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Smithsonian

How Americans are going to get there first and where we might stay along the way

WELCOME to MARS

SCI-FI GETS REAL

THE ORAL HISTORY OF "STAR TREK"

ZAP HAPPY: HOW TO PLUG IN YOUR BRAIN

ROBERT BIGELOW: THE WORLD'S FIRST SPACE ARCHITECT

REINVENTING THE WHEELS: YOUR FLYING CAR IS HERE

ABOUT THIS IMAGE

An exclusive new picture from the Mars Reconnaissance Orbiter.

University of Arizona / JPL / NASA

THE ROAD BEST *TRAVELED*







Images by Erik Johansson
Prototypes shown with options. Production models may vary.

For decades, new car buyers faced a few fairly simple choices: a sexy sports car; cushy, comfortable luxury vehicle; or boxy-but-safe family van? Then Toyota changed the rules of the road entirely with the introduction of the Prius—its cutting-edge gasoline/electric hybrid that made fuel efficiency practical, became an international best-seller and helped ignite the worldwide eco-friendly transportation movement.

Having established itself as the industry leader, what would Toyota introduce next? More innovation, and the future is already here—with the 2016 Toyota Prius. This newest version of the global green icon pushes the hybrid concept farther down the road, with design and technology breakthroughs that will delight the Prius faithful and turn heads of those new to the game.

DESIGNED TO MOVE

Toyota's design team took the image of a runner in the starting blocks as inspiration for the 2016 Prius design, and the result is a sporty profile that conveys a palpable sense of forward motion even when the car is in park. The "triangle silhouette" that defined the second- and third-generation Prius is now longer, sleeker and more athletic, with a lower hood and edgy character lines that run along the sides to accentuate the low stance. The exterior design might be hard for the eye to resist, but it is resolutely easy on wind resistance, slicing through the air with a 0.24 coefficient of drag—among the lowest of current passenger cars. Such sleekness does not come at the cost of compromised driver visibility, however. Views to the front, sides and back are now all bigger and wider, thanks to ingenious design adjustments such as larger and better positioned windows and mirrors. The exterior folding side mirrors—with their new shape and location—cut wind noise so you see more and hear less.

The all-new Prius is much quieter than the previous models. Its lighter, more efficient hybrid system and high-strength, lightweight body materials maximize noise control without harming fuel economy or performance. Throughout, the innovation of the fourth-generation interior design has been pushed forward, with functional features you'd expect in a Prius reimagined in fun and pleasing new ways. The wraparound dash features intuitive, readily reachable and easy-to-use controls. The form-hugging seats accommodate five comfortably.

HANDLES WITH CARE

Of course, it's only when you slide behind the wheel of a car that you truly know if you've met your match. And it is here, on the open road, that the 2016 Prius truly struts its stuff. The new platform introduces double-wishbone rear suspension. Combined with the vehicle's low center of gravity, it delivers a highly responsive, smooth and pleasurable driving experience.

Twenty years after its game-changing hybrid innovation, Toyota has again rewritten the rules of the road with the 2016 Prius. Take the future for a spin. •

THE ALL-NEW PRIUS

TOYOTA | *Let's Go Places*



WHAT'S NEXT

With a lower center of gravity, wider stance and new double-wishbone rear suspension, the 2016 Prius is making getaways even more thrilling. An exhilarating ride is what's next.

THE ALL-NEW
PRIUS

toyota.com/prius

Prototype shown with options. Production model may vary. ©2015 Toyota Motor Sales, U.S.A., Inc.

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We create chemistry

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MAY 2016

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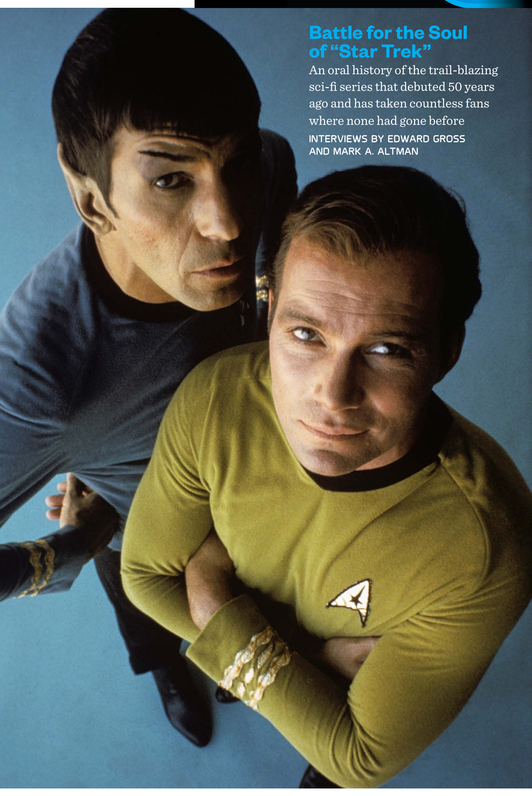

Battle for the Soul of "Star Trek"

An oral history of the trail-blazing sci-fi series that debuted 50 years ago and has taken countless fans where none had gone before

INTERVIEWS BY EDWARD GROSS AND MARK A. ALTMAN

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Traitors and Haters

The complex story behind Benedict Arnold's treachery BY NATHANIEL PHILBRICK

Tweet All About It

The way we get news today may seem messy—until you look at the past BY CLIVE THOMPSON

Ask Smithsonian

IN THIS ISSUE

we explore visions of the future, from a TV show that transported us to far-off galaxies, to brain-charging stations, flying cars and inflatable space habitats.

SCI-FI GETS real



How to Plug In Your Brain

A neuroscientist is testing an electrical brain-stimulating treatment that shows great promise in making you sharper and more alert

BY DAVID NOONAN



Next Stop Mars

NASA's innovative deputy administrator Dava Newman discusses the big plans already underway to send Earthlings to the Red Planet

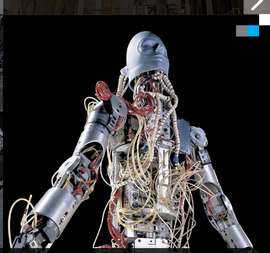
BY KATIE NODJIMBADEM



Home Away From Home

With his expandable module, the audacious hotel entrepreneur Robert Bigelow aims to revolutionize how we live and work in space

BY CHARLES FISHMAN



Model Astronaut

Created in the 1960s to test spacesuits, NASA's shiny aluminum android had surprisingly lifelike movement, but never made it off the shelf

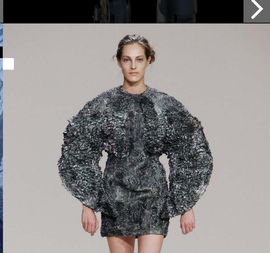
BY ANDREW CHAIKIN



Ready for Takeoff

Even before the "Jetsons," people dreamed of flying cars. Now breakthroughs in transportation technology are helping all kinds of vehicles get off the ground

BY JACK HITT



Material Girl

With her mind-bending, gravity-defying collections of haute couture, the futuristic Dutch designer Iris van Herpen redefines what it means to be fashion forward

BY NAOMI SHAVIN





The National Mall Fan Club

Family, summer fun and making memories is what America's front yard is all about. Make your next vacation amazing in Washington, DC. Find out how at WASHINGTON.ORG.

#MyDCcool

DC Cool

Contributors



Lynn Johnson

Johnson is a Pittsburgh-based photographer who has an uncanny ability to capture the intangible. In a recent, widely acclaimed portrait series, she focused on U.S. veterans injured by blast force whose scars were often invisible; they wore masks they had crafted to show their pain. Of photographing **"How to Plug In Your Brain,"** she said, "The visuals were not readily apparent," but her experience covering neuroscience stories gave her an edge, and spending a day talking with and shooting neuroscientist Aron Barbey helped, too. "Understanding his mind energized me about the whole project."



Charles Fishman

Within hours of learning that he'd scored an exclusive interview with real estate tycoon-turned-aerospace pioneer Robert Bigelow (**"Home Away From Home"**), Fishman was on a plane to meet the elusive visionary in Las Vegas. Fishman, a wide-ranging journalist, is the author of three books, including the best-selling *The Wal-Mart Effect*. He is currently at work on a book about the technology behind the first Moon landing.

Jack Hitt

Jack Hitt has spent a lot of time lately investigating trends in personal transportation. He has been tinkering with an old VW in his own garage, and now his retrofitted car runs on electricity and will soon be powered by solar panels atop his house. While researching the future of driverless vehicles, drones and flying cars for *Smithsonian* (**"Ready for Takeoff"**), Hitt spoke with a Stanford engineer studying Nascar drivers, a professor of engineering with a passion for DIY car projects and an Oregon entrepreneur building a flying car called the Switchblade. Hitt's work has appeared in the *New Yorker* and *Harper's* and on NPR's "This American Life." He is working on a book about Southern history.



Tom Jones

The scientist and former astronaut completed four missions in space. "The first thing I did when I left NASA was write *Sky Walking*," he says. "I wanted to translate the experience to other people." His guest appearance in **Ask Smithsonian** is adapted from *Ask the Astronaut: A Galaxy of Astonishing Answers to Your Questions on Spaceflight* (Smithsonian Books). Jones is now a researcher at the Florida Institute for Human and Machine Cognition.

Nathaniel Philbrick

The best-selling author of *In the Heart of the Sea* and *Bunker Hill* this month will publish a new history, *Valiant Ambition: George Washington, Benedict Arnold, and the Fate of the American Revolution* (Viking). In a piece adapted from that work (**"Traitors and Haters"**), Philbrick chronicles Arnold's personal life, military accomplishments and, crucially, the political controversy that helped push one of America's great patriots to sell out his country.

David Noonan

Noonan is a contributor to *Scientific American*'s Science of Health column and a former senior editor at *Newsweek*. For his report about an experimental electrical treatment called **transcranial direct-current stimulation (tDCS)**, he returned to his favorite subject: the brain. "It's so damn beautiful and complicated," he says. Would he undergo tDCS himself? "When administered by experts, it is safe and potentially beneficial. So yes, I'd be willing to have my brain zapped."

Helmo

The Paris-based graphic artists Thomas Couderc and Clément Vauchez, who call themselves Helmo, create striking images for museums and media, including the New York Times Magazine. For **"Battle for the Soul of Star Trek,"** they wanted to contrast "the emotional Kirk and the calm Spock," says Couderc. "Red and blue have the same primary presence, and that's why you see the double-portrait, at first glance, as a single image."

ILLUSTRATIONS BY **Irina Kruglova**



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Microsoft Cloud

Discussion

[“Catching a Wave”] is probably the best overview of the epic journey leading to the discovery of gravitational waves.
@mazen_alghoul ON TWITTER

FROM THE EDITORS *“What an intriguing and exciting development,” Susan LaDuke says on Facebook, one of many readers wowed by our April cover story about a long lost city in Cambodia. The Evotourism® articles inspired heated dialogue on science, faith and history. And Alice Gregory’s essay on the zoot suit sparked wide-ranging cultural memories, from a “Tom and Jerry” episode parodying the attire to a jazz icon. “This makes me think of Cab Calloway, who I remember in film clips I used to watch as a kid,” Jayne Derwin wrote on Facebook. “He was soooo smooooth and cool!”*



American Hero

William Barker Cushing, “the Civil War’s most daring naval officer” (“American Idol”), may be a forgotten man today with the general public, but he is well remembered by the U.S. Navy. His remains lie beneath an impressive monument at the Naval Academy, and five successive fighting ships have borne his name. Your article didn’t mention that the five men of his crew were individually awarded the Medal of Honor for this daring attack (officers were not eligible for the award in that era), or that Cushing died a mere ten years later at age 32, of an illness perhaps partly induced by the physical and mental rigors of his daring exploits during the war.

In addition, Cushing’s 22-year-old brother, Alonzo Cushing, died heroically at Gettysburg; he was buried at West Point and posthumously awarded the Medal of Honor by President Obama. And a third brother, Howard Cushing—“the Custer of Arizona”—died at age 32 fighting Apaches near Tucson in 1871. They were quite a family of whom we in western New York State are rightly proud.

Jack Horst
WESTFIELD, NEW YORK

Buried Treasure

I enjoyed the good article by Joshua Hammer, “Invisible Kingdom,” but I wonder about the dearth of photographs of Phnom Kulen, the article’s focus. As a side note, [Marcelo de] Ribadeneira, a Roman Catholic friar cited in the piece, was an explorer in the sense that he came upon places in his zeal to convert Asians to Christianity. While history benefits from his texts, he is also remembered for justifying the enslavement of non-Europeans in Asia as Christian charity.

Wilbur Norman
SANTA FE, NEW MEXICO

Birds of a Feather

Fossils (“Darwin’s Favorite Fossils”) have a profound way of allowing people to see the present in a different light. The Munich specimen of *Archaeopteryx* was discovered about the same time I was graduating from college with my geology degree. I’ve never looked at birds the same way since.

Glen Bray
FACEBOOK

Green Book Blues

Jacinda Townsend’s fine article “Driving While Black” concentrates on risks black motorists took when driving south in the 1940s, but ones traveling west-east routes also encountered racism. For black persons who left the West Coast for Chicago, there were hardly any places along the way where they could stop for hot meals and comfortable lodging.

One was in Elko, Nevada, where my step-grandfather, Sam Hearon, owned “Sam’s Cafe & Hotel.” “Daddy Sam” opened his business after leaving Alabama to seek more opportunities. It became known as a place where black travelers could dine and rent rooms.

Hosea L. Martin
CHICAGO, ILLINOIS

Animal Nature

The photos (“The Secret Lives of Animals”) are great but nothing compares to being at the Masai Mara to see these magnificant animals up close.

Al Bienstock
FACEBOOK

Correction

The artist Molly Crabapple did not enter the solitary confinement “hole” at the Pennsylvania State Correctional Institution, as reported in “Drawing Fire.” She based her drawing of the facility on a leaked cellphone video.

CONTACT US

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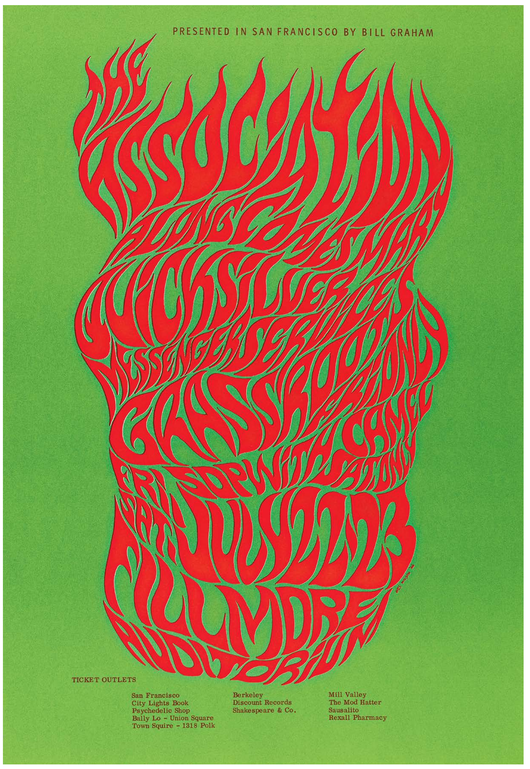
C'mon Baby Light My Flier

How the psychedelic concert poster rocked the world



July 16, 1966, the Fillmore Auditorium, San Francisco. Jefferson Airplane and the Grateful Dead have just finished their sets, and as patrons shuffle to the exits they're handed fliers for another concert, The Association and Quicksilver Messenger Service. The lettering on the 14- by 20-inch poster is a bright orange flame, electrifying, disorienting. Later Bill Graham, the Fillmore's promoter, will head out on his Lambretta motor scooter to plaster the posters around the city, as has been his practice for the last few months.

More and more, though, he notices them disappearing. His advertisements have become coveted works of art.

The psychedelic concert poster, with bubbled, flowing lettering and lava lamp colors, was invented by the man behind that now classic "Flames" flier, a local artist named Wes Wilson. Fifty years ago, as San Francisco transformed from a beatnik era of black and white to a hippie decade spiked with color, Wilson's designs for concerts featuring bands such as Santana, Muddy Waters and even the Beatles became the signature style for America's fomenting counterculture, as central to our comprehension of that era's visual landscape as long hair, bell-bottoms and VW buses.

Wilson started working in a San Francisco print shop in 1965. The 28-year-old had little formal training but was inspired by the freedom of Art Nouveau's sinuous shapes and the block-like lettering of Vienna Secessionist artists like Alfred Roller. "I started to see lettering as a form maker as well as a content of information," recalls Wilson, who now lives in Missouri's Western Ozarks. Early in 1966, Wilson made a few posters for Chet Helms, a force behind 1967's "Summer of Love." But it was when Wilson hooked up with Graham later that year that his style exploded. "Use all the space and put as much color in there as possible was kind of my feeling," Wilson says.

It was a radical departure from the functional typography then in wide use, such as the clean, legible Swiss Style familiar on highway signs, which communicates information without passersby having to stop. Concert posters were typically utilitarian, with plain type and maybe a photo of the act. But Wilson's hit you with the whole freak scene. His wild imagery offered a "slow leak of the information," says Jennifer Dunlop Fletcher, curator at the San Francisco Museum of Modern Art. "You really have to stop and stare." The museum will showcase nine of Wilson's posters in an exhibition opening this month, "Typeface to Interface," which covers graphic design from 1950 to the present.

Wilson created his posters at top speed. Graham needed to promote shows, and Wilson needed the paycheck. He created 40 for the Fillmore alone in 1966. Once other San Francisco poster artists—Victor Moscoso, Rick Griffin, Stanley "Mouse" Miller and Alton Kelley—began working in a similar vein, a 1967 *Time* magazine article dubbed the style "Nouveau Frisco," and called Wilson its foremost practitioner. In 1968, Wilson won a National Endowment for the Arts grant for his contributions to American art.

But as the style he pioneered moved from the streets into museums and department stores, Wilson grew discontented by the commercial side of his work. He left the city for life on a farm, but he kept making art.

