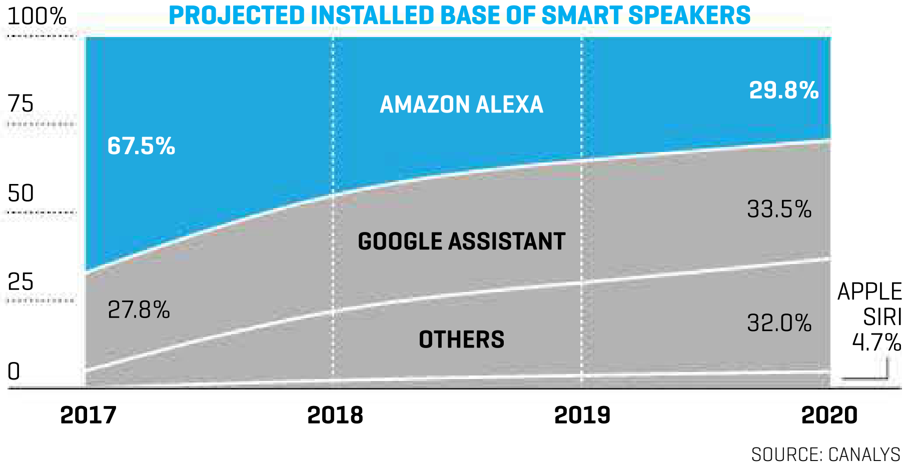
2010 Apple's Siri
2012 Google Assistant
2014 Amazon's Alexa
2014 Microsoft's Cortana

SHOEBOX: COURTESY OF IBM CORPORATE ARCHIVES, © 1961 INTERNATIONAL BUSINESS MACHINES CORPORATION; HAL: KEVIN BRAY—MGM/PHOTOFEST; HARPY: RAJ REDDY—YOUTUBE; DEVICES: COURTESY OF AMAZON, APPLE, AND GOOGLE

SALES OF SMART SPEAKERS ARE GROWING FAST ...



... AND GOOGLE IS NIPPING AT AMAZON'S LEAD.



in artificial intelligence, is the user interface of tomorrow. And it promises to have a democratizing impact on an industry that has separated novices from experts. "Voice enables all kinds of things," says Nick Fox, a Google vice president who oversees product and design for the Google Assistant and Search. "It enables people who are less literate to use the system. It enables people who are driving. It enables people while cooking to hear a recipe. Every once in a while there is a tectonic shift in technology, and we think voice is one of those."

For all that, voice recognition remains in its infancy. Its applications are rudimentary compared with where researchers expect them to go, and there's a significant ick factor associated with voice. Legitimate concerns linger as to how much the tech companies are eavesdropping on their customers—and how much power they are accumulating in the form of data derived from the spoken information they are collecting. "With A.I. voice recognition, we've gone from the age of the biplane to the age of the jet plane," says Mari Ostendorf, a professor of electrical engineering at the University of Washington and one of the world's top scientists on speech and language technology. She notes that computers have gotten good at answering straightforward questions but still are relatively hopeless when it comes to actual dialogue. "It's truly impressive what Big Tech has done in terms of how many words voice A.I. can now recognize and the number of commands it can understand. But we're not in the rocket era yet."

VOICE RECOGNITION HAS BEEN the next killer app for decades. In the 1950s, Bell Labs created a system called Audrey that could recognize the spoken digits one through nine. In the 1990s, PC users installed Dragon NaturallySpeaking, a program that could process simple speech without the speaker having to pause awkwardly after each word. But it wasn't until Apple unleashed Siri on the iPhone in 2010 that consumers got a sense of what a voice-recognition engine tied to massive computing power could accomplish. Around the same time, Amazon, a company full of *Star Trek* aficionados—and led by a true Trekkie in CEO Jeff Bezos—began dreaming about replicating the talking computer aboard the *Starship Enterprise.* "We imagined a future where you could interact with any service through voice," says Amazon's Prasad, who has published more than 100 scientific articles on conversational A.I. and other topics. The result was Alexa, a multifaceted device designed to let consumers communicate more easily with Amazon.

As voice recognition improves—which it does as computing power gets faster, cheaper, more ubiquitous, and thus more mainstream—Amazon, Google, Apple, and others can more easily build a seamless network where voice links their smart home devices with other systems. It's possible for Apple CarPlay users, for example, to tell Siri on the drive home to slot the latest episode of *Game of Thrones* as "up next" on their Apple TV and to command their HomePod to play it once they've arrived. Two years ago, Google released its voice-enabled Home that ties together its music offerings, YouTube, and its latest Pixel phones and tablets. Each tech giant, in other words, sees voice as a tether to the myriad digital products it is creating.

The combatants, each wildly profitable and therefore able to fund ample research and marketing efforts, bring different assets to the table. Apple and Google, for example, own the two dominant mobile operating systems, iOS and Android, respectively. That means Siri and Google Assistant come preinstalled on nearly all new phones. Amazon, in contrast, needs to get consumers to install and then open the Alexa app on their iPhones or Android devices. "The extra step to open the Alexa voice app puts Amazon at a distinct disadvantage," says Loup's Munster, formerly a Wall Street analyst of computer companies. By contrast, all that's required to activate Siri and the Google Assistant is to say their names.