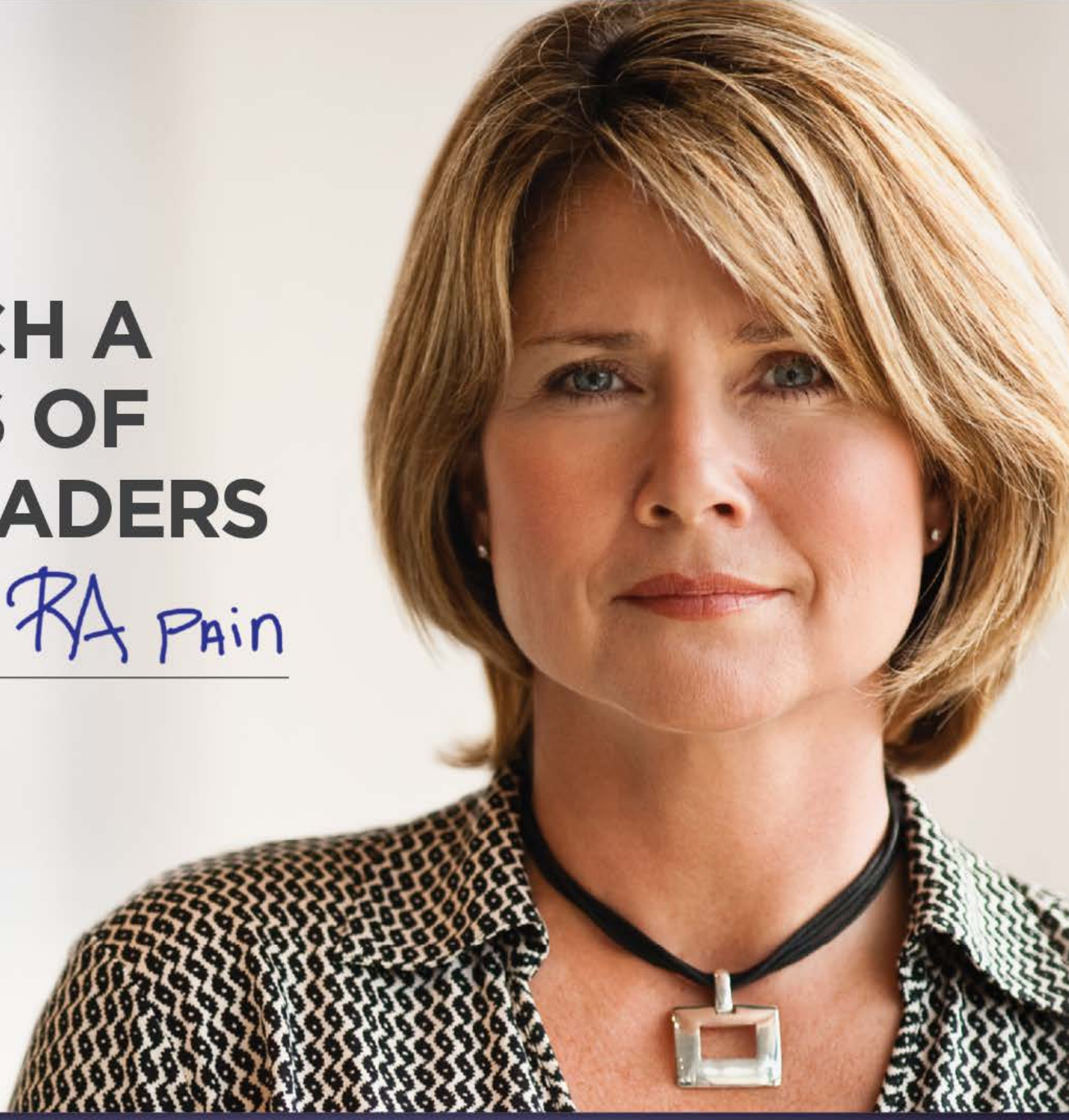
And his groovy style lives on. Nate Duval, who designs posters with a bold handcrafted aesthetic for bands like Wilco and the Black Keys, is inspired by the art of Wilson and his peers. "It was so loose and expressive yet had a commercial viability," Duval says. "If you walked past it and it didn't catch your eyes or make you want to stop and read it, then it wasn't for you anyway." BY AARON SKIRBOLL

One of a series of psychedelic concert posters done by artist Wes Wilson between 1966 and 1968 for concert promoter Bill Graham of San Francisco's Fillmore Auditorium.

AMERICAN ICON

I TEACH A CLASS OF 4TH GRADERS

with my RA pain



IT'S NOT OK TO JUST GET BY WITH RA PAIN.

Nobody chooses to have RA, but you do have control over how you live your life with it. If you feel like you're just getting by, talk to your doctor. But keep in mind that patients and rheumatologists often think about RA in different ways. Rethinking how you have the conversation could make a difference in what your doctor recommends.

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Identity Crisis

Capturing the chaos of living in a world of endless distraction



***Autogram Duo,* Berlin, 2014.**

"It's very tense. People wait for hours to see their idols," observes **Klaus Mitteldorf**, who took this photo (*Autogram Duo*) of autograph-seekers queuing to meet the actress Jennifer Connelly at the 2014 Berlin International Film Festival. The Brazilian-born Mitteldorf, 62, whose latest book, *Next,* comes out this month, uses digital manipulation to represent his anonymous subjects' imagined internal lives. "I try to create an identity for them," he says, explaining that this chaotic scene, layered upon itself several times, reminded him of "a fight." Though Mitteldorf makes a living as a fashion photographer, he has experimented with this technique since the 1980s, when altering photographs involved scissors and glue, and his latest project has an almost anti-aesthetic quality. Lacking any obvious focal point, these images may frustrate and even exhaust the eye—reflecting, Mitteldorf says, the anxiety and divided attention of our media-frenzied age. **–AMY CRAWFORD**


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Red Alert

The deadly cunning of the black widow's color scheme



Black widows' red hourglass tells birds to back off but is almost invisible to insects.

If your PhD adviser suggests that you spend more time with a creature famed for its incapacitating neurotoxins, is he trying to say it's time for a career change? Nicholas Brandley didn't think so, and embraced the study of black widow spiders. "Their fangs don't even usually pierce human skin!" he says in an effort to be reassuring.

While widows are indeed among the most venomous arachnids in North America, Brandley, who now teaches at Colorado College, was more curious about the distinctive red hourglass on their bellies.

Many insects use bright red coloration to ward off predators, but most of those bugs are red all over, with maybe a scattering of black spots. (Think ladybugs, which contain a nasty-tasting chemical.) North American black widows are solid black with just the crimson hourglass and, in some species, a few red spots. As birds also tend to be leery of high-contrast bright colors in places where they don't expect them, Brandley guessed the hourglass was a bird deterrent, since widows point it skyward when dangling in their webs.

But if crimson makes predators jumpy, why weren't the spiders even redder? Brandley suspected that a second selective force was at work, involving the spider's prey. Had evolution finessed the spiders' color scheme to warn off birds without also alerting beetles?

The first part of his experiment, started at Duke University, required plastic widows made with a 3-D printer. He painted "Berry Red" hourglasses on some, left others plain black and placed both types on bird feeders. The birds attacked the unadorned spiders three times more often.

When Brandley compared the widows' hourglass colors with the vision capabilities of insects and birds, he found that birds can detect reds three times better than bugs can. So he thinks widows evolved a discrete marking instead of becoming red all over, because birds could see it easily but not insects. "Here's a warning signal that has been shaped by something other than just predators," Brandley concludes. "Signals aren't given in a vacuum."

In another test, Brandley, armed with foot-long forceps, installed two types of live black widows in terrariums. The species with extra red spots on its back tended to spin webs higher up than the other spiders. Because of its lofty habitat preference, that species likely risks predation from above and below, and may bear extra warning spots at a cost to its own hunting. Missing a meal or two sure beats becoming one. -ABIGAIL TUCKER

ADAPTATION

Nathalia Holt

Author of *Rise of the Rocket Girls: The Women Who Propelled Us, From Missiles to the Moon to Mars*



SMALL TALK

What potential breakthrough are you most excited to see?

Interstellar travel. Voyager 1 is the first spacecraft to leave the solar system, but NASA isn't stopping there. The 100-year starship project, led by the first African-American woman to travel in space, Dr. Mae Jemison, aims to make human interstellar travel possible within a century. It's bold, yet necessary for human survival.

You say that women at NASA's Jet Propulsion Lab weren't called "engineers" until 1970.

Many people, men and women, worked as "computers," but the women were called "computresses." They hated it. So they called themselves Helen's Girls, after one very influential supervisor, Helen Ling, who did an incredible job bringing women into NASA and into the lab. And then of course they also called themselves "the sisters" because they were this really close group that supported one another.

Who's another woman scientist who deserves more credit?

Rosalind Franklin, the British chemist who took the famous "Photo 51" that demonstrated DNA's helical structure in 1952. Her research led to breakthroughs from genome mapping to gene therapies. Tragically, she died at age 37 of ovarian cancer without receiving proper recognition for her work.


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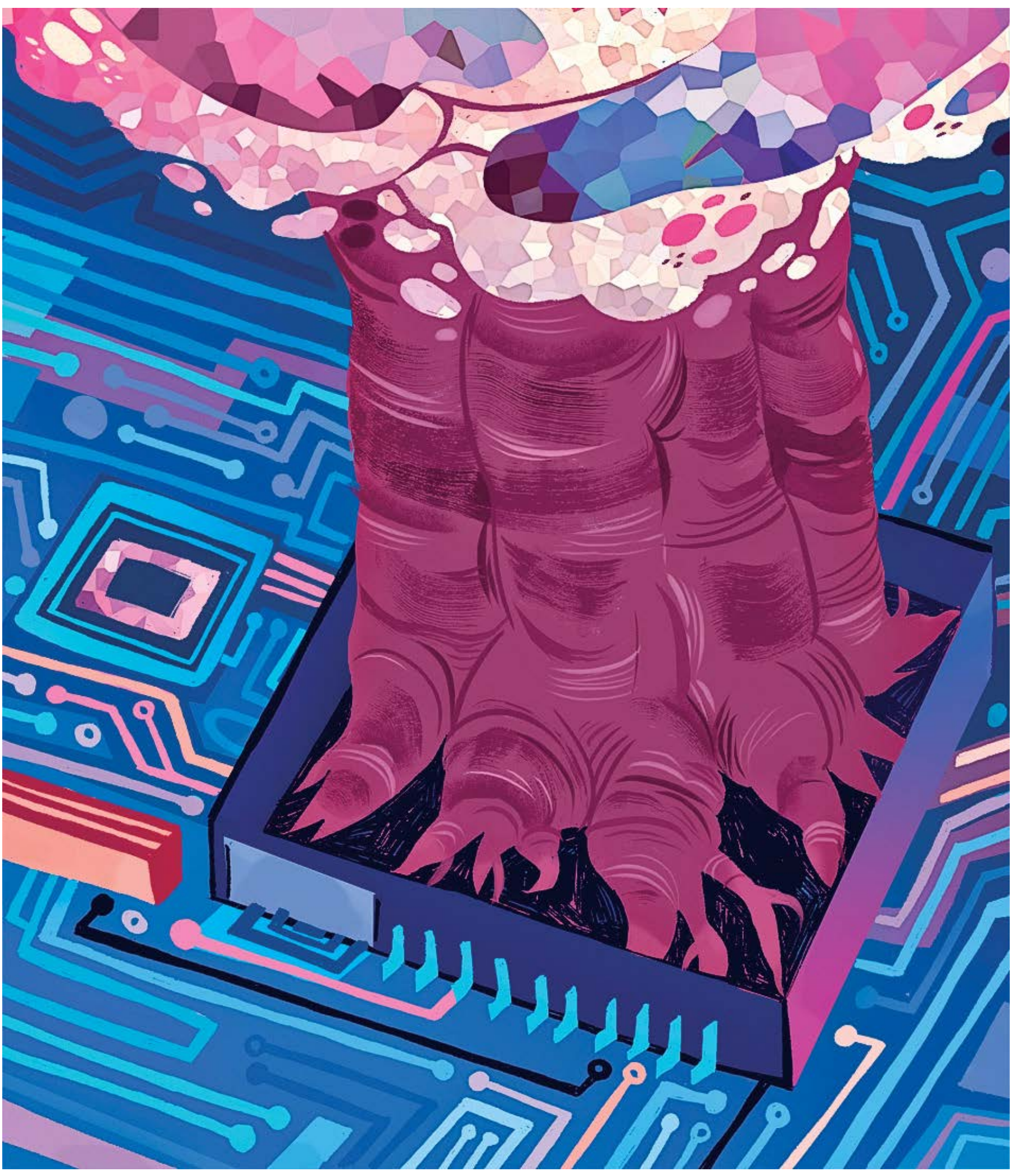
When Nature Knows Best

Can proteins from living cells solve problems that vex supercomputers?



Our daily life is so digitized that even technophobes know that a computer is a bunch of electronic transistors that process *1* and *0* signals encoded in a program. But a new kind of computing may force us to reboot our thinking: For the first time scientists have tapped the energy source used by living cells to power tiny proteins to solve a math problem.

The research, led by a father-son duo, is a boost for biocomputing, which promises devices that tackle complex tasks and use much less energy than electrical machines. "It's not a question of making faster computers," says Dan Nicolau Jr., lead author of the new study, who earned a PhD in mathematical biology at Oxford. "It's a question of solving problems a computer can't solve at all."

Take code-breaking, which can involve sifting through trillions of combinations to reach one correct solution. Perhaps surprisingly, mainframe computers aren't so great at solving a problem like that because they tend to work linearly, making calculations in one sequence at a time. Parallel processing—trying multiple possible solutions simultaneously—is a better bet.

Which is where the new experiment comes in. For years, Dan Nicolau Sr., head of bioengineering at McGill University in Montreal, has studied the movement of cytoskeletal proteins, which help give cells their structure. Around 2002, his son, then an undergraduate, was thinking about how rats in mazes and ants on the hunt solve problems. Could the proteins that his dad researched also be put to work solving puzzles?

To test the question, they first had to translate it into a form that the proteins could react to. So the researchers chose a mathematical problem, plotted it as a graph and then converted the graph into a kind of microscopic maze, which was etched onto a one-inch-square silica chip. "Then you let that network be explored by agents—the quicker, the smaller, the better—and see where they're getting out," Nicolau Sr. says. In this case, the agents were cytoskeletal protein filaments from rabbit muscle (and some grown in the lab), and they "explored" the various solutions of the maze, like a crowd looking for exits. Meanwhile, the meandering proteins picked up energy from the breakdown of ATP, the energy-releasing molecule that powers cells, and the "answers" emerged from watching where the proteins escaped, then retracing their steps.

This experimental biocomputer can't outperform an electronic machine, and it's designed to solve just one problem. But researchers think the concept can be scaled up someday to tackle challenges that currently befuddle conventional computers, using "thousands of times less power per calculation," says Nicolau Jr. Cryptography, drug design and circuit paths all pose big mathematical challenges that are just begging for a natural parallel processor. And as Nicolau Jr. says, "Life does things more efficiently." -ERICK TRICKEY

Some molecular motors in this "biocomputer" are made in the lab but copy those found in brains.

ILLUSTRATION BY **Meg Hunt**

FAST FORWARD

ENERGIZER ULTIMATE LITHIUM LASTS LONGER THAN

MONDAY MORNINGS

AND YOUR DRAMATIC QUITTING FANTASY

AND THE DAY YOU FINALLY WALKED AWAY

AND THE TERROR OF OPENING A SMALL BUSINESS

AND THE FIRST QUARTERLY PROFIT YOU REINVESTED

AND LOVING MONDAY MORNINGS BECAUSE YOU'RE FREE



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Sparks Fly Over Tabloid Biz Flick!

On its 75th anniversary, new controversies arise over the legendary *Citizen Kane*



Joseph Cotten, Orson Welles and Everett Sloane in the offices of Kane's *Inquirer*.

How fitting that a film about the elusiveness of truth is the subject of endless argument. The most lauded American movie ever, *Citizen Kane* was controversial even before it premiered 75 years ago this month—"Within the withering spotlight as no other film has ever been before," the *New York Times* intoned, noting William Randolph Hearst's angry effort to bury the movie about a rapacious news magnate clearly based on him—and the roiling continues. In just the last few months there has been plenty of gnashing over the inspiration for "Rosebud," the movie's central motif. And now two books make starkly opposing claims about the origin of the movie itself.

The screenplay is credited to the director and star, Orson Welles, and Herman Mankiewicz. But a posthumous memoir by his son Frank Mankiewicz charges that Welles wrote "not one word." In *So As I Was Saying*, Frank, who served as Robert F. Kennedy's press secretary, channels his father's memory and insists Welles "literally pleaded for at least a joint screen credit 'so [he] could get paid at all'" under the terms of his contract.

But research presented in *Citizen Kane: A Filmmaker's Journey* contradicts Mankiewicz's view. Analyzing two overlooked copies of a *Kane* "corrections script" unearthed in the archives at the Museum of Modern Art in New York City and the University of Michigan, the journalist-turned-historian Harlan Lebo found that Welles revised the script extensively, even crafting pivotal scenes from scratch—such as when the aging Kane muses, "If I hadn't been very rich, I might have been a really great man." Lebo also saw notes by Welles' assistant, Kathryn Trosper Popper, who recorded the director's and writer's reactions to changes in the screenplay ("Welles: Loves it. Mank: It stinks!"). Lebo's documentary evidence, to say nothing of his independence, give his account the edge.

Nothing in the movie has been deconstructed more than the dying Kane's mysterious utterance "Rosebud!" Arguably the most famous line in American cinema, it refers, of course, to his childhood sled. But its genesis has long been a matter of debate. The *Financial Times* film critic Nigel Andrews has mused that it might have been a nod to Welles' radio days. Mankiewicz's book claims his father had a Rosebud-brand bicycle as a child.

But Patrick McGilligan, in a book published last year, *The Years of Luck and Genius on the Path to Citizen Kane*, has the freshest answer yet. He points to long-forgotten court papers in which Herman Mankiewicz stated that the name came from Old Rosebud, the 1914 Kentucky Derby winner, a horse that he bet on big.

Though forever associated with Welles, the "Rosebud" metaphor was one invention he was happy to credit to Mankiewicz. Welles hated "Rosebud," calling it a "dollar-book Freudian gag." -THOMAS STACKPOLE

FILM

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by Nathaniel Philbrick

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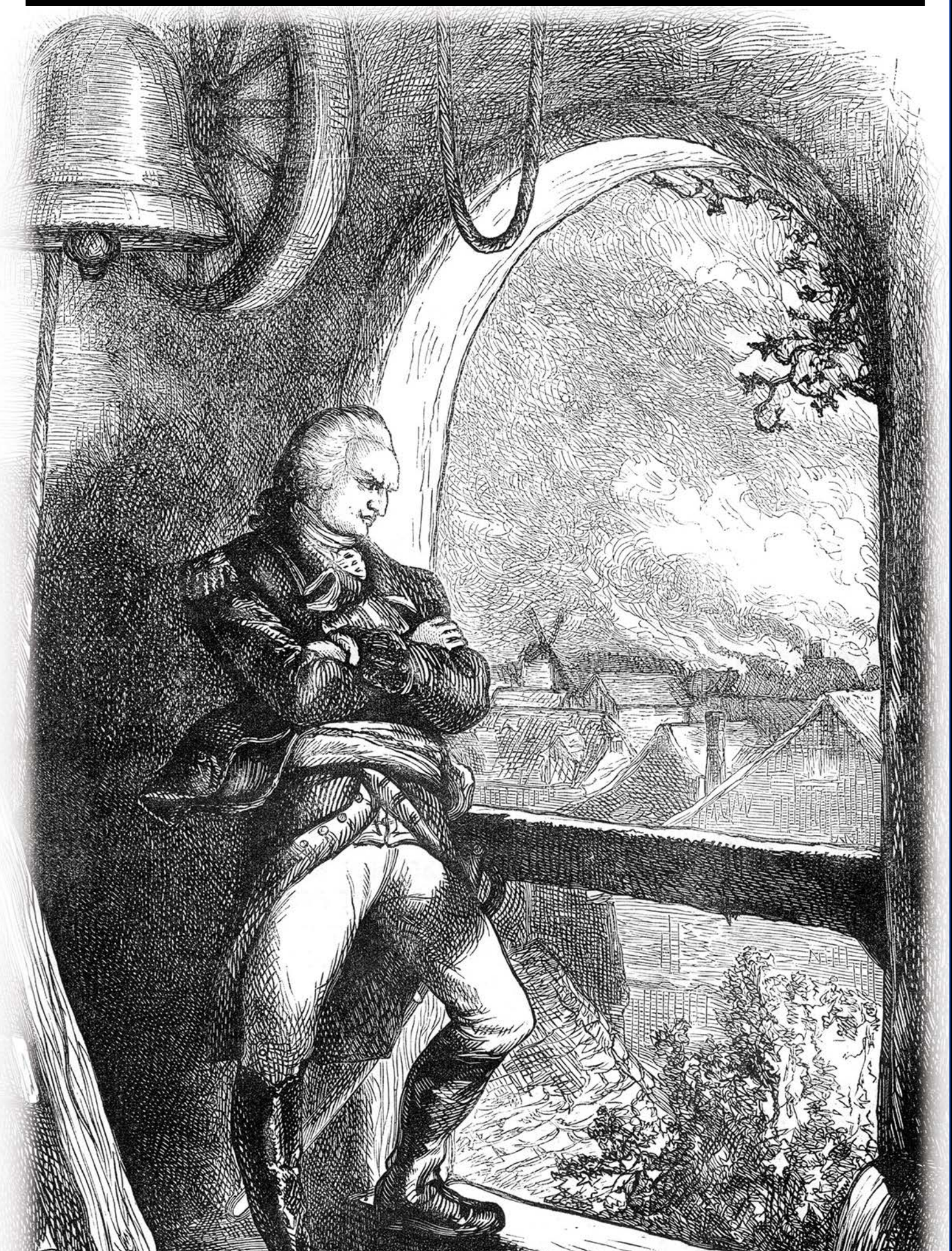

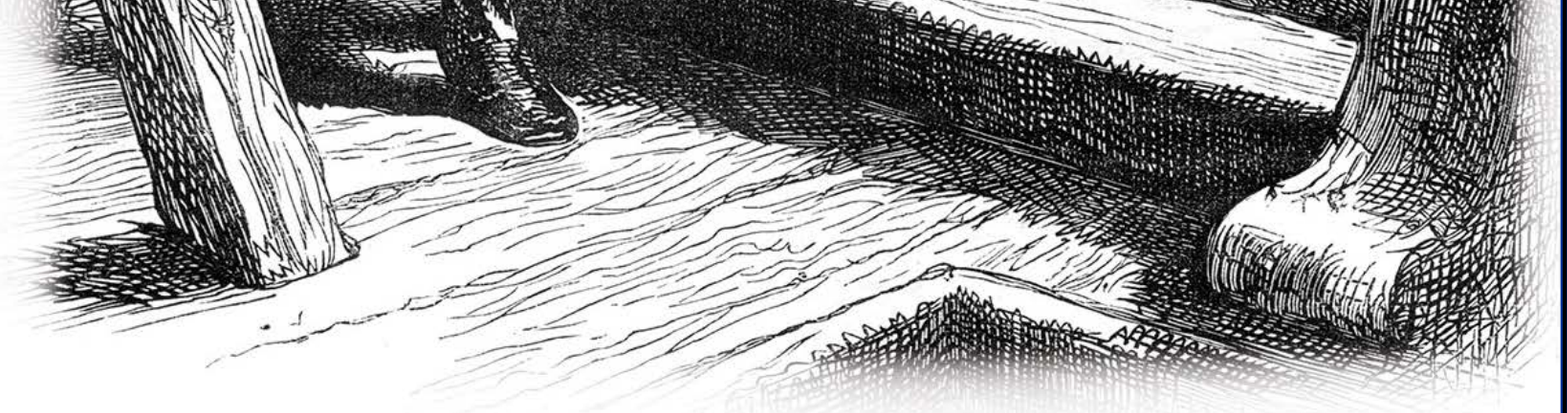

In 1781, Arnold (above) ordered British troops to burn New London, Connecticut.

Traitors and Haters

The story behind Benedict Arnold's betrayal shows how close the Revolution came to defeating itself

He was short, solidly built (one acquaintance remem-bered that "there wasn't any wasted timber in him") and blessed with almost superhuman energy and endurance. He was handsome and charismatic, with black hair, gray eyes and an aquiline nose, and he carried himself with the lissome elegance of a natural athlete. A neighbor from Connecticut remembered that Benedict Arnold was "the most accomplished and graceful skater" he had ever seen.

He was born in 1741, a descendant of the Rhode Island equivalent of royalty. The first Benedict Arnold had been one of the colony's founders, and subsequent generations had helped to establish the Arnolds as solid and respected citizens. But Arnold's father, who had settled in Norwich, Connecticut, proved to be a drunkard; only after his son moved to New Haven could he begin to free himself from the ignominy of his childhood. By his mid-30s he had had enough success as an apothecary and a seagoing merchant to begin building one of the finest homes in town. But he remained hypersensitive to any slight, and like many gentlemen of his time he had challenged more than one man to a duel.

From the first, he distinguished himself as one of New Haven's more vocal and combative patriots. On hearing of the Boston Massacre, he thundered, "Good God, are the Americans all asleep and tamely giving up their glorious liberties?" When in April 1775 he learned of the skirmishes at Lexington and Concord, he seized a portion of New Haven's gunpowder supply and marched north with a company of volunteers. In Cambridge, Massachusetts, he convinced Dr. Joseph Warren and the Massachusetts Committee of Safety to authorize an expedition to capture Fort Ticonderoga in New York State and its 80 or more cannons.

As it turned out, others had the same idea, and Arnold was forced to form an uneasy alliance with Ethan Allen and his Green Mountain Boys before the two leaders strode side by side into Ticonderoga. While Allen and his men turned their attention to consuming the British liquor supply, Arnold sailed and rowed to St. John, at the opposite end of Lake Champlain, where he and a small group of men captured several British military vessels and instantly gave America command of the lake.

Abrupt and impatient with anything he deemed superfluous to the matter at hand, Arnold had a fatal tendency to criticize and even ridicule those with whom he disagreed. When a few weeks later a Continental Army officer named James Easton dared to question the legitimacy of his authority as the self-proclaimed commodore of the American Navy on Lake Champlain, Arnold proceeded to "kick him very heartily." It was an insult Easton never forgot, and in the years ahead, he became one of a virtual Greek chorus of Arnold detractors who would plague him for the rest of his military career. And yet, if a soldier served with him during one of his more heroic adventures, that soldier was likely to regard him as the most inspiring officer he had ever known.

The American Revolution as it actually unfolded was so troubling and strange that once the struggle was over, a generation did its best to remove all traces of the truth. Although it later became convenient to portray Arnold as a conniving Satan from the start, the truth is more complex and, ultimately, more disturbing. Without the discovery of his treason in the fall of 1780, the American people might never have been forced to realize that the real threat to their liberties came not from without, but from within.

In that first Revolutionary spring of 1775, Arnold learned of the death of his wife, Margaret. Upon returning from Lake Champlain to New Haven, he visited her grave with his three young sons at his side. Arnold's letters to her prior to the Revolution had been filled with pleas for her to write more often, and his grief upon her death seems to have been almost overpowering. And yet, for someone of Arnold's restless temperament, it was inconceivable to remain in New Haven with his sorrow. "An idle life under my present circumstances," he explained, "would be but a lingering death." After just three weeks, Arnold left his children under the care of his sister Hannah and was on his way back to Cambridge, where he hoped to bury his anguish in what he called "the public calamity." Over the next three years—in Canada, on Lake Champlain, in Rhode Island and Connecticut and again in New York—he made himself indispensable to his commander in chief, George Washington, and the Revolutionary cause.

Having lost once-significant wealth, Arnold embarked on a campaign of secret, and underhanded, schemes to re-establish himself as

a prosperous merchant.

It is impossible to say when 37-year-old Benedict Arnold first met 18-year-old Peggy Shippen, but we do know that on September 25, 1778, he wrote her a love letter—much of it an exact copy of one he'd sent to another woman six months before. But if the overheated rhetoric was recycled, Arnold's passion was genuine. Knowing of "the affection you bear your amiable and tender parents," he had also written to Peggy's loyalist-leaning father. "Our difference in political sentiments will, I hope, be no bar to my happiness," he wrote. "I flatter myself the time is at hand when our unhappy contest will be at an end." He also assured Peggy's father that he was wealthy enough "to make us both happy" and that he had no expectations of any kind of dowry.

Here in this letter are hints as to the motives behind Arnold's subsequent behavior. While lacking the social connections of the Shippens, who were the equivalent of Philadelphia aristocracy, Arnold had had prospects of accumulating a sizable personal fortune. Now the British had abandoned their occupation of the revolutionaries' capital, and Washington, needing something for Arnold to do while he recuperated from a battle-shattered left thigh, had named him the city's military governor. Having lost once-significant wealth, Arnold embarked on a campaign of secret, and underhanded, schemes to reestablish himself as a prosperous merchant. That end—and those means—were not uncommon among officers of the Continental Army.

But in September 1778 he did not yet have the money he needed to maintain Peggy in the style to which she was accustomed. There was also the matter of the Shippens' politics. They might not be outright loyalists, but they had a decided distaste for the radical patriots who were waging an undeclared war on Philadelphia's upper classes now that the British had gone. Given Arnold's interest in Edward Shippen's daughter and his lifelong desire to acquire the wealth his bankrupt father had denied him, it is not surprising that he embraced the city's marginalized nobility with a vengeance.

Thumbing his nose at the pious patriots who ruled the city, he purchased an ornate carriage and entertained extravagantly at his new residence, the same grand house the British general William Howe had occupied. He attended the theater, even though the Continental Congress had advised the states to ban such entertainments as "productive of idleness, dissipation and general depravity." He issued passes to suspected loyalists wanting to visit friends and relatives in New York City, which was held by the British. He even appeared at a ball in a scarlet uniform, which led a young lady whose father had been arrested for corresponding with the British to joyfully exclaim, "Heyday, I see certain animals will put on the lion's skin."

One of Arnold's misfortunes was that Joseph Reed had become a cham-pion, however unlikely, of Pennsylvania's radical patriots. A London-educated lawyer with an English wife, Reed had a reputation as one of Philadelphia's finest and most ambitious attorneys before the Revolution. But the

Reeds had not fit well into the upper echelons of Philadelphia society. Reed's pious wife complained that one of Peggy Shippen's relatives had accused her of being "sly," claiming that "religion is often a cloak to hide bad actions."

Joseph Reed, Arnold's adversary in Pennsylvania, antagonized even his closest friends. A minister who met him wrote that he was "more formed for dividing than uniting."

Reed had served on Washington's staff as adjutant general at the beginning, when Washington faced the daunting task of dislodging the British from Boston in 1775. But by the end of the year, with the Continental Army run out of New York City and retreating across New Jersey, he had lost faith in his commander. Reed was away from headquarters when a letter arrived from the army's second-ranking officer, Maj. Gen. Charles Lee. Assuming the letter related to official business, Washington promptly broke the seal. He soon discovered that Reed had established his own line of communication with Lee and that the primary topic of their correspondence was the failings of their commander in chief.

Washington forwarded the letter to Reed with a note explaining why he had opened it, but otherwise let him twist in the icy emptiness of his withheld wrath. He kept Reed on, but their intimacy had ended.

Brilliant, mercurial and outspoken, Reed had a habit of antagonizing even his closest friends and associates, and he eventually left Washington's staff to serve in a variety of official capacities, always restless, always the smartest, most judgmental person in the room. As a New England minister wrote to Washington, the man was "more formed for dividing than uniting."

In the fall of 1778, Reed stepped down as a Pennsylvania delegate to Congress to help the state's attorney general prosecute 23 suspected loyalists for treason. He lost 21 of those cases—there wasn't much evidence to work with—but the position established him as one of the city's most zealous patriots. That November, the two wealthy Quakers who had been convicted were hanged.

In an apparent act of protest, Arnold hosted "a public entertainment" at which he received "not only Tory [or loyalist] ladies but the wives and daughters of persons proscribed by the state" in "a very considerable number," Reed sputtered in a letter to a friend. Perhaps contributing to his ire was the fact that he and his wife had recently moved into the house next to Arnold's and hadn't been invited to the party.

By December Reed was president of the state's Supreme Executive Council, making him the most powerful man in one of the most powerful states in the country. He quickly made it clear that conservative patriots were the enemy, as were the Continental Congress and the Continental Army. As council president, he insisted that Pennsylvania prevail in any and all disputes with the national government, regardless of what was best for the United States as a whole. Philadelphia was at the vortex of an increasingly



Joseph Reed

rancorous struggle involving almost all the seminal issues related to creating a functioning democratic republic, issues that would not begin to be resolved until the Constitutional Convention of 1787.

Amid all this upheaval, Reed launched an investigation into the military governor's conduct. The prosecution of Benedict Arnold—a Washington favorite, an emblem of national authority and a friend to Philadelphia's wealthy—would be the pretext to flex his state's political muscle. And it would lead Arnold to doubt the cause to which he had given so much.

By late January 1779, Arnold was preparing to leave the military. Officials in New York State, where he was held in high regard, had encouraged him to consider becoming a landowner on the scale of the loyalist Philip Skene, whose vast estate at the southern tip of Lake Champlain had been confiscated by the state. Arnold's financial dealings in Philadelphia had failed to yield the anticipated returns. Becoming a land baron in New York might be the way to acquire the wealth and prestige that he had always craved and that Peggy and her family expected.

By early February he had decided to journey to New York, stopping to visit Washington at his headquarters in New Jersey. Reed, fearing that Arnold might escape to New York before he could be brought to justice for his sins in Philadelphia, hurriedly put together a list of eight charges, most of them based on rumor. Given the pettiness of many of the charges (which included being ungracious to a militiaman and preferring loyalists to patriots), Reed appeared to be embarked on more of a smear campaign than a trial. That Arnold was guilty of some of the more substantive charges (such as illegally purchasing goods upon his arrival in Philadelphia) did not change the fact that Reed lacked the evidence to make a creditable case against him. Arnold knew as much, and he complained of his treatment to Washington and the commander's family of officers.

Washington had refused to take sides in the dispute between Philadelphia's radicals and conservatives. But he knew that Reed was hardly the steadfast patriot he claimed to be. For the last year, a rumor had been circulating among the officers of the Continental Army: Reed had been in such despair over the state of the war in late December 1776 that he'd spent the night of Washington's assault on Trenton at a home in Hessian-occupied New Jersey, poised to defect to the British in the event of an American defeat. In that light, his self-righteous prosecution of Quakers and other loyalists seemed hypocritical in the extreme. It's likely that Washington had heard at least some version of the claim, and just as likely that he took the charges against Arnold with a grain of salt. Still, Reed's position on the Supreme Executive Council required that Washington accord him more civility than he probably deserved.

On February 8, 1779, Arnold wrote to Peggy from the army's headquarters in Middlebrook, New Jersey. "I am treated with the greatest politeness by General Washington and the officers of the army," he assured her. He claimed that the consensus at headquarters was that he should ignore the charges and continue on to New York.

Despite this advice, he had resolved to return to Philadelphia, not only to clear his name but because he was so desperately missing Peggy. "Six days' absence without hearing from my Dear Peggy is intolerable," he wrote. "Heavens! What must I have suffered had I continued my journey—the loss of happiness for a few dirty acres. I can almost bless the villainous . . . men who oblige me to return." In utter denial regarding his complicity in the trouble he was now in, he was also deeply in love.

Back in Philadelphia, Arnold came under near-ceaseless attack from the Supreme Executive Council. But since the council was unwilling to provide the required evidence—primarily because it did not have any—the Congressional committee appointed to examine the charges had no choice but to find in Arnold's favor. When the council threatened to withhold the state militia and the large number of state-owned wagons upon which Washington's army depended, Congress tabled its committee's report and turned the case over to Washington for a court-martial.

More than a few Congressional delegates began to wonder what Reed was trying to accomplish. As a patriot and a Philadelphian, Congress's secretary Charles Thomson had once considered Reed a friend. No more. Reed's refusal to bring forward any legitimate evidence, combined with his continual assaults on the authority and integrity of Congress, made Thomson wonder whether his former friend was trying to destroy the political body upon which the country's very existence depended. Was Reed, in fact, the traitor?

The previous summer Reed had received an offer of £10,000 if he would assist a British peace commission's efforts with Congress. In a letter published in a Philadelphia newspaper, Reed claimed to have indignantly refused the overture. But had he really? One of the commissioners had recently assured Parliament that secret efforts were under way to destabilize the government of the United States and that these "other means" might prove more effective in ending the war than military attempts to defeat Washington's army. There is no evidence that Reed was indeed bent on a treasonous effort to bring down Congress, but as Thomson made clear in a letter to him, his monomaniacal pursuit of Arnold was threatening to accomplish exactly that.

In the meantime, Arnold needed money, and fast. He had promised Edward Shippen that he would bestow "a settlement" on his daughter prior to their marriage as proof that he had the financial resources Peggy's father required. So in March of 1779, Arnold took out a loan for £12,000 and, with the help of a sizable mortgage, bought Mount Pleasant, a mansion on 96 acres beside the Schuylkill that John Adams had once claimed was "the most elegant seat in Pennsylvania."

There was one hitch, however. Although he had technically purchased Peggy a mansion, they were not going to be able to live in it, since Arnold needed the rental payments from the house's current occupant to help pay the mortgage.

Harassed by Reed, carrying a frightening burden of debt, Arnold nonetheless had the satisfaction of finally winning Edward Shippen's consent, and on April 8, he and Peggy were married at the Shippens' house. Now Arnold had a young, beautiful and adoring wife who was, he proudly reported the next morning to several of his friends, good in bed—at least that was the rumor the Marquis de Chastellux, a major general in the French Army who was fluent in English, heard later when visiting Philadelphia.

However, within just a few weeks, Arnold was finding it difficult to lose himself in the delights of the connubial bed. Reed had not only forced a court-martial upon Arnold; he was now attempting to delay the proceedings so that he could gather more evidence. What's more, he had called one of Washington's former aides as a witness, an even more disturbing development since Arnold had no idea what the aide knew. Arnold began to realize that he was, in fact, in serious trouble.

Aggravating the situation, his left leg was not healing as quickly as he had hoped, and his right leg became wracked by gout, making it impossible for him to walk. Arnold had been in tight spots before, but always had been able to *do* something to bring about a miraculous recovery. But now, what was there to do?



After Arnold's betrayal, Philadelphians paraded a two-faced effigy of him through the streets before burning it.

If the last nine months had taught him anything, it was that the country to which he had given everything but his life could easily fall apart. Instead of a national government, Congress had become a facade behind which 13 states did whatever was best for each of them. Indeed, it might be argued that Joseph Reed was now more influential than all of Congress combined.

What made all of this particularly galling was the hostility that Reed— and apparently most of the American people—held toward the Continental Army. More and more Americans regarded officers like Arnold as dangerous hirelings on the order of the Hessian mercenaries and British regulars, while local militiamen were looked to as the patriotic ideal. In reality, many of these militiamen were employed by community officials as thuggish enforcers to terrorize local citizens whose loyalties were suspect. In this increasingly toxic and volatile environment, issues of class threatened to transform a collective quest for national independence into a sordid and self-defeating civil war.