That said, iOS and Android are open to third-party developers of all stripes, and Amazon is one of them—meaning that nothing is stopping developers on both platforms from writing Alexa programs. Bezos bragged in an earnings release earlier this year that "tens of thousands of developers across more than 150 countries" are building Alexa apps and incorporating them into non-Amazon devices. Indeed, partnerships are a key battleground for voice applications. Alexa is built into "soundbars" from Sonos, headphones from Jabra, and cars from BMW, Ford, and Toyota. Google boasts integrations with audio equipment makers Sony and Bang & Olufsen, August smart locks, and Philips LED lighting systems, and Apple has partnerships that allow its HomePod to work with First Alert Security systems and Honeywell smart thermostats. "The beauty of these partnerships," says Google's Fox, "is that they allow us to link voice into the whole smart-appliance ecosystem. I don't have to open my phone and go to an app. I can just say to the device, 'Show me who's at my front door,' and it will pop right up. It's simplifying by unifying."

Artificial intelligence has long been a staple of dystopian popular culture, notably from films such as *The Terminator* and *The Matrix*, where wickedly clever machines rise up and pose a threat to humankind. Thankfully, we're not there yet, but advances in A.I. and the availability of cheap computing have made impressively futuristic applications a reality. Early voice-recognition programs were only as good as the programmers who wrote them. Now these apps keep getting better because they are connected through the Internet to data centers. These complex mathematical models sift through huge amounts of data that companies have spent years compiling and learn to recognize different speech patterns. They can recognize vocabulary, regional accents, colloquialisms, and the context of conversations by analyzing, for example, recordings of call-center agents talking with customers or interactions with a digital assistant.

Voice-recognition systems rely as much on physics as on computer science. Speech creates vibrations in the air, which voice engines pick up as analog sound waves and then translate into a digital format. Computers can then analyze that digital data for meaning. Artificial intelligence turbocharges the process by first figuring out whether the sound is directed toward its systems by detecting a customer-chosen "wake word" such as "Alexa." Then they use machine-learning models trained by what millions of other customers have said to them before to make highly accurate guesses as to what was said. "A voice-recognition system first recognizes the sound, and then it puts the words in context," explains Johan Schalkwyk, an engineering vice president for the Google Assistant. "If I say, 'What's the weather in …,' the A.I. knows that the next word is a country or a city. We have a 5-million-word English vocabulary in our database, and to recognize one word out of 5 million without context is a super hard problem. If the A.I. knows you're asking about a city, then it's only a one-in-30,000 task, which is much easier to get right."

Computing power allows the systems multiple opportunities to learn. In order to ask Alexa to turn on the microwave—a real example—the voice engine first needs to understand the command. That means learning to decipher thick Southern accents ("MAH-cruhwave"), high-pitched kids' voices, non-native speakers, and so on, while at the same time filtering out background noise like song lyrics playing on the radio. It then has to understand the many ways people might ask to use the microwave: "Reheat my food," "Turn on my microwave," "Nuke the food for two minutes." Alexa and other voice assistants match questions with similar commands in the database, thereby "learning" that "reheat my food" is how a particular user is likely to ask in the future.

The technology has taken off in part because it has gotten so proficient at translating human commands into action. Google's Schalkwyk says his company's voice engine now responds with 95% accuracy, up from only 80% in

NICK FOX
GOOGLE

"Every once in a while there is a tectonic shift in technology, and we think voice is one of those."

ROHIT PRASAD
AMAZON

"We wanted to remove friction for our customers, and the most natural means was voice. It's not merely a search engine with a bunch of results that says, 'Choose one.' It tells you the answer."

FOX: COURTESY OF GOOGLE; PRASAD: COURTESY OF AMAZON

2013—about the same so-so level of accuracy human listeners achieve. One of the great recent triumphs in the field has been teaching the engines to filter out nonspoken background noise, a distraction that can frustrate the keenest human ear. These systems reach this level, however, only when the question is simple, like, "What time is *Mission: Impossible* playing?" Ask the Google Assistant or Alexa for an opinion or try to have an extended back-and-forth conversation, and the machine is likely to give either a jokey preprogrammed answer or to simply demur: "Hmm, I don't know that one."

TO CONSUMERS, voice-driven gadgets are helpful and sometimes entertaining "assistants." For the tech giants that make them—and keep them connected to the computers in their data centers—they're tiny but extremely efficient data collectors. About 60% of Amazon Echo and Google Home users have at least one household accessory, such as a thermostat, security system, or appliance, connected to them, according to Consumer Intelligence Research Partners. A voice-powered home accessory can record endless facts about a user's daily life. And the more data Amazon, Google, and Apple can accumulate, the better they can serve those consumers, whether through additional devices, subscription services, or advertising on behalf of other merchants.

The commercial opportunities are straightforward. A consumer who connects an Echo to his thermostat might be receptive to an offer to buy a smart lighting system. Creepy though it may sound to privacy advocates, the tech giants are sitting on top of a treasure trove of personal data, the better with which to market more efficiently to consumers.