By the spring of 1779, Arnold had begun to believe that the experiment in independence had failed. And as far as he could tell, the British had a higher regard for his abilities than his own country did. Gen. John Burgoyne was in London defending himself before Parliament with the claim that if not for Arnold, his army would have won the Battle of Saratoga. That February, the *Royal Gazette* had referred sympathetically to his plight in Philadelphia: "General Arnold heretofore had been styled another Hannibal, but losing a leg in the service of the Congress, the latter considering him unfit for any further exercise of his military talents, permit him thus to fall into the unmerciful fangs of the executive council of Pennsylvania." Perhaps the time was right for him to offer his services to the British.



Peggy Arnold and daughter

Arnold is usually credited with coming up with the idea himself, but there are reasons to think the decision to turn traitor originated with Peggy. Certainly the timing is suspect, following so soon after their marriage. Arnold was bitter, but even he had to admit that the Revolution had catapulted him from the fringes of respectability in New Haven to the national stage. Peggy, on the other hand, regarded the Revolution as a disaster from the start. Not only had it initially forced her family to flee from Philadelphia; it had reduced her beloved father to a cringing parody of his former self. How different life had been during those blessed months of the British occupation, when noble gentleman-officers had danced with the belles of the city. With her ever-growing attachment to Arnold fueling her outrage, she had come to despise the revolutionary government that was now trying to destroy her husband.

By marrying Peggy, Arnold had attached himself to a woman who knew how to get what she wanted. When her father had initially refused to allow her to marry Arnold, she had used her seeming frailty—her fits, her hysteria, whatever you wanted to call it—to manipulate him into agreeing to the engagement for fear that she might otherwise suffer irreparable harm. Now she would get her way with her equally indulgent husband.

Given the ultimate course of Arnold's life, it is easy to assume that he had fully committed himself to treason by the time he sent out his first feelers to the British in early May 1779. But that was not the case. He still felt a genuine loyalty to Washington. On May 5, Arnold wrote his commander what can only be described as a hysterical letter. The apparent reason for it was the delay of his court-martial to June 1. But the letter was really about Arnold's fear that he might actually do as his wife suggested. "If your Excellency thinks me criminal," he wrote, "for heaven's sake, let me be immediately tried and if found guilty executed."

What Arnold wanted more than anything now was clarity. With the court-martial and exoneration behind him, he might fend off Peggy's appeals. Joseph Reed, however, was bent on delaying the court-martial for as long as possible. In limbo like this, Arnold was dangerously susceptible to seeing treason not as a betrayal of all he had held sacred but as a way to save his country from the revolutionary government that was threatening to destroy it.

With her growing attachment to her husband fueling her outrage, Peggy Arnold had come to despise the revolutionary government that was now attempting to destroy him.

In his anguish on May 5, he offered Washington a warning: "Having made every sacrifice of fortune and blood, and become a cripple in the service of my country, I little expected to meet the ungrateful returns I have received of my countrymen, but as Congress have stamped ingratitude as a current coin I must take it. I wish your Excellency for your long and eminent services may not be paid of in the same coin."

In the reference to money, Arnold unintentionally betrayed the real reason he had been moved to consider this course. If he handled the negotiations correctly, turning traitor could be extremely lucrative. Not only would he be able to walk away from his current financial obligations, he might command a figure from the British that would make him independently wealthy for life.

On May 10, an emissary from Arnold reached John André, a British captain whom Peggy had come to know well in Philadelphia. But now André was living in New York City, which would become crucial to the Revolution's prospects in the months ahead. Arnold wanted to explore the possibility of defecting, but first he needed to be assured of two things: Were the British in this war to stay? And how much were his services worth?

In the tortuous months ahead, Arnold would survive his oft-delayed court-martial with a reprimand, and Washington would restore him to command. But the emissary's visit was the first tentative step that led, in late summer-fall of 1780, to Arnold's doomed effort to hand over the fortifications at West Point to the enemy.

By reaching out to the British, Arnold gave his enemies the exquisite satisfaction of having been right all along. Like Robert E. Lee at the beginning of the American Civil War, Arnold could have declared his change of heart and simply shifted sides. But as he was about to make clear, he was doing this first and foremost for the money. ○

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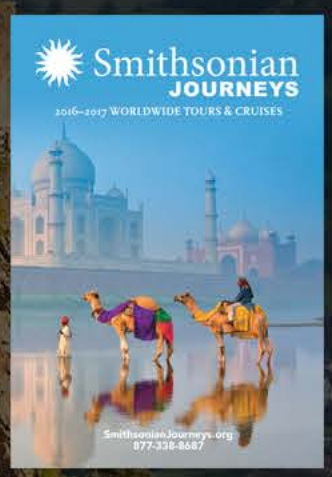

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Tweet All About It

From "user-generated content" to political screeds, the future of news happens to look a lot like the past

If you opened your BuzzFeed app on a warm day earlier this year, here are some of the pieces you'd have seen:

- Mitt Romney Speaks Out Against Trump
- Chrissy Teigen Explained That Hideous Cringing Face She Made at the Oscars
- 21 Things You'll Understand If You're Dating a Chef

Consider it a classic BuzzFeed mix—a jumble of political news, visual memes, viral videos and clickable "listicles." This blend has made BuzzFeed one of the hottest news sites in the world, with more than six billion monthly views and 200 million unique visitors per month, more than the *New York Times*, the *Washington Post* and the *Wall Street Journal* put together. While BuzzFeed is often dismissed as a mere purveyor of dumb cat videos, the site has also been expanding its reporting and editing staff—it now has 500 editorial staff around the globe, and a stand-alone app devoted entirely to hard news. Its video division, barely two years old, now accounts for half its views. And the site is heavily "social," distributing its stories far and wide: People are more likely to encounter the material on Facebook or Snapchat than on BuzzFeed's apps.

Is this what the future of news looks like? The landscape is changing dramatically, as traditional newspapers continue their advertising free-fall, while the growth is all online—from Facebook and Snapchat to celebrity sites like TMZ, the heavily partisan blogs of Daily Kos or Breitbart, or the Huffington Post's platoons of unpaid scribes. Longtime newspaper fans worry that a civic apocalypse is afoot, as the "just the facts" style of last century's papers morphs into a slurry of hot takes, tweets and six-second Vine videos. Will online media do the shoe-leather reporting that civil society requires?

It's a complex, messy time. But there's reason to hope that the future of news is bright. That's because today's world resembles nothing so much as the world of 300 years ago—when Americans began experimenting with a strange new media format: the newspaper.

Before newspapers came along, the only people who had regular access to news were the wealthy. Merchants would trade information via letters or buy encyclicals from expert scribes who compiled news from abroad. The idea that a mass public might want to read regularly published info didn't arrive in America until the late 17th and early 18th centuries—when printers began

crafting the first made-in-America papers.

If you saw them today, you'd barely recognize the form. They were tiny—usually no longer than four pages—and weren't yet daily: They published weekly or even less often, in editions of a few hundred copies. There were no reporters. Printers were just technicians who managed the presses. To fill the pages, they leaned on their audience, who contributed letters, articles and essays. Indeed, early papers more resembled the "user-generated content" of the Huffington Post than today's *New York Times*. Citizens opined on the legal system, composed poems advocating the rights of women or wrote up detailed instructions on how to self-inoculate against smallpox. This relatively open access to the press was useful for the independence cause: Revolutionaries like Sam Adams spread their ideas by submitting fiery essays to New England papers.

Publishers also did a lot of copying and pasting. If a printer spotted a nifty story in another paper, he'd copy it verbatim—and so would the next paper one town over, such that hot stories would gradually go viral around the colonies. It was deeply bloglike: "Being able to just link to other things today pretty much mirrors how printers used to clip from other papers," notes John Nerone, a communications professor emeritus at the University of Illinois at Urbana-Champaign.

If a printer spotted a nifty story in another paper, he'd copy it verbatim—and so would the next paper one town over. Hot stories would gradually go viral around the colonies.

The idea that a printer would also be a journalist himself seemed weird until Ben Franklin showed the way. While working in his brother's print shop in 1721—the elder Franklin founded the *New-England Courant*—Benjamin wrote in the voice of the middle-aged matron "Silence Dogood," penning essays that lampooned the elites. (One piece joked how Harvard students would graduate "as great Blockheads as ever, only more proud and self-conceited.")

In the face of the Revolution, the early papers were partisan—often wildly so. "Professions of impartiality I shall make none," boasted editor William Cobbett in the first issue of his *Porcupine's Gazette,* in 1797. Newspaper publisher John Holt so hated the British that he refused to print any Tory writers, calling their prose "barefaced attempts to deceive and impose upon the ignorant." Things became even more heated after independence, when the two major parties formed—the Federalists, who favored a strong government, versus Thomas Jefferson's Republicans. Parties bankrolled papers, which in return gave them slavish coverage. (One academic has found that over 80 percent of the United States' 300-odd post-Revolutionary papers had a party affiliation.)

During the 1800 election—Thomas Jefferson ran against John Adams—this produced an avalanche of mudslinging journalism. Yale's president wrote that a Jefferson victory would mean "we will see our wives and daughters the victims of legal prostitution." The writer and Jefferson supporter James Callender shot back that Adams was a "hideous hermaphroditical character."

"I tell my students, if you want to see partisan writing at its worst, take a look at the 1790s," jokes Carol Sue Humphrey, professor of history at Oklahoma Baptist University. Sometimes editors even came to blows. When William Cullen Bryant—editor of the *Evening Post*—ran into William L. Stone of his rival *Commercial Advertiser*, he swung at his head with a cowskin whip. Jefferson started his career as a fierce defender of the press, but by the end of his administration he loathed it. "The man who never looks into a newspaper is better informed than he who reads them," he sighed.

To appeal to mass audiences, many newspapers dropped the nakedly partisan tone. In place of political essays, papers hired reporters whose job it was to collect facts.

Papers weren't always profitable, or even often so. Readers failed to pay subscriptions; some journals died after only a few issues. One early financial lifeline was text-based ads, which read like Craigslist for a slaveholding public: "I wish to buy a few negroes, of both sexes, and will pay fair prices in cash," one typical ad read. Citizens purchased ads to talk, in Twitteresque fashion, to the world. In 1751, William Beasley took out a *Virginia Gazette* classified to complain about his cheating wife—"I am really of [the] opinion she has lost her senses"—and warn people not to consort with her.

Benjamin Franklin was an avid ad-pitchman, using his sharp wit to craft ads for his customers. (One general was trying to convince citizens to donate horse carts to him; a Franklin-penned ad helped the general acquire over 200.) "He was the original 'Mad Men,'" says Julie Hedgepeth Williams, a journalism professor at Samford University.





The Chicago Defender (on sale in 1942, above) catered to African-Americans.

At first, printing newspapers was slow and arduous. Printers set wooden type, wet it with "deerskin balls" soaked in ink, then hung the printed copies up to dry. A two-man team could produce barely 250 pages an hour.

But newspapers were avid adopters of newfangled high-tech. In the early 1800s, they began using the "cylinder" press, which let them feed paper through ten times more quickly than before. And they were also among the first U.S. businesses to use steam power—which let them automate their presses, churning out copies faster than ever.

In essence, newspapers were cutting-edge pioneers of the industrial revolution—the Silicon Valley of their day. "One had to be an entrepreneur and one had to be very alert to new technologies," notes Mitchell Stephens, a journalism professor at New York University and author of *Beyond News: The Future of Journalism*. "Nobody used the telegraph as much as newspapers did." Years later, they were the first adopters of the telephone and linotype machine.

By the 1830s, those innovations cut the cost of printing so much that the "penny press" was born, a paper published daily and selling for one cent. Audience size boomed: Launched in 1833, the *New York Sun* started at 5,000 copies a day, growing to 15,000 in only two years. By the 1830s there were 1,200 papers across the country, and half of all families subscribed to one.

This changed the nature of journalism itself. To appeal to mass audiences, many newspapers dropped the nakedly partisan tone; they couldn't be sure everyone agreed with their party stance. In place of the big political essays, papers hired reporters whose job was to collect facts. "You have a clear distinction between news and opinion that starts to happen," Humphrey notes.

"The world has grown tired of preachers and sermons; to-day it asks for facts," the reporter Clarence Darrow noted in 1894. Politicians were unsettled by these upstart reporters poking around and taking notes on their activities. When New York's *Tribune* described the messy way an Ohio representative ate lunch and picked his teeth, the representative angrily passed a resolution banning *Tribune* reporters from the chambers.

Reporters invented an innovative newsgathering technique: Instead of merely reprinting politicians' speeches, they'd ask questions and grill them. "The interview was an American invention," notes Michael Schudson, a journalism professor at Columbia University. European papers didn't do this; it seemed too impertinent to question authority so openly. But scrappy Americans had no such pieties. Indeed, as American reporters became more investigative, social critics got worried. "Our reporterized press," complained *Harper's Magazine*, "is often truculently reckless of privacy and decency." Still, with the partisanship gone, others complained the writing was duller. "The rank and file tended to write like bookkeepers," as a young reporter, H.L. Mencken, complained.

The explosive growth in advertising had an unexpected effect on how papers were designed. Up to the mid-19th century, papers were mostly a gray wall of text. Advertisers increasingly wanted their ads to stand out, though, so newspapers developed elegant ad design—with big dramatic fonts, illustrations and white space to catch the eye. Soon the profusion of ads became rather like the ads of today's websites: an intrusive mess of scams that readers hated. "Some of our readers complain of the great number of patent medicines advertised in this paper," the Boston *Daily Times* admitted.

But snazzy design was influential. By the mid-1800s, editors realized these techniques would help make news more appealing, too. They began running larger headlines and putting more graphics and maps into stories.

There was one population shut out from the newspaper boom, though: blacks. During slavery, American newspapers ignored blacks, except when they ran wild tales claiming they had poisoned their owners or committed burglaries. (Sections devoted to them were given names like "The Proceedings of the Rebellious Negroes.") By 1827, a group of freed blacks decided to found their own newspaper, *Freedom's Journal*. "We wish to plead our own cause," they wrote in their first issue. "Too long have others spoken for us." The black press was born, and soon there were dozens of black papers dotted across the country.

Today's best journalism, richer with context and personality, is "in some ways a throwback to an older form of journalism—Ben Franklin's form of journalism."

Getting their papers out required seat-of-the-pants ingenuity, even at the turn of the 20th century, because whites were often hostile to this upstart media. When Robert Abbott started the *Chicago Defender* in 1905, he found it hard to distribute in the South. "Once they realized it was out there, they tried to censor it—they'd arrest you if they saw you reading it, using vagrancy laws," says Clint C. Wilson II, a journalism professor emeritus at Howard University, and shipments of the paper were thrown in the trash. To sneak the papers to Southern readers, Abbott convinced black porters on north-south trains to secretly ferry copies down.

This winter, the news site Quartz launched one of the most curious news apps ever: a chatbot. When you launch the Quartz app on your phone, it starts chatting with you—delivering the news as a series of text messages, with pictures or video embedded. It feels less like reading a paper than texting with a news-obsessed friend.

Cultural critics often bemoan today's fragmented news landscape—but historians of newspapers are surprisingly optimistic about it. When they look at today's explosion of news websites and apps, they see the same spirit of mad experimentation that created American news. As Jay Rosen, a journalism professor at New York University, points out, the period of the 20th century was static for news. But now we're living through a period that probably feels like the 1830s.

"The newspaper as a product didn't fundamentally change for 100 years," he notes. "Giving birth to a new news product is now a monthly event."

One of the more unsettling parts of today's news is how partisan it has become. Is it possible to have a serious civic culture when so many online news organizations wear their perspectives on their sleeve? Can they be trusted? Stephens, the NYU professor, thinks so, and indeed he's a defender of the voicier style of today's news. Today's writers are more free to offer perspective, so the news makes more sense. The "just the facts" style of the last century meant newspapers could sometimes feel like a recitation of disconnected trivia.

Today's best journalism, richer with context and personality, is "in some ways a throwback to an older form of journalism—Ben Franklin's form of journalism, the journalism of the people who made the American Revolution, Tom Paine's journalism," Stephens says. "And it can actually be a higher form of journalism than the one I was born into."

Meanwhile, social media may have created a cacophony of voices online, and a fervid rumor mill, but it also allows for marginalized voices to work much like the black press—routing around a mainstream that ignores their issues. The national debate over police violence, for example, was propelled not by mainstream newspapers but by individuals and "Black Lives Matter" activists, expertly wielding tools like Twitter, YouTube and Facebook to make their case.

It may be that 30 years from now, the ferment will have settled down—and we'll have a new firmament of mainstream news organizations. As BuzzFeed co-founder Jonah Peretti points out, if you were alive in the 19th century, you wouldn't have predicted the rise of the *New York Times*. It's the same today.

"All these environments and experiments lead to forms that, at the time, nobody really knows where it's going to head," he says. "Lots of them fail."

Though he believes BuzzFeed won't be one of them. "I think, oh, BuzzFeed's creating something new," he says. This story is still being written. ○

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SCI-FI GETS real

BATTLE FOR THE SOUL OF STAR TREK

Kirk's ego! Spock's salute! Lucille Ball's regrets! A new oral history reveals the clashes behind pop culture's final frontier

INTERVIEWS BY
EDWARD GROSS AND MARK A. ALTMAN
ILLUSTRATION BY HELMO



It was the most wildly successful failure in television history. First shown on NBC 50 years ago this September, the original "Star Trek" lasted just three seasons before it was canceled—only to be resuscitated in syndication and grow into a global entertainment mega-phenomenon. Four live-action TV sequels, with another digital-platform spinoff planned by CBS to launch next year.



The legend begins: In the first pilot, Jeffrey Hunter (right) as Capt. Pike and Majel Barrett as Number One swap views with an inhabitant of the planet Talos IV.

A dozen movies, beginning with 1979's *Star Trek: The Motion Picture* and resuming this July with the director Justin Lin's *Star Trek Beyond*. It finds Capt. Kirk (Chris Pine) and Spock (Zachary Quinto) in deep space, where they are attacked by aliens and stranded on a distant planet—a plot that may make some viewers glad that at least the special effects are new. Over the decades "Star Trek" merchandise alone (because who does not need a Dr. McCoy bobblehead?) has reportedly brought in some $5 billion.

This is quite an outpouring for a concept that its creator, the Los Angeles police officer-turned-TV-writer Gene Roddenberry, pitched to producers as a "space western" and once described as a "'Wagon Train' to the Stars." There's much, much more to the appeal of the original "Star Trek" than gunplay in the wilderness, of course, as countless articles and dissertations have tried to explain, but in one key respect Roddenberry's notion was right on target: People everywhere, especially Americans, are fascinated by the frontier, whether final or not. And fans are still intrigued that Roddenberry, a World War II veteran, set his 23rd-century multiracial epic in a universe that seemed to be moving beyond bigotry and petty conflict, a cold war-era imagining of the future that was reassuringly counter-dystopian. Plus, you've got to love the gadgets—mobile communicators, videoconferencing, diagnostic scanners, talking computers—which have had an uncanny habit of turning up in real life lately, a tribute to the wit and ingenuity of not only Roddenberry but also the show's designers and writers.

The richness and persistence of the original vision are what make an extensive oral history of "Star Trek" so compelling. (The same cannot be said of "The Newlywed Game," for instance, another TV show that debuted in 1966.)

For more than 30 years, Edward Gross and Mark A. Altman have made it their mission to document the creative process underlying "Star Trek" in all its iterations. In tens of thousands of hours of interviews conducted everywhere from Gene Roddenberry's Bel Air mansion to movie set camper trailers, the writers recorded virtually anyone who put his or her stamp on this pop culture monument. The result is *The Fifty-Year Mission: The Complete, Uncensored, Unauthorized Oral History of Star Trek: The First 25 Years*, excerpted here. (Volume 2 is in the works.)

"What I loved about the oral history format," says Altman, "was that it was like getting 500 people in a room and telling the story in a linear fashion." It was, adds Gross, a "genuine labor of love."

GENE RODDENBERRY

Creator and executive producer, "Star Trek"

I remember myself as an asthmatic child, having great difficulties at 7, 8 and 9 years old, falling totally in love with *Tarzan, Lord of the Jungle* and dreaming of having his strength to leap into trees and throw mighty lions to the ground.

There was a boy in my class who life had treated badly. He limped, he wheezed. He was a charming, intelligent person. Because of being unable to do many of the things that others were able to do, he had sort of gone into his own world of fantasy and science fiction. He had been collecting the wonderful old *Amazing* and *Astounding* magazines, and he introduced me to science fiction. I then discovered in our neighborhood, living above a garage, an ex-con who had come into science fiction when he was in prison. He introduced me to John Carter and those wonderful Burroughs things. By the time I was 12 or 13 I had been very much into the whole science fiction field.

In World War II, Roddenberry served in the U.S. Army Air Corps as a B-17 pilot. He joined the Los Angeles Police Department in 1949, and wrote speeches for Chief William Parker as well as articles for the LAPD newsletter, The Beat. *Resigning in 1956, Roddenberry provided scripts to the screenwriter Sam Rolfe, for "Have Gun Will Travel," the TV western starring Richard Boone. Roddenberry had his first pilot produced by MGM in 1963, for the short-lived NBC series "The Lieutenant." The studio turned down his pitch for a new series called "Star Trek." But his agents contacted Desilu Studios, which was looking to produce more dramas after years of success in comedy.*

GENE RODDENBERRY

I was tired of writing for shows where there was always a shoot-out in the last act and somebody was killed. "Star Trek" was formulated to change that. I had been a freelance writer for about a dozen years and was chafing at the commercial censorship on television. You really couldn't talk about anything you cared to talk about. It seemed to me that perhaps if I wanted to talk about

sex, religion, politics, make some comments against Vietnam, and so on, that if I had similar situations involving these subjects happening on other planets to little green people, indeed it might get by, and it did.

DOROTHY "D.C." FONTANA

Writer, "Star Trek" story editor

Gene asked me to read the very first proposal for "Star Trek" in 1964. I said, "I have only one question: Who's going to play Mr. Spock?" He pushed a picture of Leonard Nimoy across the table.

GENE RODDENBERRY

Leonard Nimoy was the one actor I definitely had in mind—we had worked together previously. I was struck at the time with his high Slavic cheekbones and interesting face, and I said to myself, "If I ever do this science fiction thing, he would make a great alien. And with those cheekbones some sort of pointed ear might go well." To cast Mr. Spock I made a phone call to Leonard and he came in. That was it.

LEONARD NIMOY

Actor, "Mr. Spock"

I went in to see Gene at Desilu Studios and he told me that he was preparing a pilot for a science fiction series to be called "Star Trek," that he had in mind for me to play an alien character. I figured all I had to do was keep my mouth shut and I might end up with a good job here. Gene told me that he was determined to have at least one extraterrestrial prominent on his starship. He'd like to have more, but making human actors into other life-forms was too expensive for television in those days. Pointed ears, skin color, plus some changes in eyebrows and hair style were all he felt he could afford, but he was certain that his Mr. Spock idea, properly handled and properly acted, could establish that we were in the 23rd century and that interplanetary travel was an established fact.

MARC CUSHMAN

Author, *These Are the Voyages*

Desilu came into existence because Lucille Ball and Desi Arnaz owned "I Love Lucy." It was the first time someone owned the rerun rights to a show. Seems like a no-brainer today, but back then no one had done it. Eventually CBS bought the rerun rights back from Lucy and Desi for a million dollars, a lot of money back then. Lucy and Desi take that money and buy RKO and turn it into Desilu Studios. The company grows, but then

the marriage falls apart and Lucy ends up running the studio and by this point, they don't have many shows. Lucy says, "We need to get more shows on the air," and "Star Trek" was the one she took on, because she thought it was different.

HERBERT F. SOLOW

Executive in charge of production, "Star Trek"

I had so many people at the studio, so many old-timers trying to talk me out of it. "You're going to bankrupt us, you can't do this. NBC doesn't want us anyway, who cares about guys flying around in outer space?" The optical guy said it was impossible to do.

MARC CUSHMAN

Desi wasn't there anymore. So Lucy is asking herself, "What would Desi do?" because she really loved and respected him. "Desi would get more shows on the air that we own, not just that we're producing for other companies." That was her reasoning to do "Star Trek"—and she felt that this show could, if it caught on, rerun for years like "I Love Lucy." And guess what? Those two shows—"I Love Lucy" and "Star Trek"—are two shows that have been rerunning ever since they originally aired.

In the teleplay for the first pilot, "The Cage," starring Jeffrey Hunter as Capt. Christopher Pike, Roddenberry described the establishing shot in detail: "Obviously not a primitive 'rocket ship' but rather a true space vessel, suggesting unique arrangements and exciting capabilities. As CAMERA ZOOMS IN we first see tiny lettering 'NCC 1701- U.S.S. ENTERPRISE.*'"*

WALTER M. "MATT" JEFFERIES

Production designer, "Star Trek"

I had collected a huge amount of design material from NASA and the defense industry which was used as an example of designs to avoid. We pinned all that material up on the wall and said, "That we will not do." And also everything we could find on "Buck Rogers" and "Flash Gordon" and said, "That we will not do." Through a process of elimination, we came to the final design of the *Enterprise*.

GENE RODDENBERRY

I'd been an Army bomber pilot and fascinated by the Navy and particularly the story of the *Enterprise*, which at Midway really turned the tide in the whole war in our favor. I'd always been proud of that ship and wanted to use the name.



The transporter (teleporting crew, from left, Hikaru Sulu, Nyota Uhura, Pavel Chekov and Scotty) first became operable—in "Star Trek" chronology—in the 22nd century.

Roddenberry's attention to detail even extended to the ship's computer at a time when computers were punch card–operated behemoths that filled entire rooms. In a memo on July 24, 1964, to production designer Pato Guzman, Roddenberry suggested, "More and more I see the need for some sort of interesting electronic computing machine designed into the USS Enterprise*, perhaps on the bridge itself. It will be an information device out of which the crew can quickly extract information on the registry of other space vessels, spaceflight*

plans for other ships, information on individuals and planets and civilizations."

GENE RODDENBERRY

The ship's transporters—which let the crew "beam" from place to place—really came out of a production need. I realized with this huge spaceship, I would blow the whole budget of the show just in landing the thing on a planet. And secondly, it would take a long time to get into our stories, so the transporter idea was conceived so we could get our people down to the planet fast and easy, and get our story going by Page 2.

HOWARD A. ANDERSON

Visual effects artist, "Star Trek"

For the transporter effect, we added another element: a glitter effect in the dematerialization and rematerialization. We used aluminum dust falling through a beam of high-intensity light.

Though the network had warned the studio not to make the pilot too esoteric—"Be certain there are enough explanations on the planet, the people, their ways and abilities so that even someone who is not a science fiction aficionado can clearly understand and follow the story," a 1964 memo said—the network wasn't satisfied. NBC commissioned another pilot—a rare second chance at being picked up for a series.

GENE RODDENBERRY

The reason they turned the pilot down was that it was too cerebral and there wasn't enough action and adventure. "The Cage" didn't end with a chase and a right cross to the jaw, the way all manly films were supposed to end. There were no female leads then—women in those days were just set dressing. So, another thing they felt was wrong was that we had Majel as a female second-in-command of the vessel.

MAJEL BARRETT

Actress, "Number One," "Nurse Christine Chapel"

NBC felt that my position as Number One would have to be cut because no one would believe that a woman could hold the position of second-in-command.

GENE RODDENBERRY

Number One was originally the one with the cold, calculating, computerlike mind. When we had to eliminate a feminine Number One—I was told you could cast a woman in a secre-

I was told you could cast a woman in a secretary's role or that of a housewife, but not in a position of command over men on even a 23rd-century spaceship.

tary's role or that of a housewife, but not in a position of command over men on even a 23rd-century spaceship—I combined the two roles into one. Spock became the second-in-command, still the science officer but also the computerlike, logical mind never displaying emotion.

LEONARD NIMOY

Vulcan unemotionalism and logic came into being. Gene felt the format badly needed the alien Spock, even if the price was acceptance of 1960s-style sexual inequality.

The network's objections to Roddenberry's Spock included taking exception to the character's pointed ears, perceived as imparting a vaguely sinister Satanic appearance.

GENE RODDENBERRY

The idea of dropping Spock became a major issue. I felt that was the one fight I *had* to win, so I wouldn't do the show unless we left him in. They said, "Fine, leave him in, but keep him in the background, will you?" And then when they put out the sales brochure when we eventually went to series, they carefully rounded Spock's ears and made him look human so he wouldn't scare off potential advertisers.

Work on the second pilot, "Where No Man Has Gone Before," began in 1965. The show aired on September 22, 1966, and featured William Shatner as Capt. James T. Kirk, replacing actor Jeffrey Hunter.

GENE RODDENBERRY

At that time, TV was full of antiheroes, and I had a feeling that the public likes heroes. People with goals in mind, with honesty and dedication, so I decided to go with the straight heroic roles, and it paid off. My model for Kirk was Horatio Hornblower from the C.S. Forester sea stories. Shatner was open-minded about science fiction, and a marvelous choice.

WILLIAM SHATNER

Actor, "James T. Kirk"

I talked to Gene Roddenberry about the objectives we hoped to achieve, and one was serious drama as well as science fiction. I felt confident that "Star Trek" would keep those serious objectives for the most part, and it did.

SCOTT MANTZ

Film critic, "Access Hollywood"

I'd follow Kirk in a second. Shatner's performance as Kirk is the reason I became a "Trek" fan.

LEONARD NIMOY

Bill Shatner's broader acting style created a new chemistry between the captain and Spock.

WILLIAM SHATNER

Captain Kirk and I melded. It may have been only out of the technical necessity; the thrust of doing a television show every week is such that you can't hide behind too many disguises. You're so tired that you can't stop to try other interpretations of a line, you can only hope that this take is good, because you've got five more pages to shoot. You have to rely on the hope that what you're doing as yourself will be acceptable. Captain Kirk is me. I don't know about the other way around.

JAMES DOOHAN

Actor, "Montgomery 'Scotty' Scott"

[A few days] before they were actually going to shoot the second "Star Trek" pilot, the director, Jim Goldstone, called me and said, "Jimmy, would you come in and do some of your accents for these 'Star Trek' people?" I had no idea who they were, but I did that on a Saturday morning. They handed me a piece of paper—there was no part there for an engineer, it was just some lines, but every three lines or so I changed my accent and ended up doing eight or nine accents for that reading. At the end, Gene Roddenberry said, "Which one do you like?" I said, "To me, if you want an engineer,

he'd better be a Scotsman," because those were the only engineers I had read anything about—all the ships they had built and so forth. Gene said, "Well, we rather like that, too."

GEORGE TAKEI

Actor, "Hikaru Sulu"

The first time I talked to Gene about "Star Trek," it was for the second pilot and it was an exhilarating prospect, because almost every other opportunity was either inconsequential or defamatory, and here was something that was a breakthrough for a Japanese-American actor. Until then any regular series roles for an Asian or an Asian-American character were either servants, buffoons or villains.

ALEXANDER COURAGE

Composer, "Star Trek"

When Lucille Ball bought Desilu, Wilbur Hatch came in as head of music. When "Star Trek" came on the scene, Wilbur suggested me to Roddenberry and I turned out a theme. Roddenberry liked it and that was it. He said, "I don't want any space music. I want adventure music."

The second pilot became a monumental achievement: It persuaded NBC to greenlight the series.

GENE RODDENBERRY

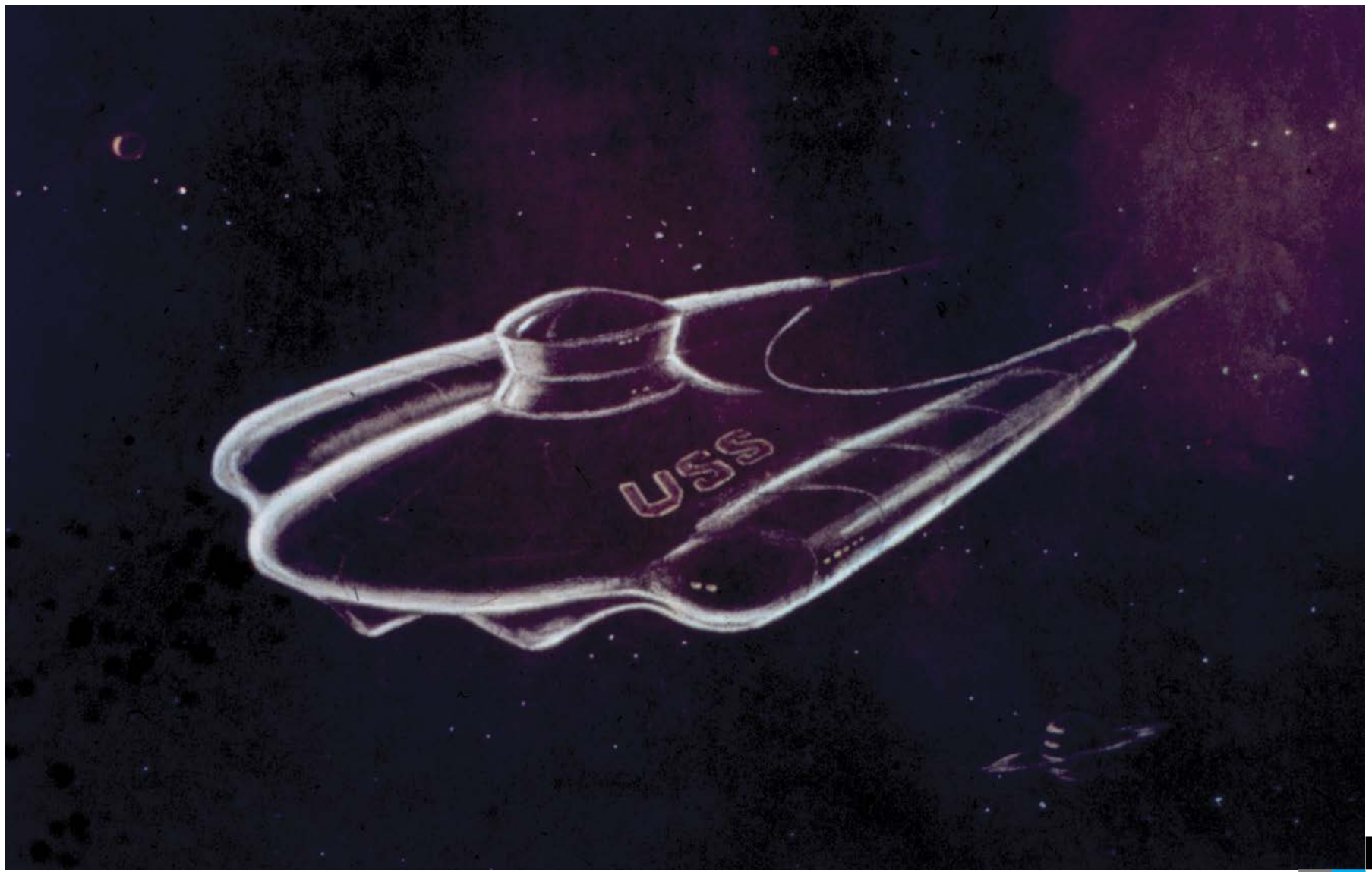
The biggest factor in selling the second pilot was that it ended up in a hell of a fistfight with the villain suffering a painful death. Then, once we got "Star Trek" on the air, we began infiltrating a few of our ideas, the ideas the fans have all celebrated.

ROBERT H. JUSTMAN

Associate producer, "Star Trek"

On the last day of production when we were a day over, we did two days' work in one day. That's the day that Lucy came on the stage, because we were supposed to have an end-of-picture party and we were still shooting, so in between setups she helped Herb Solow and me sweep out the stage. I think she just did that for effect, because she wanted to get the party started.

On March 6, 1966, Roddenberry dispatched a Western Union telegram to Shatner at the Hotel Richmond in Madrid: "Dear Bill. Good news. Official pickup today. Our Five Year Mission. Best Regards, Gene Roddenberry."



Artists conjured up variations of the *Enterprise*, including this version, before settling on the starship created by production designer Walter M. "Matt" Jefferies.

Not long after "Star Trek" was launched, the audience embraced Leonard Nimoy's Spock, and the stoic Vulcan science officer soon threatened to eclipse Captain Kirk. Nimoy came up with a list of demands that resulted in the possibility that the character would be replaced. In the end, Nimoy's demands were met, and the scripts began focusing on Kirk and Spock as a team. But the sense of competition continued.

MARC CUSHMAN

They almost didn't have Spock for the second season of "Star Trek." The fan mail got so intense during the first year, sacks and sacks of mail every day. His agent said, "He's getting only $1,250 a week and he needs a raise." But Desilu is losing money on the show and the board of directors was thinking of canceling it, even if NBC wanted to continue, because it was bankrupting the studio. The one that broke the stalemate was the one that didn't want Spock in the first place: NBC. "You are not doing the show without that guy. Pay him whatever you need to pay him."

DAVID GERROLD

Writer, "The Trouble With Tribbles"

The problems with Shatner and Nimoy really began during the

The last thing we wanted was to have the network, the sponsors or the audience feel that it was not a wonderful, marvelous family on “Star Trek.”

first season when *Saturday Review* did this article about “Trek” which stated that Spock was much more interesting than Kirk, and that Spock should be captain. Well, *nobody* was near Shatner for days. He was *furious*. All of a sudden, the writers are writing all this great stuff for Spock, and Spock, who’s supposed to be a subordinate character, suddenly starts becoming the equal of Kirk.

ANDE RICHARDSON
Assistant to writer Gene L. Coon

Shatner would take every line that wasn’t nailed down. “This should be the captain’s line!” He was very insecure.

HERBERT F. SOLOW

The last thing we wanted was to have the network, the sponsors or the television audience feel that it was not a wonderful, marvelous family on “Star Trek.” We didn’t want anybody to see a crack in this dam that we built.

If push came to shove, and we had to recast both characters, it would have been easier to recast Bill’s part than Leonard’s, so you tell me: Who’s the star of the show?

WILLIAM SHATNER

Occasionally, I’ll hear something from an ardent fan of mine who’ll say, “So and so said this about you.” And it bewilders me because I have had no trouble with them. We have done our job and gone on and I have never had bad words with anyone.