As with their overall strategies, the tech giants have different approaches to the data they collect. Amazon says it uses data from Alexa to make the software smarter and more useful to its customers. The better Alexa becomes, the company claims, the more customers will see the value of its products and services, including its Prime membership program. Although Amazon is making a big push into advertising—the research firm eMarketer projects the company will pull in $4.61 billion from digital advertising in 2018—a spokesperson says it does not currently use Alexa data to sell ads. Google, counterintuitively, considering its giant ad business, also isn't positioning voice as an ad opportunity—yet. Apple, which loudly plays up the virtue of its unwillingness to exploit customer data for commercial gain, claims to be approaching voice merely as a way to improve the experience of its users and to sell more of its expensive HomePods.

DESPITE ONE OF AMAZON'S early selling points, what people aren't asking their devices to do is help them shop. Amazon won't comment on how many Echo users shop with the device, but a recent survey of book buyers by consulting firm the Codex Group suggests that it's still early days. It found that only 8% used the Echo to buy a book, while 13% used it to listen to audiobooks. "People are creatures of habit," says Vincent Thielke, an analyst with research firm Canalys, which focuses on tech. "When you're looking to buy a coffee cup, it's hard to

THE FUTURE OF VOICE

▶ **ASK ALEXA** something easy, like, "Play 'In My Feelings' by Drake," and she gets it right about every time. Try to engage in an in-depth conversation on the midterm elections, and you're likely to find her tongue-tied. A.I. scientists say the holy grail of voice recognition is to make computers so smart that they can have a long, nuanced conversation with humans. The better computers get at this, the more useful they will be as smart assistants.

Each year, Amazon offers a $1 million reward for any university team of programmers who design a piece of software that can keep a conversation with a human going for 20 minutes without getting confused or straying off topic. No one has yet to claim the full prize, but a team from the University of Washington came close last year and walked off with $500,000 for keeping the chatter going for 10 minutes on average. "The biggest challenge," says Mari Ostendorf, a UW professor who advised the team, "is open-ended conversations where someone suddenly asks why or how someone did something. The machine has too many choices."

Even so, voice is getting smarter. Najim Dehak, a computer and electrical engineering professor at Johns Hopkins, uses voice recognition to identify irate customers. He has fed his voice software recordings of 2,000 negative and 2,000 positive customer conversations gleaned from a company call center. By focusing on keywords—profanities are a dead giveaway for negativity—the machine can identify which calls are from teed-off customers. "The idea," says Dehak, "is that managers can listen to those negative calls to know if the service agent did something wrong or needs more training." The software is in test phase, but Dehak says it should be available within a year or so.

describe what you want to a smart speaker."

Amazon does say it's not overly fixated on the Echo as a shopping aid, especially given how the device ties in with the other services it offers through its Prime subscription. Still, it holds out hope the Amazon-optimized computers it has placed in customers' homes will boost its retail business. "What is available for shopping is your buying history," says Amazon's Prasad, the natural-language-processing scientist. "If you want to buy double-A batteries, you don't need to see them, and you don't need to remember which ones. If you've never bought batteries before, we will suggest Amazon's brand, of course."

The potential to boost shopping remains far bigger than selling replacement batteries, especially because so many merchants will want to partner with—and take advantage of—the platforms associated with the tech giants. The research firm OC&C Strategy Consultants predicts that voice shopping sales from Echo, Google Home, and their ilk will reach $40 billion by 2022—up from $2 billion today. A critical evolution of the speakers helps explain the promise. Both Amazon and Google now offer smart home devices with screens, which make the gadgets feel more like a cross between small computers and television sets and thus better for online shopping. Amazon launched the $230 Echo Show in the spring of 2017. Like other Echo devices, the Show has Alexa embedded, but it also enables users to see images. That means shoppers can see the products they are ordering as well as their shopping lists, TV shows, music lyrics, feeds from security cameras, and photos from that vacation in Montana, all without pushing any buttons or manipulating a computer mouse.

For its part, Google has partnered with four consumer electronics manufacturers, some of which have recently started selling smart screens integrated with the Google Assistant. The Lenovo Smart Display, for example, looks a lot like Facebook's new Portal and retails for $250, the same price as the JBL Link View. LG plans to launch the ThinQ View. In October, Google started selling its own version, the Home Hub, for $149, with a seven-inch screen.

In the long run, Google is betting that having a screen will make voice shopping easier. The search company doesn't sell products directly like Amazon, but its Google Shopping site connects retailers to the Google search engine. Already it is empowering the Google Home device as a shopping tool. It has a partnership with Starbucks, for example, that enables a user to tell the Google Assistant to order "my usual," and the order will be ready upon arrival. Last year, Google cemented a partnership with Walmart, the world's largest retailer. Shoppers can link their existing Walmart online account to Google's shopping site and simply ask Google Home to check whether a favorite pair of running shoes is in stock, reserve a flat-screen TV for same-day pickup, or find the nearest Walmart store.

The rise of vision-recognition tech—voice recognition's A.I. sibling, long used for matching faces of criminals in a crowd—will make shopping on these devices even more convenient. In September, Amazon announced it was testing with Snapchat an app that enables shoppers to take a picture of a product or a bar code with Snapchat's camera and then see an Amazon product page on the screen. It's not hard to imagine that the next step for shoppers will be to use the camera embedded in the Echo Show to snap a picture of something they'd like to buy and then see onscreen the same or similar items along with prices, ratings, and whether they're available for Prime two-day free shipping.

E**XCITING AS THIS** technology is, it may take nontechnophiles a bit of time to get used to speaking to machines. The tech giants aren't the most trusted of companies right now, and they'll need to convince consumers their devices aren't eavesdropping for nefarious reasons. Smart speakers are supposed to click into listen mode only when they detect "wake words," such as "Alexa," or "Hey, Google." In May, Amazon mistakenly sent a conversation about hardwood floors that a Portland executive was having with his wife to one of his employees. Amazon publicly apologized for the snafu, saying it had "misinterpreted" the conversation.

The spoken word has the potential for errors far beyond that of typed commands. This can have commercial repercussions. Last year a 6-year-old Dallas girl was talking to Alexa about cookies and dollhouses, and days later, four pounds of cookies and a $170 dollhouse were delivered to her family's door. Amazon says Alexa has parental controls that, if used, would have prevented the incident.

Still, widespread adoption is likely because of the growing convenience of a voice-connected world. With more than 100 million of these devices already installed and in listening mode, it's only a matter of time before voice becomes the dominant way humans and machines communicate with each other—even if the conversation involves little more than scatological sounds and squeals of laughter. F

Brian Dumaine is the author of a forthcoming book on Amazon to be published by Scribner.

A FORK IN THE ROAD FOR AVIS

Self-driving cars and ride-hailing services could make the car-rental industry obsolete—or create a once-in-a-generation opportunity. Here's what Avis Budget is doing to avoid a wrong turn.

BY PHIL WAHBA

ARE THERE ANY EXPERIENCES MORE JOYLESS THAN renting a car at the airport? Cranky after a long flight, you clamber onto a crowded shuttle bus. There you join the line at the counter, waiting your turn to endure a hard sell for insurance policies and a GPS device. (Pro tip: You already have a GPS built into your phone.) Then it's off to the lot to hunt down your car in a sea of identical sedans. It says something particularly unflattering about this industry that, in a society in which technology makes most routines faster, the average wait time to pick up a rental car got two minutes *longer* between 2013 and 2017, according to consumer insights firm J.D. Power.

If you'd like to see this whole business model disappear in a cloud of smoke—well, so would a lot of people in the rental-car business. Before long, they hope, you'll be able to skip the counter-kiosk complex entirely. Once you get to the lot, you'll use your smartphone to activate your car's headlights so you can easily find it. Your phone will unlock it and

▲ PHOTOGRAPH BY **CHRISTOPHER LANE**

A LOT TO FIX Wait times for rental-car pickup have actually increased since 2013; Avis hopes that better tech can eliminate the delays.

turn on the ignition. You'll drive off without having to go through yet another line at the don't-back-up-or-we'll-puncture-your-tires exit gate. And that's if you go to the lot at all: Someday, the rental agency may send a self-driving car to pick you up at your terminal.

"In the future, we don't need to see you at the counter," says Avis Budget CEO Larry De Shon. Every big rental-car company is taking steps in this direction, but Avis, the smallest of the industry's "Big Three" by U.S. market share (behind Hertz and Enterprise), is making the most concerted effort to update its 600,000-vehicle fleet—and protect its $9-billion-a-year business from obsolescence.

In the past 18 months, Avis Budget, which owns those two namesake brands along with Payless Car Rental and car-sharing pioneer Zipcar, has struck one partnership after another with Big Tech's boldface names. In June 2017 it landed a deal with Waymo, Alphabet's autonomous-vehicle division, to manage its growing fleet of self-driving cars. Soon after, it teamed up with Amazon and Google so customers could use voice tech to make or change reservations. And this August, Avis announced it would begin renting thousands of cars to Lyft drivers.

Underlying all those partnerships, there's a bigger project at Parsippany, N.J.–based Avis: an endeavor to connect the bulk of its fleet to the Internet by 2020. That's a more aggressive deadline than any of its rivals have embraced. And it's no small task for a company that offers 250 different makes of vehicles, scattered across almost 4,400 locations in the Americas alone. But it's an urgent one, because car connectivity is a cornerstone of the industry's efforts to keep up with the automobile sector's dramatic changes.

That hassle-free airport experience, for starters, depends on connectivity. It'll help Avis wring more revenue out of its cars by increasing their time in service, cutting maintenance costs, and pitching ads and services to drivers. Above all, connectivity will provide the infrastructure to support more self-driving cars—a technology that will inevitably shake up the rental industry.