On August 17, 1967, Roddenberry addressed an ultimatum to Shatner and Nimoy, with DeForest Kelley (Dr. McCoy) thrown in for good measure:

"Toss these pages in the air if you like, stomp off and be angry, it doesn't mean that much since you've driven me to the edge of not giving a damn," Roddenberry wrote in that letter, excerpted here for the first time: "No, William, I'm not really writing this to Leonard and just including you as a matter of psychology. I'm talking to you directly and with an angry honesty you haven't heard before. And Leonard, you'd be very wrong if you think I'm really teeing off at Shatner and only pretending to include you. The same letter to both; you've pretty well divided up the market on selfishness and egocentricity.

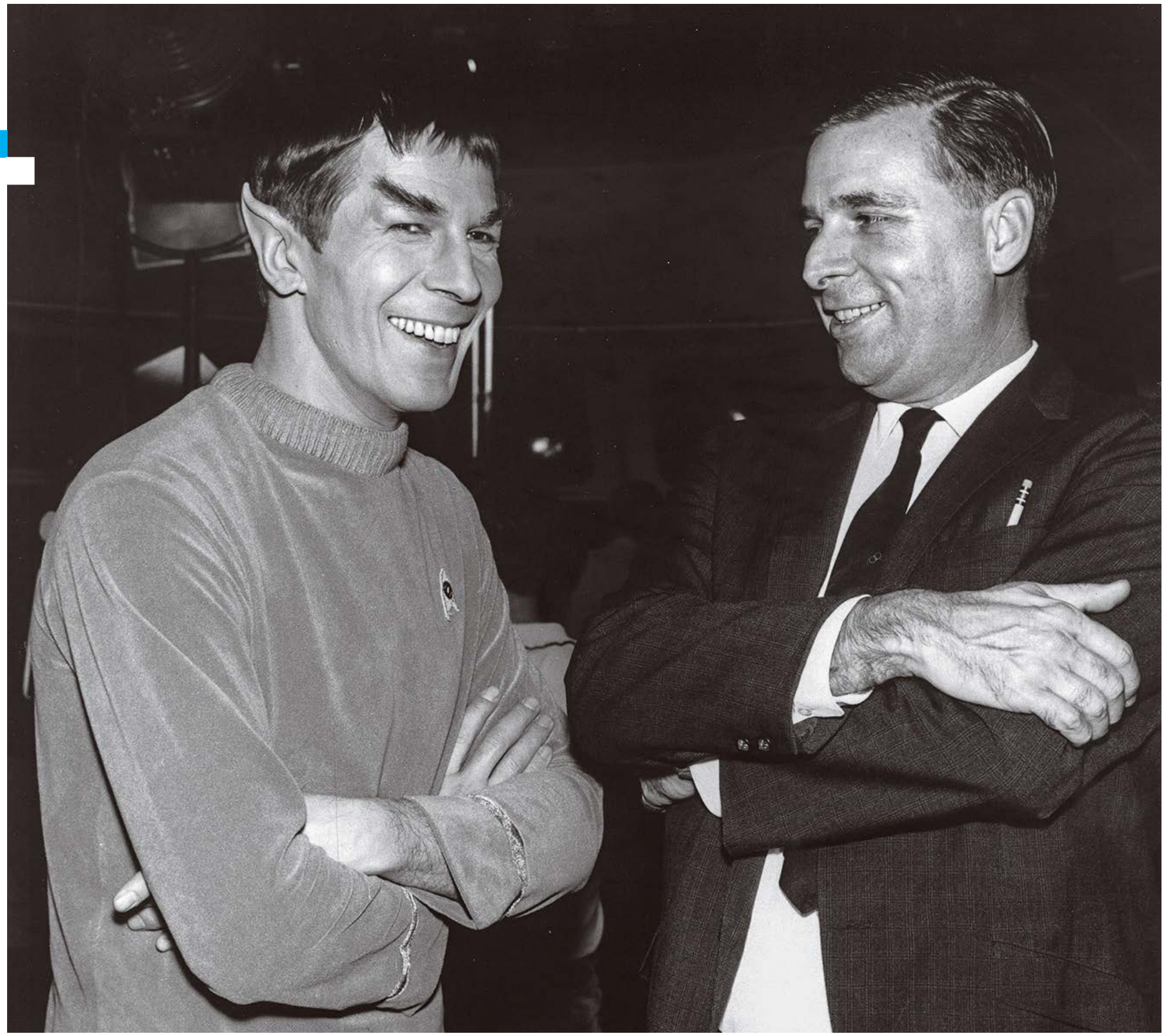
"Star Trek began as one of the TV productions in town where actors, as fellow professionals, were not only listened to but actually invited to bring their script and series comments to the production office. When small problems and pettiness begins to happen as it happens on all shows, I instructed our people that it should be overlooked where possible because we should all understand the enormous physical and emotional task of your job. . . . The result of Gene Roddenberry's policy of happy partnership? Star Trek is going down the drain.

". . . I want you to realize fully where your fight for absolute screen dominance is taking you. It's already affecting the image of Captain Kirk on the screen. We're heading for an arrogant, loud, half-assed Queeg character who is so blatantly insecure upon that screen that he can't afford to let anyone else have an idea, give an order, or solve a problem. You can't hide things like that from an audience.

"And now, Leonard. I must say that if I were Shatner, I'd be nervous and edgy about you by now, too. For a man who makes no secret of his own sensitivity, you show a strange lack of understanding of it in your fellow actors.

"For as long as I stay with the show, starting Monday," Roddenberry decreed, "there will be no more line switches from one to another. No more of the long discussions about scenes which lose us approximately a half day of production a show—the director will permit it only when there is a valid dramatic story or interpretation point at stake which he believes makes it necessary. The director will be told he is also replaceable and failure to stay on top and in charge of the set will be grounds for his dismissal.

"All right, my three former friends and 'unique professionals,' that's it. In straight talk."



Leonard Nimoy and Gene Roddenberry confer on set in 1964. Nimoy, said associate producer Robert H. Justman, "always wanted to make his character more believable."

DAVID GERROLD

All the episodes hold together because Shatner holds it together. Spock is only good when he has someone to play off of. Spock working with Kirk has the magic and it plays very well, and people give all of the credit to Nimoy, not to Shatner.

LEONARD NIMOY

During the series we had a failure—I experienced it as a failure—in an episode called "The Galileo Seven." The Spock character had been so successful that somebody said, "Let's do a show where Spock takes command of a vessel." We had this shuttlecraft mission where Spock was in charge. I really appreciated the loss of the Kirk character for me to play against. The Bill Shatner Kirk performance was the energetic, driving performance, and Spock

could kind of slipstream along and offer advice, give another point of view. Put into the position of being the driving force, the central character, was very tough for me.

THOMAS DOHERTY

Professor of American studies, Brandeis University

At the core of "Star Trek" is something profound, which is teamwork and adventure and tolerance. That's why it's a World War II motif in the space age. It really is a team; you're making a heroic contribution by doing your bit.

At the beginning of the second season, several changes greeted viewers. Not only was DeForest Kelley's name now added to the opening credits, there was a new face at the helm: Navigator Pavel Andreievich Chekov, played by Walter Koenig.

GENE RODDENBERRY

The Russians were responsible for the Chekov character. They put in *Pravda* that, "Ah, the ugly Americans are at it again. They do a space show, and they forget to include the people who were in space first." And I said, "My God, they're right."

WALTER KOENIG

Actor, "Pavel Chekov"

They were looking for someone who would appeal to the bubblegum set. All that stuff about *Pravda*, that's all nonsense. That was all just publicity. They wanted somebody who would appeal to 8- to 14-year-olds and the decision was to make him Russian. My fan mail came from 8- to 14-year-olds who weren't that aware of the cold war. Getting fan mail was so novel to me that I read every single letter I got. I was getting about 700 letters a week.

ROBERT H. JUSTMAN

We had another problem in the second season. We were cut down on how much we could spend per show by a sizable amount of money.

MARC CUSHMAN

Lucille Ball lost her studio because of "Star Trek." She had gambled on the show, and you can read the memos where her board of directors is saying, "Don't do this show, it's going to kill us." But she believed in it. She moved forward with it, and during the second season she had to sell Desilu to Paramount Pictures. Lucille Ball gave up the studio that she and her husband built, it's all she had left of her marriage, and she sacrificed that for "Star Trek."

RALPH SENENSKY

Director, "Metamorphosis"

Desilu was like a family. Herb Solow [the production head] used to come down and talk with you on the soundstage. Herb went out of his way to help you. Can you imagine a studio working like that? When Paramount bought it, a kind of corporate mentality took over. That's why I resent Paramount having such a hit in "Star Trek." If they had their way, they would have killed it off. It survived in *spite* of them. Now they have this bonanza making them all of this money.

MARC CUSHMAN

Lucy's instincts were right about "Star Trek," that it would become one of the biggest shows in syndication ever. The problem was that her pockets weren't deep enough. They were losing $15,000 an episode, which would be like $500,000 per episode today. You know, if she could have hung on just six months longer, it *would* have worked out, because by the end of the second season, once they had enough episodes, "Star Trek" was playing in, I believe, 60 different countries around the world. And all of that money is flowing in.

She had no choice but to sell. She actually took off and went to Miami. She ran away because it was so heartbreaking to sign the contract. They had to track her down to get her to do it. There's a picture of her cutting the ribbon after they've torn down the wall between Paramount and Desilu, and she's standing next to the CEO of Gulf and Western, which owns both studios now, and she's trying to fake this smile for the camera, and you know it's just killing her.

Among the now-classic episodes in Season 2 of the original are "Amok Time," in which Spock is driven to return to Vulcan to mate or die and finds himself in a battle to the death with Kirk.

JOSEPH PEVNEY

Director, "Amok Time"

What made the fight in "Amok Time" dramatically interesting is that it took place between Kirk and Spock. During this episode, Leonard Nimoy and I also worked out the Vulcan salute and the statement "live long and prosper" together.

TO BOLDLY RETURN

The starship *Enterprise* comes in for a new landing

After a conservation effort lasting almost two years, the model of the starship *Enterprise* that appeared in the original "Star Trek" television series is headed back for display at the National Air and Space Museum. Conservators subjected it to a slew of cutting-edge analyses—infrared and ultraviolet photography, microspectroscopy and even X-ray fluorescence spectrometry with a device that was designed to resemble a "Star Trek" phaser (though it functions more like a tricorder). The goal has been to restore the model as much as possible to its condition in August 1967, the last time it was modified for broadcast. A previous museum treatment had led to some fanboy grumbling about the paint job ("Gives the model the appearance of an over-the hill movie star wearing cake makeup," in one judgment), but Malcolm Collum, the museum's chief conservator, says a great deal of "paint layer archaeology" has subsequently gone into getting it right. After it's reassembled, the *Enterprise* will be beamed to a custom-made, climate-controlled case in the Boeing Milestones of Flight Hall in time for the museum's 40th anniversary, on July 1 (and the "Star Trek" series' 50th, on September 8). And which milestone will this non-flying craft celebrate? "The museum has long been interested in how spaceflight has been imagined," says Margaret Weitekamp, the museum's curator of space memorabilia. "And this is the perfect object to represent that." **–T.A. FRAIL**



The model arrived at the Smithsonian in 1974 lacking most of its lights, and replacements burned hot and gave off damaging ultraviolet light. Specialists Will Lee (left) and David Wilson work on ways to deploy new LEDs, which give off little heat and no UV light.



An X-ray fluorescence spectrometer was used to analyze metal parts.



A 1991 system for lighting the ship's nacelles—the pods housing the warp drives—is being replaced with an LED system that will come closer to the original flame effects.



To match the colors of the original paints, Wilson used an array of tools, including a high-tech colorimeter and old auto-paint chips that had belonged to his father.

GENE RODDENBERRY

Leonard Nimoy came into my office and said, "I feel the need for a Vulcan salutation, Gene," and he showed it to me. Then he told me a story about when he was a kid in synagogue. The rabbis said, "Don't look or you'll be struck dead or blind," but Leonard looked and, of course, the rabbis were making that Vulcan sign. The idea of my Southern kinfolk walking around giving each other a Jewish blessing so pleased me that I said, "Go!"

JOSEPH PEVNEY

"The Trouble With Tribbles" was a delightful show. I had a lot of fun with it, went out and shopped for the tribbles. My biggest contribution was getting the show produced, because there was a feeling that we had no business doing an outright comedy. Bill Shatner had the opportunity to do the little comic bits he loves.

Season 2 also featured visits to a number of Earthlike planets, including one where the society mirrored the Roman Empire.

RALPH SENENSKY

Gene Roddenberry is a very creative man. When we did "Bread and Circuses," we were doing the Roman arena in modern times with television. We didn't want to tip that we were doing a Christ story from the word go. Originally when they were talking about the sun, you knew right away that they were talking about the son of God.

DOROTHY "D.C." FONTANA

Certainly there was a nice philosophy going on there with the worshiping of the "sun," and then the indication that it was the son of God, that Jesus or the concept had appeared on other planets.

The series was not a ratings powerhouse. Indeed, it seemed that Season 2 could very well be the show's last. The future was in the hands of the fans.

BJO & JOHN TRIMBLE

Longtime fans

Cancellation was certain at the end of the second season. We wrote up a preliminary letter, ran it off on our ancient little mimeograph machine, and mailed it out to about 150 science fiction fans. We didn't have enough money to have a letter printed, so we used the Rule of Ten: Ask ten people to write a

letter and they ask ten people to write a letter, and each of those ten asks ten people to write a letter.

NBC was convinced that "Star Trek" was watched only by drooling idiot 12-year-olds. They managed to ignore the fact that people such as Isaac Asimov and a multitude of other intellectuals enjoyed the show. So, of course, the suits were always looking for reasons to cancel shows they didn't trust to be a raging success.

ELYSE ROSENSTEIN

Early organizer of "Star Trek" conventions

Do you realize how many pieces of mail NBC eventually received on "Star Trek"? They usually got about 50,000 for the year on everything, but the "Star Trek" campaign generated one million letters. They were handling the mail with shovels—they didn't know what to do with it. So they made an unprecedented on-air announcement that they were not canceling the show and that it would be back in the fall.

GENE RODDENBERRY

The letter-writing campaign surprised me. What particularly gratified me was not the fact that there was a large number of people who did that, but I got to meet and know "Star Trek" fans, and they range from children to presidents of universities.

JOHN MEREDYTH LUCAS

Producer; writer, "Patterns of Force"

Some of the most fanatic support came from Caltech.

GENE RODDENBERRY

We won the fight when the show got picked up for a third season. NBC was certain I was behind every fan, paying them off. And they finally called me up and said, "Listen, we know you're behind it." And I said, "That's very flattering, because if I could start demonstrations around the country from this desk, I'd get the hell out of science fiction and into politics."

"Star Trek" concluded its second season on a high note, with NBC essentially acknowledging the success of the fans' letter-writing campaign by announcing that the series would be returning.

GENE RODDENBERRY

I told NBC that if they would put us on the air as they were promising—on a weeknight at a decent time slot, 7:30 or 8 o'clock—I

About ten days or two weeks later, I received a phone call at breakfast, and the network executive said, “Hello, Gene, baby...” I knew I was in trouble.

would commit myself to produce “Star Trek” for the third year. Personally produce the show as I had done at the beginning. About ten days or two weeks later, I received a phone call at breakfast, and the network executive said, “Hello, Gene, baby . . .” I knew I was in trouble right then. He said, “We have had a group of statistical experts researching your audience, and we don’t want you on a weeknight at an early time. We have picked the best youth spot that there is. All our research confirms this and it’s great for the kids and that time is 10 o’clock on Friday nights.” I said, “No doubt this is why you had the great kiddie show ‘The Bell Telephone Hour’ on there last year.” As a result, the only gun I then had was to stand by my original commitment, that I would not personally produce the show unless they returned us to the weeknight time they promised.

DAVID GERROLD

Roddenberry, rather than try and do the very best show possible, walked away and picked Fred Freiberger [as the producer]. I wish Roddenberry had been there in the third season to take care of his baby.

MARC CUSHMAN

NBC didn’t like Gene Roddenberry, and they didn’t like the type of shows that “Star Trek” was airing. It was too controversial and too sexy, and they couldn’t get Roddenberry to tone it down. So they move it to Friday night—they didn’t even want to pick it up, but there was the letter-writing campaign that made them cry uncle. They put it in the death slot. And they knew when they picked it up that they were determined that Season 3 would be the last year.

ROBERT H. JUSTMAN

If your audience is high-school kids and college-age people and young married people, they're not home Friday nights. They're out, and the old folks weren't watching. So our audience was gone.

MARGARET ARMEN

Writer, "The Paradise Syndrome"

Working with Gene was marvelous, because he *was* "Star Trek" and he related to the writers. Fred came in and to him "Star Trek" was "tits in space." And that's a direct quote. Fred had been signed to produce and was being briefed. He watched an episode with me, smoking a big cigar, and said, "Oh, I get it. Tits in space." You can imagine how a real "Star Trek" buff like myself reacted to *that*.

FRED FREIBERGER

Producer, "Star Trek," Season 3

Our problem was to broaden the viewer base. To do a science fiction show, but get enough additional viewers to keep the series on the air. I tried to do stories that had a more conventional story line within the science fiction frame.

MARC CUSHMAN

You had some of the most talented people from "Star Trek" that were leaving. You didn't have Gene Coon, Gene Roddenberry or Dorothy Fontana finessing the scripts. It's like having the Beatles and taking away John Lennon and Paul McCartney. "OK, we still have George and Ringo. We're still the Beatles." No, you're not. You're still good, but not *as* good.

JAMES DOOHAN

Fred Freiberger had no inventiveness in him at all. Paramount bought Desilu and here was this damn space show as part of the package and they couldn't care less about it.

WILLIAM SHATNER

There was a feeling that a number of Fred Freiberger's shows weren't as good as the first and second season, and maybe that's true. But he did have some wonderfully brilliant shows and his contribution has never been acknowledged.

BJO & JOHN TRIMBLE

The third season ground down, show after show being worse than the last, until even the authors of the scripts were having their names removed or using pseudonyms. To be fair, there



New aliens perennially confronted the crew (Spock, left, with Yeoman Rand and Kirk). Yet the greatest danger, Kirk believed, was "irrational fear of the unknown."

were a few good scripts in the third season, but in the main those few seemed to be almost mistakes that slipped by.

While the third year of "Star Trek" has largely been dismissed as a creative failure, several notable episodes were produced. "Spectre of the Gun" is a surrealistic western in which Kirk, Spock and McCoy find themselves reliving the shootout at the O.K. Corral. "Day of the Dove" focuses on an energy force that feeds on hatred. In "Plato's Stepchildren," aliens with telekinetic abilities torture Enterprise *crewmen for their amusement—and Kirk and Uhura share television's first interracial kiss.*

BJO & JOHN TRIMBLE

The last third-season episode, "Turnabout Intruder," was very good; it might have won an Emmy for William Shatner. But all

TV shows got rescheduled for President Eisenhower's funeral coverage. So the episode missed the Emmy-nomination deadline.