Shareholders would certainly like to see a shake-up: They've driven Avis's and Hertz's stock down by more than 50% over the past three years. (Enterprise is privately held.) Profit margins are stagnant, and new competitive pressure is coming from all sides: Ride-hailing services like Uber and Lyft are wooing rental companies' business customers, and big automakers are contemplating a future as "mobility companies" that rent cars directly to consumers. "In next five years you're going to have Google, Uber, Avis, Hertz, and Ford all in the same business," says Neil Abrams, a veteran car-industry analyst.

For Avis, it adds up to an evolve-or-die moment, one in which its rivals will be just as aggressive (indeed, Hertz had a Lyft partnership before Avis did). "This isn't one where we can sit back for the next 10 years," says chief innovation officer Arthur Orduña. "We don't have a heck of a lot of time."

CEO LARRY DE SHON IS PUSHING TO GET ALL 600,000 CARS IN THE AVIS BUDGET FLEET CONNECTED TO THE INTERNET BY 2020.

AVIS HAS BEEN AHEAD of the curve on many occasions since its debut. The company was founded in 1946—well before air travel went mainstream—on the idea that rental cars should be available at airports. In 1987, Avis was the first rental-car company to introduce a key-drop return process that bypassed the counter; in 1996, it was the first to offer online reservations.

But in recent years, being the Most Innovative Rental-Car Company has been like being the Fastest Turtle. The Big Three have a combined 94% share of the $30 billion U.S. rental market, but that dominance hasn't translated into pricing power. The giants all offer vehicles from the same carmakers, so they struggle to differentiate themselves. Income from incidentals like GPS and toll-paying devices has waned, even as those add-ons have annoyed customers. The upshot: IBIS World expects the industry's U.S. revenues to grow just 2% annually through 2023, far slower than the broader travel industry.

Avis hasn't been immune to the malaise. In 2010, the company earned $41.70 per car per "rental day," by 2017, that had fallen to $40.03. None of the rental companies scores well on customer surveys, but Avis ranks slightly below its rivals on that front. That makes its tech reinvention that much more

DRIVING CHANGE Avis's 2013 acquisition of Zipcar (top) has helped it experiment with car sharing and improve its app. Providing maintenance for Waymo (above) is giving it a foot in the door in the self-driving-car industry.

THIS SPREAD: COURTESY OF AVIS

critical, as a chance to revitalize its business and a path back into customers' good graces. "Tech that gets me into the car faster will be a big factor in molding customer satisfaction," says Michael Taylor, J.D. Power's head of travel.

Avis began laying the groundwork for a tech-driven rebound in 2013. That year, Avis paid $500 million to acquire Zipcar, the startup that rents cars on an hourly basis from self-service sites scattered through neighborhoods and downtowns. The move seemed quixotic to some—at the time, Hertz was doubling down on its core business, digesting a $2.3 billion acquisition of Dollar Thrifty. But while the car-sharing market remains small, Zipcar has turned into an internal catalyst for ideas about rejuvenating Avis.

Since the acquisition, Avis's capital spending on technology has tripled, reaching $128 million last year. In 2016, not long after De Shon became CEO, Avis rolled out a new, more sophisticated (and partly Zipcar-inspired) app for its namesake brand that lets customers book or change a reservation, keep receipts and speed up check-ins and drop-offs. Orduña, who became head of innovation that year, set about updating Avis's tech plumbing. He created an application programming interface (API)—an open software-development system that allows ride-hailing services, digital mapmakers, city planners, and other potential partners to add elements to and share data with Avis's app. API platforms could be a key revenue driver down the line: Orduña envisions a scenario in which, for example, a department store would pay Avis a fee, in return for which Avis would embed ads in its app to steer users to the store's website. The app could also literally steer them to the store: A traveler who forgot to pack socks could be chauffeured to a shopping site by her self-driving rental sedan.

Orduña's team has done even more ambitious work on the connectivity project. In August, Avis reached the milestone of 100,000 vehicles connected to the Internet. The device that's central to those connections is a contraption installed on the underside of each car's hood. It's loaded with sensors that read the car's vital signs, from its exact location to the precise state of metrics like fuel levels, tire pressure, and brake-pad health.

These prosaic-looking devices could have a big financial impact. For a given car to make a penny of profit for a rental company, it needs to be rented out at least 82% of the time. If Avis can monitor a car's vital signs in real time, it can avoid spending money servicing cars that don't need it. Conversely, it can reduce the odds of a breakdown that would take a car out of service (not to mention alienate renters who suffered a roadside mishap).

Location tracking also helps Avis milk more revenue-earning days out of its fleet.

When cars get impounded because of parking violations, renters often walk away, leaving the agencies to deal with the consequences—including figuring out where the car has been towed. Avis won't say how much revenue it loses to this scenario. But it's a big enough problem that the company has set up geofencing around more than 160 of the country's biggest impound lots, so it doesn't have to wait for pound workers to call the company. That move, combined with internal location tracking, has cut the average recovery time for an impounded car by half, to six days. (In a similar if more upscale vein, location tracking helps Avis more quickly retrieve rentals that have been dropped off early at airports that serve the private-jet crowd.)

Connected cars could also allow Avis to widen its customer base, by putting its cars closer to more drivers. The company hopes to become less reliant on airport locations, where it currently gets 70% of its revenue. Avis is talking with retailers, mall developers, and city planners about creating self-service, counter-free hubs where people could pick up and drop off a car, much as they do with Zipcar. "Anywhere I can park five to 10 cars, I can call it a rental location," says De Shon, the CEO.

Avis has begun testing that model in the Kansas City, Mo., area, where all of its roughly 5,000 cars are connected. Avis is sharing live car-location data to help city planners refine their computerized traffic flow models, the better to determine which roads are used most frequently and to plan repairs more efficiently. In return, Avis stands to get something any city dweller can appreciate: a bunch of dedicated parking spots.

IF YOU RENT A CAR from some Avis locations in the Phoenix area for three days or more, you'll soon get an extra perk: a coupon for a ride in a driverless Waymo. Your *Jetsons* moment, should you choose to accept it, will be part of an experiment with high stakes for Avis and its rivals.

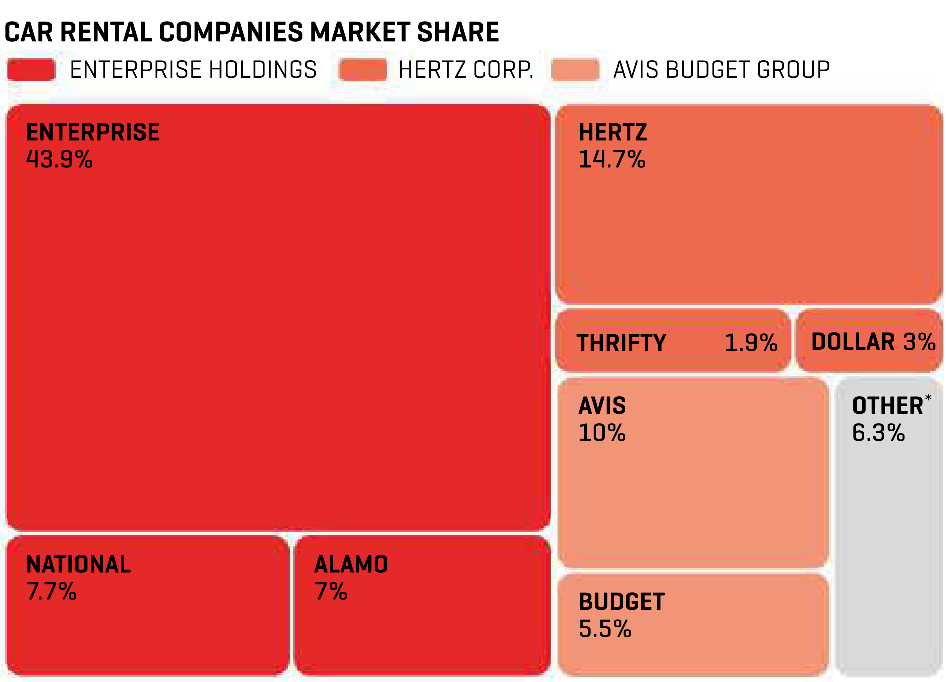
Avis's shares shot up 21% on the day it announced its Waymo partnership last year. Enterprise and Hertz have been exploring the same terrain, but Avis's deal with Waymo is the splashiest so far, and Waymo, in turn, is further along in its development than many competitors. While autonomous vehicle (AV) makers have numerous regulatory and technological hurdles to clear, few doubt self-driving cars' day is near: Boston Consulting Group estimates that by 2030, 25% of miles driven on U.S. roads could be logged by shared, self-driving electric cars.

For a shared-car business model to work, however, these robo-taxis will need to be on the road practically around the clock, which means they'll need to be serviced and cleaned far more regularly than typical cars. That's where the Avis-Waymo deal comes in. In Phoenix, a testing-ground for many AV-makers, Avis is servicing Waymo's self-driving Chrysler Pacifica minivans, a fleet of 600 cars and counting. Avis handles tasks like oil changes, tire rotations, and cleaning; Waymo maintains the more high-tech AV hardware.

Avis is betting that its huge infrastructure of garages and storage facilities will make it an essential partner to provide such "fleet management services" for the car-sharing companies of the future. (This, too, will be a

GOTTA TRY HARDER

The Avis Budget Group has the smallest market share among the "Big Three" in the U.S. rental-car industry.



*OTHERS INCLUDE PAYLESS, AN AVIS SUBSIDIARY WITH VERY SMALL MARKET SHARE SOURCE: EUROMONITOR

GRAPHIC BY NICOLAS RAPP

FIVE REASONS YOUR RENTAL-CAR COMPANY WILL LOOK VERY DIFFERENT IN FIVE YEARS

Ride-sharing and self-driving cars have forced the industry to reinvent itself. Here's how the big players are adapting.

1.
CONNECTED CARS

The rental-car companies are gradually connecting their millions of vehicles to the Internet. The aim: to cut maintenance costs, make sure cars spend more time on the road, and generate new sources of revenue from selling ads and services. Avis Budget has committed to getting all 600,000 of its cars connected by 2020.