SCOTT MANTZ

That's how production ended. There is something somewhat apropos about the last words of the last episode, "Turnabout Intruder": "Her life could have been as rich as any woman's. If only . . . If only." And then Kirk walks off.

SCI-FI GETS real

HOW TO PLUG IN YOUR BRAIN

If neuroscientists are right, you'll soon be able to sharpen your focus and boost your memory by recharging your brain—with electricity

BY DAVID NOONAN

ILLUSTRATION BY DANIEL HERTZBERG
PHOTOGRAPHS BY LYNN JOHNSON



Two hundred and thirty-five years after the Italian scientist Luigi Galvani reported that dismembered frog legs twitch in response to a static charge applied to a nerve, we are still exploring the mysteries of what he called "animal electricity," especially in the brain. That the brain generates a bit of its own electricity, which can be detected by an electroencephalogram, or EEG,



Researchers refine a study on fitness and the brain. Air Force members make good subjects because they are physically fit.

is well established, as is the fact that some neurosurgeons today sometimes use hair-thin electrodes to stimulate deep brain structures and stop Parkinson's tremors. But scientists are now exploring a question that is, well, mind-boggling: Can low-voltage doses of electricity, transmitted through hair, skin and skull directly into particular regions of the brain, make already healthy people sharper and more alert?

Aron Barbey, a 39-year-old neuroscientist at the University of Illinois, is a leader in this research, though he is excruciatingly cautious about its prospects. He resists the idea that tomorrow's malls and airports will feature commercial brain-charging stations, updated versions of today's massage stops, but if that future (or something like it) comes to pass, his work will have played a critical role in bringing it about. Barbey is the director of the UI's Decision Neuroscience Laboratory at the university's Beckman Institute for Advanced Science and

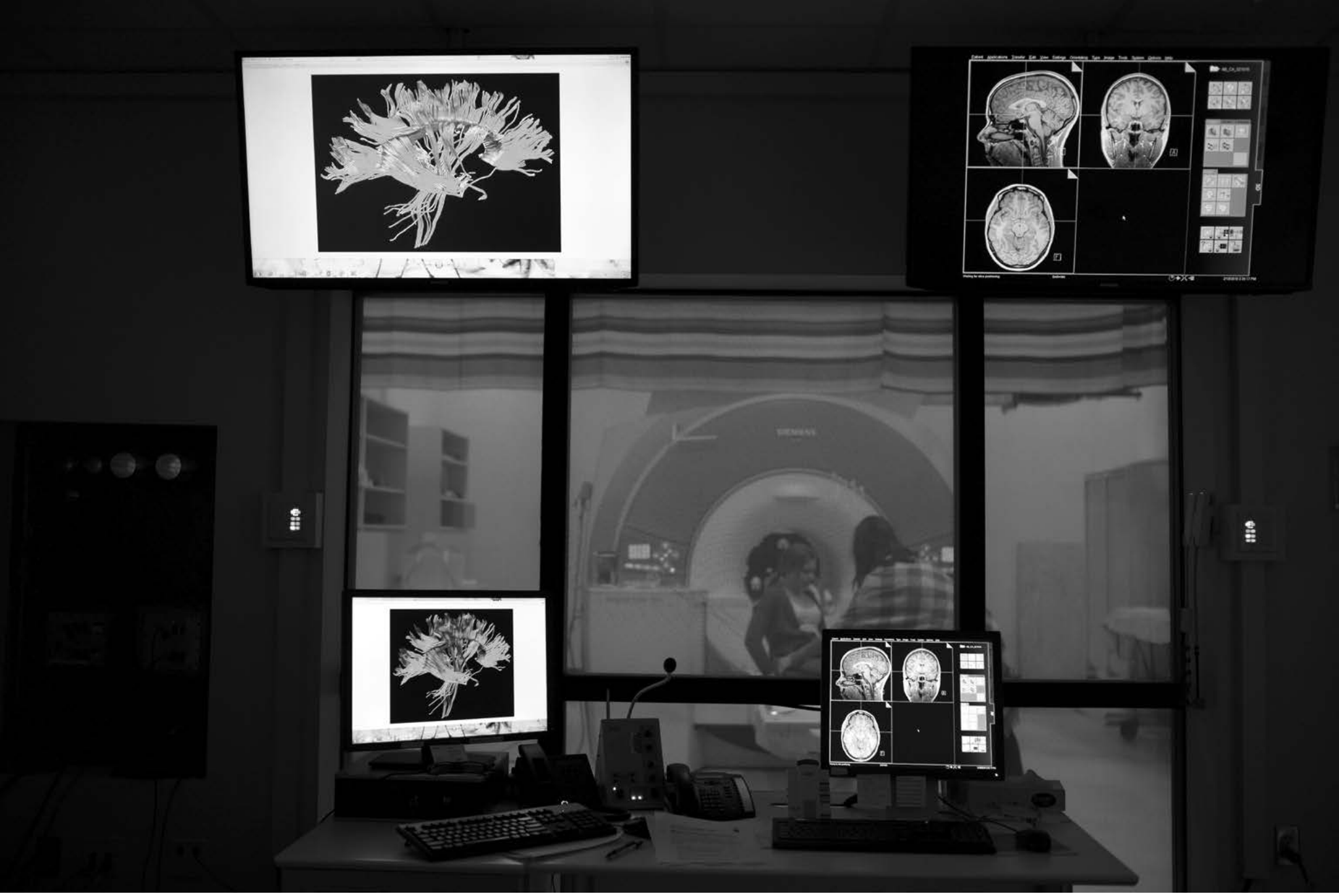
Technology, and his experiments appear to point to a time when students, soldiers, executives and the elderly could all benefit from a treatment called transcranial direct-current stimulation (tDCS).

In a windowless room at Wright-Patterson Air Force Base, near Dayton, Ohio, I watch John McIntire, a 33-year-old civilian volunteer, receive tDCS. He sits at a computer, clicking on a series of tiny blinking lights, a gauze bandage wrapped under his chin and across the top of his head. The bandage keeps a small cluster of electrodes in place on the upper left side of his head. There's another cluster of electrodes on his upper right arm. Wires from a small blue box on the desk carry a weak electrical charge that flows from the box to the electrodes on his head and down though his brain to the electrodes on his arm. Researchers believe the current is hitting some key areas of his mid-brain, including the locus coeruleus, which releases norepinephrine and is involved in attention and wakefulness.

"I feel fine," says McIntire at the end of the 30-minute session. Did he experience any physical sensations as the current passed through his brain? "No," he says, "I can't actually tell if I'm receiving the treatment or not." Because it's a double-blind study, some subjects receive sham tDCS, with no current. (McIntire got the real thing.) Researchers say they haven't seen significant side effects, just some skin sensitivities from the electrodes. Some subjects who receive tDCS report headaches afterward, but so do some of those who receive sham treatments.

The ongoing study at Wright-Patterson is a collaboration between Barbey's group and the Air Force Research Laboratory (AFRL). It's just one of many experiments Barbey has launched with major research partners. "Our goal," he says, "is to understand the neural mechanisms that underlie human intelligence and decision-making—how intelligence and decision-making are implemented in the brain—and then use that knowledge to develop these new interventions."

It's not hard to understand why the Air Force would be interested in what Barbey has to offer. Many of its personnel spend up to 12 hours a day, six days a week, looking at pictures of surveillance imagery and trying to identify their drone marks. Research shows that their performance starts to decline after just 20 minutes on duty. "Missing targets in real-life battle situations is a



A research participant at the University of Illinois gets ready to go into an MRI machine. Researchers use this data to analyze the brain structure and function of subjects who receive tDCS.

big deal, because that could cost somebody their life," says Andy McKinley, an AFRL neuroscientist. "And we think tDCS might be a tool to help the analysts, when they start getting fatigued, to maintain their performance."

So far, the findings have been promising. In a series of studies published since 2013 in *NeuroImage*, *Brain Stimulation* and other journals, tDCS alone was shown to reduce fatigue and improve or preserve performance. Service members who received the current in the morning were far more alert and vigilant than control subjects when they were tested in the late afternoon. The treatment also seemed to improve their moods and energy levels. McKinley, who has been working with tDCS since 2007, says the effect of a 30-minute tDCS dose of two milliamperes in the morning "lasts all day long." (By comparison, modern electroconvulsive therapy treatments involve up to 900 milliamperes.) In a related, yet-to-be-published AFRL sleep deprivation study, subjects were kept awake for 21 hours, then given either caffeine, sham tDCS or actual tDCS before continuing their duties for up to another 15 hours. Members

of the third group boasted twice the accuracy in finding targets of the other two groups. They also reported higher subjective mood scores and said the tDCS made them feel refreshed.

The protocol Barbey has designed combines tDCS, nutrition, and cognitive and physical exercise in a comprehensive regimen with the potential to enhance everything from math skills to abstract reasoning. Through his work, he is probing the nature and structure of the human mind and, in the process, asking what it really means to be smart.

It was his work with another generation of service members that taught Barbey the intricacies of the human brain. Between 2007 and 2011, he was a research fellow at the National Institutes of Health, studying a group of Vietnam veterans who had suffered brain trauma. The damage had been caused by low-velocity shrapnel and bullet wounds—it was limited to discrete areas, which meant most of their cognitive functions were preserved. The locations and sizes of their wounds caused different deficits, including issues with memory, language and with higher cognitive functions such as planning and problem solving.

Using a process called lesion mapping, Barbey gathered diagnostic images of the veterans' brains and then matched the men's damaged anatomy to their documented problems. The result was a brain atlas that made it possible to link specific cognitive functions to their underlying neural networks.

Building on that knowledge, Barbey, with various co-authors, went on to publish a formidable series of papers identifying brain networks for general intelligence, emotional intelligence, cognitive flexibility, working memory and more. In what might be considered his lesion-mapping masterwork, published in the journal *Brain* in April 2012, Barbey and colleagues ambitiously laid out an architecture for general intelligence and executive function—complex, goal-directed behaviors that involve widely distributed parts of the brain, including the prefrontal cortex. That study, one of the largest and most comprehensive assessments of its kind conducted to date, involved 182 Vietnam veterans and concluded that intelligence "reflects the ability to effectively integrate verbal, spatial, motor and executive processes via a circumscribed set of cortical connections." Barbey and his team were able to pinpoint many of these connections and describe how they worked.

Barbey resists the idea of commercial brain-charging stations. But if that future comes to pass, his work will have played a critical role.

Barbey's experience with the veterans left him with much more than an impressive CV. "It was incredibly profound," says Barbey, who now serves as editor or board member at four journals, including *Frontiers in Neuroscience*. "We spend all this time developing these theories and thinking about the nature of the human mind and really working hard to try to understand the function of these brain networks. And it becomes this very scientific, very technical enterprise. But then, once you begin working with individuals, working with patients, with Vietnam veterans, it becomes immediately clear that there is this very important issue at stake. And it really is about improving the quality of people's lives, and finding solutions to these very hard problems that they are facing."

The maddening complexity of the brain itself is the biggest obstacle to addressing such problems. Or so it would seem. But that very complexity also makes it possible for science to improve performance on a wide range of tasks—as long as researchers know which networks to target. Stimulating the correct networks, Barbey says, depends on knowing which ones are involved in a given task and being able to target those networks at the correct dose and duration. "So how do we know if we're stimulating the right structures?" he asks. "It depends on the task. The task is critical."

In the long shadow of everything we don't know about the brain, tDCS is shedding new light on how it works. Neurons are the media for electrical activity in the brain, but as Barbey points out, "there are like a 100 billion of them and they have many properties that elude us." Barbey's research focuses on

human intelligence and decision-making. Intelligence, he says, emerges from the interaction among multiple brain networks, including the central executive network, a distributed neural system (a sort of 3-D spider web) that is well known to support functions like planning, problem-solving, judgment and decision-making.

In a typical tDCS experiment targeting the central executive network, Barbey arranges the electrodes to send the current through the frontal and parietal lobes as his subjects perform a computer-based task. In one such test, called the n-back task, participants are shown letters and must recall whether they match letters they saw previously.

Barbey says the electrical current enhances the excitability of the neurons involved in the task, making them more likely to fire and strengthening the synaptic connections between them. "Neurons that fire together wire together," Barbey says, quoting an axiom by the legendary Canadian psychologist Donald Hebb. In a September 2015 paper, the AFRL scientist Ryan Jankord and colleagues reported that 30 minutes of tDCS in rats "induced a robust enhancement" of the connections between cells in the hippocampus that are critical for learning and memory.

In humans, tDCS also appears to recruit additional neurons not originally involved in a task, creating what Barbey calls subnetworks that improve performance. But there's nothing inherently beneficial about increasing the excitability of neurons, he adds. "It's only effective under specific conditions, where you are delivering electric current to regions that are involved in the task." This is a key part of how he administers tDCS: The subject has to be actively using the parts of the brain in question. Ever cautious, however, Barbey emphasizes that "the underlying biophysical mechanisms are not well characterized." In other words, researchers aren't entirely sure why tDCS does what it does.

Some have questioned whether it does anything at all. In January 2015, the Australia-based scientist Jared Horvath and two of his colleagues published an analysis of more than 200 tDCS studies. Their conclusion: "Our quantitative review does not support the idea that tDCS generates a reliable effect on cognition in healthy adults." The paper set off a controversy, with defenders of tDCS questioning Horvath's methods—he excluded more than 170 studies whose results had not been replicated by



Barbey's treatment is designed to improve performance on a specific task at hand. Here, student research subjects use tablets to complete a cognitive training program as a low-level electric current courses through their brains.

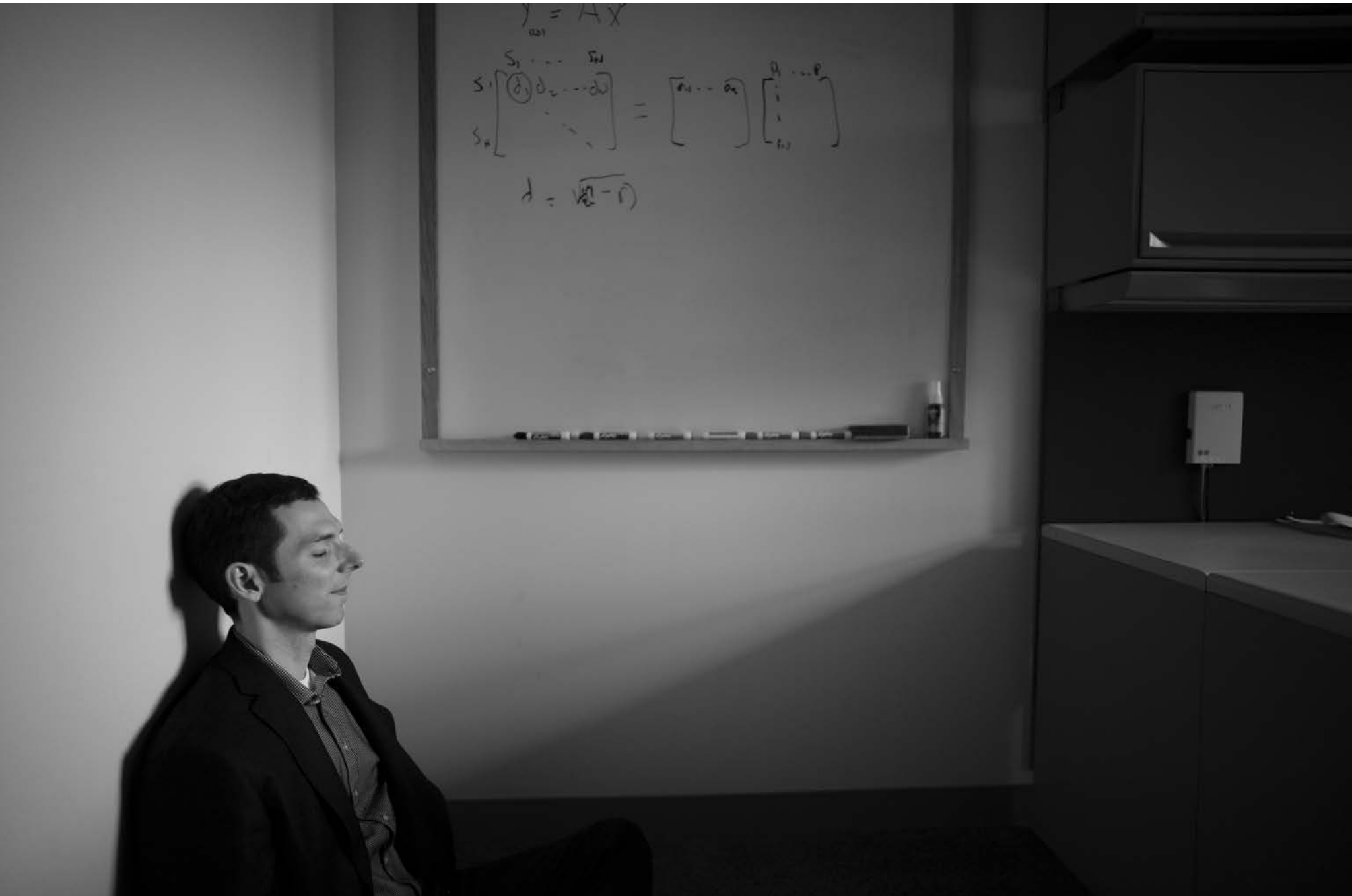
at least one other lab. Barbey takes Horvath's point and notes that, while tDCS has been widely investigated, enthusiasm for it has "outpaced mechanistic theories" of how it works. These gaps in knowledge, he says, delay the development of more effective protocols and produce a diversity of findings that can't be explained, lending themselves to critiques like Horvath's.

"People have been trying to change their consciousness ever since they realized they had consciousness," says Jonathan D. Moreno, a professor of medical ethics and health policy at the University of Pennsylvania's Perelman School of Medicine. Moreno says he's underwhelmed by the progress in the tDCS field so far. "I just think we're so much in the woods on this still, and we will be for a long time," he says. "It depends on who you are trying to enhance, and for what. You could never get me to be Einstein and Einstein probably doesn't need much enhancement."

He's less skeptical about the therapeutic use of tDCS to restore some degree of normal function in people with certain disorders. "Therapy seems to be more doable than enhancement," he says. Multiple studies in recent years have shown it to have potential as an effective treatment for major depression, post-traumatic stress disorder and other neuropsychiatric problems. It has also shown promise for Alzheimer's and stroke patients during word-memory and picture-recognition tasks. And a 2014 study found that tDCS improved language learning, suggesting its potential as a treatment for the language deficits caused by stroke. Research by the Air Force, unrelated to clinical disorders, may point to another potential benefit of therapeutic tDCS: Teams of researchers in Germany, Brazil and the U.S. have found that two weeks of daily tDCS can result in weeks or even months of improved performance on a very specific task. "It looks like you are making lasting changes to neural connections in the brain," McKinley says.

A 42-month project called Insight might provide more concrete answers. Barbey's lab launched the program in 2014, with $12.7 million in funding from the Office of the Director of National Intelligence. It's one of the largest-ever studies of the ability to reason under novel conditions. The government's stated goal is to improve the adaptive reasoning and problem-solving skills of intelligence personnel. Under Barbey's supervision, 1,000 healthy volunteers between ages 18 and 44 (many of them University of Illinois students) are receiving doses of tDCS while performing cognitive training exercises that test those skills. But that's only part of the protocol: They're also undergoing physical fitness training sessions, and their diets and nutritional health are being monitored.