2.
AUTONOMOUS VEHICLES

Autonomous vehicles (AVs) are coming, and analysts expect them to be especially attractive to the lucrative business-traveler market. The rental companies are trying to get in at the ground level with the AV-makers. Key partnerships: Avis and Waymo; Hertz and Aptiv; Enterprise and Voyage.

3.
FLEET MANAGEMENT

Rental rates have stalled, so Avis and others want to diversify their revenue sources. With sprawling networks of garages and expertise in maintaining, fixing, and cleaning cars, these companies see opportunity in selling fleet management services to other companies, including AV-makers.

4.
CAR SHARING

Car sharing accounts for less than 1% of revenues in the "mobility" sector, but the industry leaders all dabble in the field. This is helping them prepare for a future with more counter-free locations for their rental fleets. Key brands: Zipcar (Avis), EnterpriseCar Share, and Hertz 24/7.

5.
RESALE RETAIL

Rental-car companies resell their cars after a few years, and the biggest drag on industry profits has been a weak secondhand auto market. To better control the timing and location of those resales, the Big Three are building their own physical used-car sales lots. Avis now has seven stores and plans to add more.

hotly contested field: Hertz and Enterprise also have strong fleet-management businesses.) For Avis, deals like its Waymo partnership offer the chance to earn extra revenue without the heavy fixed cost that comes from owning those cars. Waymo and other tech companies, in turn, avoid the expense of managing maintenance. As De Shon puts it, "Why go out and develop something that's already built?"

Getting a foot in the door with the AV-makers also sets the stage for Avis to someday radically overhaul its own fleet. Hans-Werner Kaas, senior partner at consultancy McKinsey & Co., thinks business travelers will be the first to clamor for self-driving rental cars, which will enable them to work instead of drive and still get to their destination. "The value of freed-up time is simply more relevant for them," says Kaas. Such travelers account for 40% of Avis Budget's customers: If they want robo-rentals, Avis will need to deliver.

NOT LONG AGO Larry De Shon's son called him with some news: The young man, who lives in Chicago, was selling his car because he didn't need one. The news "broke my heart, because it was his graduation gift," De Shon recalls. "I ask, 'How can you sell your car?' The kid answers, 'I can take a Zipcar, I can take an Uber.'" The upside: The kid also rented cars from Avis four times in the ensuing months, for longer weekend trips.

All signs indicate that car-ownership rates will continue to drop as younger generations opt out. As De Shon's story suggests, that's a potential opportunity for rental-car companies. The trend may well create a much bigger customer base. But the rise of Lyft, Uber, and the robo-taxi crowd creates much more competition.

Avis's Lyft partnership, announced in August, is the latest example of how Avis hopes to use technology to hedge multiple bets. Under the agreement, the Avis brand will provide thousands of cars to Lyft's Express Drive program, which mobilizes prospective drivers who don't own cars. The deal gives Avis an in with a future big user of AVs, and more experience working with the ride-sharing business model. It also helps it get more revenue-generating days out of its regular fleet cars.

Avis's core business, meanwhile, is far from extinct. Its typical rental today is a four-day contract involving some 450 miles. A family of four landing in Salt Lake City en route to visit the national parks in Utah is not about to use Uber or Lyft. Hertz CEO Kathryn Marinello estimates there is only currently a 10% overlap between the traditional rental-car market and the mostly urban short-haul market where the ride-sharing services dominate.

Still, the change that has swept through that 10% in recent years has shown Avis Budget that it can't afford to sit still. The tech partnerships, says Orduña, the innovation officer, are finally beginning to change "the perception of us as a dinosaur sitting there, waiting for a comet to hit."

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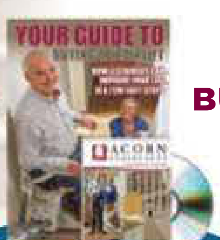

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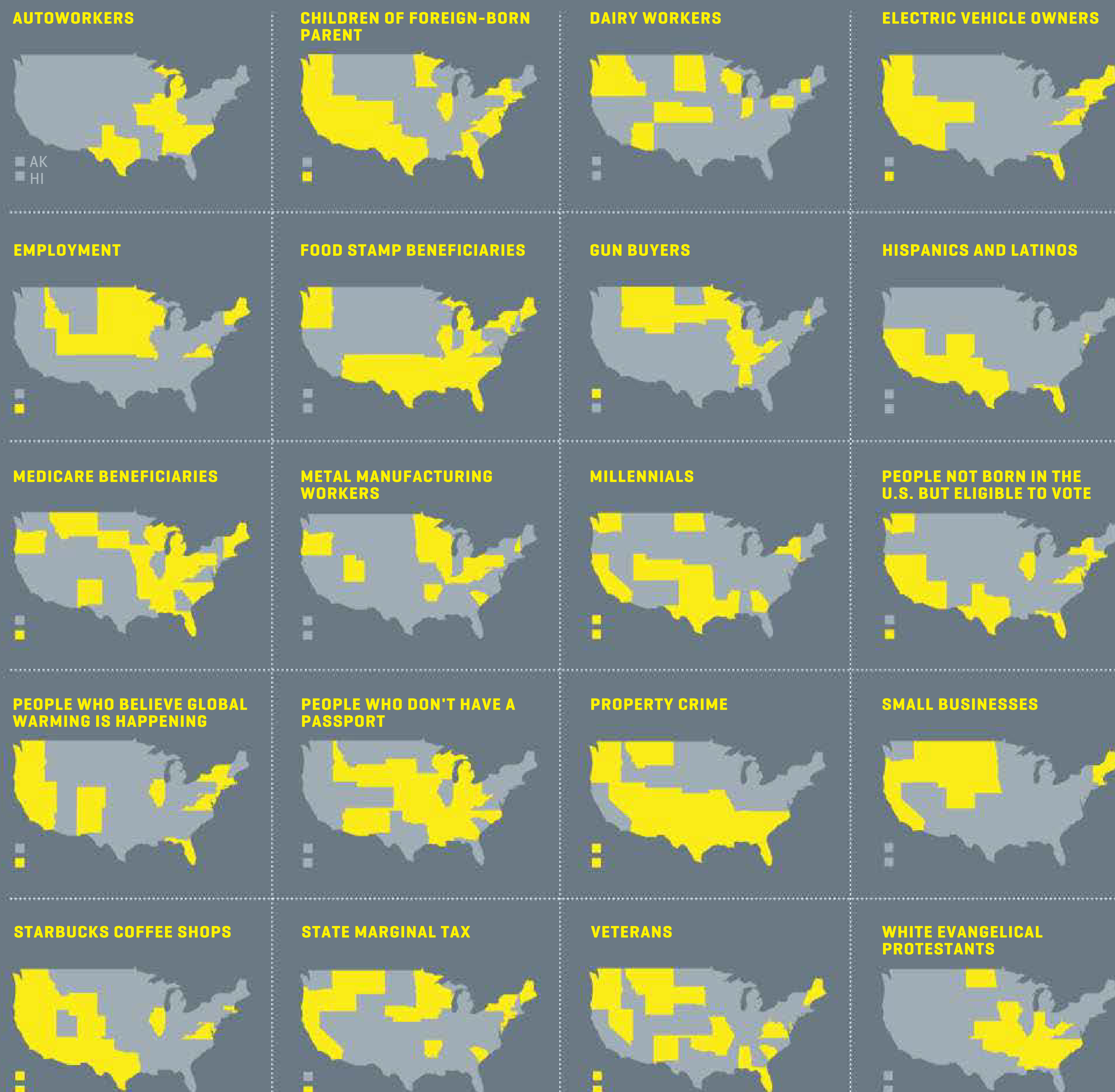

VOTER ID

GRAPHIC BY **NICOLAS RAPP**

ON NEARLY EVERY POLITICAL MAP TODAY, America is a land riven into red and blue—a stark bifurcation that pollsters and pundits never fail to remind us of. But the complexions of American voters—and the issues that matter to them—are far more nuanced than any rigid two-color scheme implies. And so, on the eve of the midterm congressional elections, *Fortune* has put together 20 U.S. maps that break through the red-blue partition—as well as the standard demographic dividing lines of age, race, and gender—and hint at concerns that may influence some voters as they head to the polls on Nov. 6. —CLIFTON LEAF

HIGH RATE DEFINED AS: AUTOWORKERS: Represents at least 20 per 100,000 of state population. CHILD OF FOREIGN-BORN PARENTS: At least 4% of children under 18 with at least one non-native parent. DAIRY WORKERS: At least 22 per 100,000. EV OWNERS: At least three fully electric cars sold per 10,000 in 2017. EMPLOYMENT: Under 3.3% unemployment. FOOD STAMPS: At least 13% recipients. GUN BUYERS: At least nine gun background checks per 100 population in 2017. [Federally licensed firearms dealers only.] HISPANICS/LATINOS: At least 20%. MEDICARE BENEFICIARIES: At least 18% on Original Medicare. METAL MANUFACTURING: At least 100 per 100,000. MILLENNIALS: At least 15% of the population. PEOPLE NOT TRAVELING: Passport issued to less than 3% of the population yearly. GLOBAL WARMING OPINION: Less than 70% of adults believe that global warming is happening. PROPERTY CRIME: At least 2,500 per 100,000 population. SMALL BUSINESSES: At least 32 per 1,000 population. STARBUCKS COFFEE SHOPS: At least 3.5 per 100,000 population. STATE MARGINAL TAX: 6.5% or above. VETERANS: At least 7.5% of the population. NOT BORN IN THE U.S./ELIGIBLE TO VOTE: At least 5% of the population. WHITE EVANGELICAL PROTESTANTS: At least 20% of the population.

SOURCES: **CENSUS BUREAU; BUREAU OF LABOR STATISTICS; ALLIANCE OF AUTO MANUFACTURERS; USDA; FBI; U.S. CENTERS FOR MEDICARE & MEDICAID SERVICES; U.S. DEPT. OF STATE; YALE UNIVERSITY; U.S. DEPT. OF JUSTICE; STARBUCKS; TAX FOUNDATION; DEPT. OF VETERANS AFFAIRS; PUBLIC RELIGION RESEARCH INSTITUTE**


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