Exercise might seem low-tech compared with tDCS. But Barbey is just as interested in the power of sweat as he is in the potential of electricity. He's involved in a separate project with the Air Force focusing pointedly on high-intensity interval training. Exercise on its own has already proven at least as effective as tDCS in enhancing cognitive performance. Though Barbey says the definitive clinical trial remains to be done, more than 40 years of research show an increase in gray-matter volume among aerobically fit older adults, as well as a 40 percent reduced risk of cognitive decline among those who exercise regularly. Alzheimer's patients who take part in acute exercise programs



Barbey takes a meditation break. In keeping with his holistic approach to the brain, he takes time to meditate each day and finds it especially helpful for dealing with job-related stresses, such as navigating grant proposals.

have increased brain-derived neurotrophic factor, a protein that promotes the health and growth of brain cells.

According to Barbey, exercise has an especially impressive effect on the executive functions. “If we were to go outside right now and run at full speed all the way down to the end of the street and then run full speed all the way back,” says Barbey, “when we sat down here to continue our conversation we would be more attentive, our memory would be improved, we would have better executive control functions, and those effects would last about 20 to 30 minutes.”

Barbey also wants to understand the impact of nutrition on brain health and cognition. “We know that if you want to be an athlete you have to eat particular things and engage in particular types of physical activity,” he says. “That nutrition also operates on the brain.” The subjects in his Air Force project take a special supplement created by Barbey’s lab in collaboration with Abbott

Nutrition. The formula is proprietary, but Barbey says it includes ingredients to promote muscle strength, cardiovascular health and aerobic fitness, as well as brain health. "In addition to that, we have specific nutritional profiles that we hypothesize play an important role in enhancing brain health and cognitive ability," he says. In short, Barbey believes that exercise and nutrition can provide lasting, holistic benefits that just stimulating specific brain networks could likely never deliver.

Still, tDCS remains the most exotic of the interventions. It's tempting to assume that multiple treatment sessions might increase general intelligence, instead of merely improving performance on the task at hand. But Barbey has found no evidence that tDCS can make a person smarter across the board. "The answer seems to be no," he says.

That's one reason he envisions a future where people will use targeted tDCS along with lifestyle changes: the latter will improve their overall health and mental performance, while the former will enhance specific cognitive abilities. As Barbey sees it, the suite of interventions will depend on an individual's goals. A subject might want improved working memory, for instance, and need to enhance the brain networks involved. "The ability to develop a tailored intervention depends on understanding the underlying mechanisms," says Barbey. "If we don't understand the mechanisms, we certainly can't achieve tailoring."

But Barbey knows that his work feeds an alternate vision of the future, one where people in all kinds of private and commercial settings can routinely sit down for brain-charging sessions. He'd rather not speculate about such things, but when prodded about whether this model may exist 50 years from now—a kind of LensCrafters for the brain—he says, "Assuming that we're on the right track, assuming that tDCS actually can produce robust improvements, then yes." Then he quickly returns to present-day reality. "But we're still learning about these methods, and we're still running experiments to evaluate their efficacy. So it's still too early. And that's what happens with commercialism. They go way too fast." Barbey holds a dim overall view of the commercial brain-training industry and doesn't want people to lump his work in with its offerings. Millions of smartphone users, for instance, have downloaded games like Lumosity, which claim to improve memory significantly. "There is definitely evidence to suggest

that if you play a working memory game, you'll get better at that working memory game," he says. "What's less clear is whether that has any other impact." (Barbey's skepticism was reinforced in January, when Lumosity agreed to pay $2 million to settle federal charges of deceptive advertising for claiming its product could slow cognitive decline. A $50 million judgment was suspended because the company didn't have the money.)

Barbey insists that there are no shortcuts in neuroscience. At least two commercial tDCS devices, Halo and Thync, are currently available, but he's put off by the suggestion that it's possible to become smarter by just flipping a switch or playing a game. "We've really got to take the hard road," he says. For Barbey, the brain demands nothing less.

VIEW NEXT ARTICLE

SCI-FI GETS real

BY NAOMI SHAVIN

MATERIAL GIRL



Dutch designer Iris van Herpen redefines what it means to be fashion forward



The first 3-D printed design van Herpen sent down the runway, in 2010, this top was a major breakthrough in her career and in the world of haute couture. “Combining craftsmanship with the latest technology is a way to optimize beauty and intricacy,” says van Herpen.



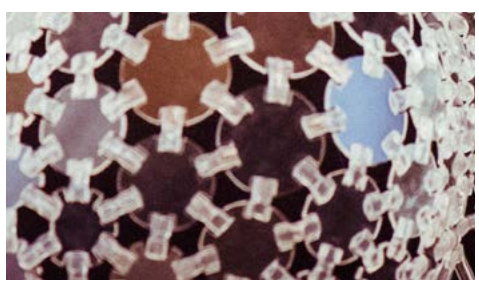
Van Herpen's most recent collection, Lucid, was critically acclaimed at Paris Fashion Week 2016. For the collection, she collaborated with Canadian artist and architect Philip Beesley, and drew inspiration from her state of mind when draping material on a mannequin. "It's a very unconscious, almost meditative state," she says.

The haute couture works of Dutch fashion designer Iris van Herpen can seem mind-bendingly ahead of their time. At Paris Fashion Week, in March, models in seemingly gravity-defying ensembles strode down a runway dotted with strategically placed optical screens that reflected and distorted

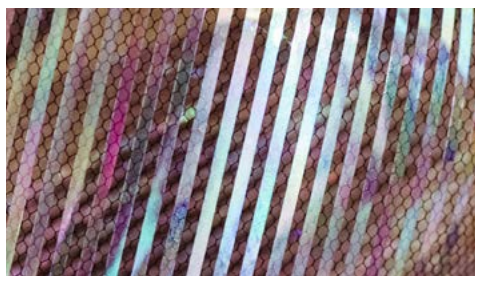












Van Herpen's uncanny materials beckon to be touched, and the High Museum has a selection of them available for visitors to do exactly that. Since the exhibit opened, attendance has been brisk.

the models' appearance like high-tech fun house mirrors. Van Herpen's designs are sleek in a way that calls to mind marvels of evolutionary design, like stingrays or coral, combined with the type of repetitive structures one expects only a machine could produce. Her silhouettes range from close-fitting to outsized and geometric. One outfit looked like a freeze frame of a dress swept upward by a strong wind. Another, with exaggerated shoulders and hips, had the shape of a moth with its wings spread. The show's focal dress was made from 5,000 individual pieces, each 3-D printed and then hand-woven together to evoke a glimmering, gothic needlepoint. Van Herpen has been hailed by the *New York Times* for her "different way of thinking," a high-concept designer who fuses an interest in fashion, art and architecture with cutting-edge technologies and fields of science as diverse as particle physics, robotics and microbiology. "Iris van Herpen's astonishing designs don't look like 'clothes,'" the *Washington Post* wrote last year. "They look like the future."

The 31-year-old van Herpen, who grew up in a small town in Holland, studied fashion design at the esteemed Dutch art academy Artez and had an internship during college with the path-breaking fashion designer Alexander McQueen. She does think about the future, but less, perhaps, than many of her admirers might expect. "I don't find my work futuristic," says van Herpen, in a recent interview with *Smithsonian*. "It's bizarre how the mind works. Many of the concepts and explorations happening today," she says, like those she tries to conjure with the designs she puts on display at her fashion shows, "feel as though they are the future, not yet real." The fact that we are seeing them, she believes, proves exactly the opposite, and those most familiar with her work agree. "We're so quick to cast her work that way, because it seems other, it seems futuristic," says Sarah Schleuning, a curator at the High Museum, in Atlanta, whose first-ever fashion show, a retrospective of van Herpen's work, runs until May 15. It may be worth noting that the OCT Contemporary Art Terminal in Shanghai and the OCT Art & Design Gallery in Shenzhen, China, have been showcasing van Herpen's work in a traveling exhibit called "The Future of Fashion Is Now."



“This dress is made from 5,000 individual 3-D printed pieces, hand-stitched to a soft tulle,” explains van Herpen. “When you look inside the dress, you see the thousands of intricate lines, created by the hundreds of hours of hand-stitching, and when you look closely at the outside of the dress, you see thousands of little lines also, the lines that the 3-D printer made to build up the texture. When you look at the tiny printing lines, you’re looking at the process, it’s like the life rings of a tree, you see the history of time and movement in its structure.”

IRIS VAN HERPEN COLLECTIONS

JULY 2007 / FRAGILE FUTURITY
A statement on her view of the future: "fragile, vulnerable, evolved"

JANUARY 2008 / CHEMICAL CROWS
Gold ribs from children's umbrellas become bird-like dresses

JULY 2008 / REFINERY SMOKE
IVH's metal gauze dresses change color with oxidization

JANUARY 2009 / MUMMIFICATION
Riffs on the strange beauty and devotion of the ancient ritual

SEPTEMBER 2009 / RADIATION INVASION
Visualizes the electromagnetic waves all around us

FEBRUARY 2010 / SYNESTHESIA
Optical illusion ensembles made from metal foil and treated leather

JULY 2010 / CRYSTALLIZATION
The debut of the "Water" dress and IVH's first 3-D printed design

JANUARY 2011 / ESCAPISM
Interprets the emptiness accompanying escape into digital devices

JULY 2011 / CAPRIOLE
French for "leap in the air," inspired by a free-fall parachute jump

JANUARY 2012 / MICRO
Draws on images of microorganisms, invoking cellular structures

JULY 2012 / HYBRID HOLISM
Evokes the possibility of a future where clothing itself can change

JANUARY 2013 / VOLTAGE
Seeks to tangibly portray electricity's movement and power

JULY 2013 / WILDERNESS EMBODIED
Magnetics, 3-D printing and craftsmanship mimic nature

OCTOBER 2013 / EMBOSSED SOUNDS
Interactive clothing makes music via touch-sensitive audio wires

MARCH 2014 / BIOPIRACY
Considers advances in genetics by suggesting metamorphosis

SEPTEMBER 2014 / MAGNETIC MOTION
Explores magnetism following a visit to the Large Hadron Collider

MARCH 2015 / HACKING INFINITY
The central shape of the circle represents ideas of terraforming

OCTOBER 2015 / QUAQUAVERSAL
Clothing that imitates roots, "tangled like a maze around the body"

MARCH 2016 / LUCID
Parts of her creative process can seem like lucid dreaming to IVH

Sometimes van Herpen's imagination pushes even the most cutting-edge technologies to their limits. "So many things that I imagine should logically be here by now are not yet here," she says. Take, for example, van Herpen's "Water" dress, a translucent, sculptural affair that splashes away from the body in three dimensions like a still image of water hitting a hard surface. Her initial idea was to 3-D-print the dress—she was, after all, the first fashion designer to send the technology down the runway, in 2010, for a top that looked like several interlocking pairs of ram's horns, which van Herpen calls "a fossil-like structure." But the Water dress as she conceived it wasn't possible to make—3-D printing technicians hadn't yet developed a transparent material that could print reliably and maintain its structure. Sometimes, van Herpen says, "I imagine a technique or material that doesn't exist yet. Sometimes it works, and sometimes it doesn't." She settled instead on a relatively low-tech method, using a hand-held heating tool not unlike a blow-dryer to soften a sheet of polyethylene terephthalate, a material she says was the "30th or 40th" she tried, and then manipulated it with pliers and by hand to her desired shape.

Part of what makes van Herpen's approach so novel are the partnerships she forges while designing and executing her otherworldly visions. For a collection called Magnetic Motion, inspired by a visit to the Large Hadron Collider at CERN, in Switzerland, where she learned about forces of attraction and repulsion, she teamed up with architect Niccolo Casas and the California-based company 3-D Systems to finally print a transparent "Ice" dress. The dress is all Sugar Plum Fairy, an ice sculpture's best impression of lace. "I spoke to the technicians, and they said, '99.99 percent, it's going to fail,'" van Herpen recalled in an interview with the High. "We



The "Snake" dress, for van Herpen, recalls her state of mind before doing a free-fall parachute jump. "All my energy is in my head and I feel as though my mind is snaking through thousands of bends," she has explained.

really pushed the technology, even into a stage where no one believed in it." The dress was ultimately "printed" using an industrial-scale process called stereolithography and a unique photopolymer-resin blend that had never been used before.

Each of van Herpen's collections is conceptually coherent and technologically eclectic. The Biopiracy collection was inspired by van Herpen wondering what it means to live at a time when our very genes can be manipulated and patented. It included ensembles that evoked flesh and scales, seeming alive and suggestive of grotesque genetic manipulation. One sweater looked like a cocoon-emergent mutant woolly bear caterpillar, the dark, fuzzy crawler famous among farmers for predicting the weather. The collection's cornerstone "Kinetic" dress, a collaboration with designer and artist Julia Koerner and 3-D printing company Materialise, was made from silicone-coated 3-D printed feathers, which were laser-cut and stitched to the dress; it made the model wearing it look as though she'd developed a thick set of wings that danced, wisp-like, around her body as she moved. For several designs, van Herpen worked with a nylon-silk weave commonly called "liquid fabric" because it looks like water. The show itself was full of visual high jinks: Models in silvery dresses, curled up like embryos, floated in plastic bubbles suspended along the side of the catwalk, a collaboration with the installation and performance artist Lawrence Malstaf.

A recent collection called Hacking Infinity was inspired by the human quest to live forever at a moment when we are confronted with the dwindling (some say plundering) of natural resources and the promise of life-extending medicines and, potentially, colonizing other worlds. "The idea of terraforming," van Herpen says, of the concept of manipulating a foreign planet's ecology to sustain human life, "opens up a whole new world of possibilities to me." The collection included large circular dresses meant to call to mind planets. Van Herpen worked with a long list of collaborators, including the Canadian architect and designer Philip Beesley, known for his large-scale artworks that integrate synthetic biology, engineering and advanced computation to create "living" sculptures that interact

"The designs, setting and music put the audience in a dream-like state, and models appeared as ghosts behind 17 large optical light screens," Vanessa Palsenbarg, a blogger at 3-D printing company Materialise, wrote of van Herpen's Lucid show at Paris Fashion Week in March. Van Herpen has worked with Materialise on several collections, including Lucid.

with viewers. For one dress, van Herpen created an ultralight weave of stainless steel, which she then hand-burnished to create shades of orange, yellow, purple and blue, evoking the colors of interstellar nebulae.

Beesley described their collaborations as focused on finding the best techniques for fabricating individual components. "The dialogues are on the one hand practical—laser-cutting and clipping or adhesions or thermal processes," he said. Vanessa Palsenbarg, a representative of the 3-D printing company Materialise, wrote in an email that these collaborations can take on a life of their own, "to inspire our other customers—in the automotive, consumer goods, aerospace and other industries." Beesley, too, believes their value goes beyond exploding the conventions typically associated with fashion design by using cutting-edge techniques and materials. "The fertility of these dialogues is that friends in multiple disciplines are exchanging ideas and opening the sense of what the applications can be," he went on. "What could a dress be? What could clothing offer? It is a wondrous meditation on how we relate to other people, and to the world." O

Van Herpen's work can be seen in two shows overlapping this month: "Iris van Herpen: Transforming Fashion," a retrospective of her work at the High Museum, will run until May 15. "Manus x Machina," a show exploring how designers have reconciled innovations in machine-made clothing with craftsmanship and handiwork, opens May 5 at the Metropolitan Museum of Art in New York.

SCI-FI GETS real

NEXT STOP MARS

NASA's Dava Newman explains just how close we are to sending astronauts far, far away

BY KATIE NODJIMBADEM

PHOTOGRAPH BY JARED SOARES

Dava Newman's light blue eyes gleam as she regards a model of the most powerful rocket ever to come off a NASA drawing board. She places it on the coffee table in her stately sun-filled office at the agency's headquarters in Washington, D.C. "Orion's this little part on the top. All the rest is the heavy lift launch system," she adds with a chuckle.

The 18-inch-tall white plastic spacecraft model looks like something you might find in a hobby store, but it embodies the nation's greatest ambitions: Orion is the capsule that, if all goes according to plan, will take four people to Mars in the 2030s. It sits on a massive new rocket, known formally as the Space Launch System. In its initial iteration, the SLS will be 322 feet tall and 15 percent more powerful than the Saturn V rocket, which powered the Apollo missions to the Moon.

The reality of traveling 250 million miles is still so mind-blowing that it makes even one of the officials tasked with getting us there almost giddy. But NASA is already deep into the engineering phase of how to get to the Red Planet. "We're living it," says Newman, who was a professor of astronautics and engineering systems at MIT before she became NASA's deputy administrator a year ago. "That's what the future is. It's now for us."

In an interview at her office, Newman talked about what the agency officially calls the Journey to Mars. She allowed that a great deal of R&D has been achieved, what with 15 years of experience aboard the International Space Station. "That's been hugely important, because we're studying astronaut performance," she says. Yet there's no denying that living aboard the space station is only a beginning, given that the orbiting habitat, a few hundred miles away, is, in space-exploration terms, "Earth-reliant."



Newman says NASA, which has had five partners from 15 nations on the International Space Station, is seeking more collaborators, both international and commercial, for the Journey to Mars: “It’s kind of an open call. Who wants to go with us?”

Just over the horizon, though, is the next big step into "cislunar space," the area between Earth and the Moon, which is some 239,000 miles away. "You're still Earth-reliant, but you're in deep space," Newman says. "We call that the Proving Ground," because the journeys will be farther and last longer, and the technologies will have to get more and more sophisticated. "That's the game-changer." In 2018, NASA hopes to launch the SLS and Orion together for the first time, though the capsule won't carry any people for Exploration Mission-1, a three-week trip that will take the spacecraft 40,000 miles beyond the Moon and back to Earth. Exploration Mission-2, when astronauts will travel into deep space in the Orion capsule, is slated for the 2020s.

Among the countless tech challenges that must be met before people can safely go to Mars (and back) is that of protecting astronauts from both cosmic and solar radiation, which in deep space are more potent and thus more harmful than what they encounter even over long periods aboard the space station. So researchers are designing new radiation-shielding spacesuits (Newman herself achieved a measure of geek fame for designing a new spacesuit before joining NASA) and habitats. Another problem way out there, of course, is the lack of stations in deep space, so the agency hopes to develop a solar electric propulsion system for deep-space flight.

If there's a job that sounds more science fictiony than that, perhaps it's manhandling an asteroid, a chore that, NASA insists, will yield useful new information about docking spacecraft, collecting extraterrestrial samples and moving multi-ton objects in space. This September, the agency is scheduled to launch a robotic spacecraft, OSIRIS-REx, which will fly to within a few miles of a near-Earth asteroid named Bennu, map it for several months and then get close enough to extend a robotic arm to gather a few ounces of surface material, which the craft will return to Earth by 2023. That sample is expected to contain new clues to planet formation and the potential impact of asteroids on Earth, but Newman also notes that "robotic capability is critical to the future and our whole Journey to Mars."

A subsequent mission, scheduled for late 2021, might remind movie buffs of *Armageddon*, the 1998 disaster thriller: A robotic spacecraft will make contact with an asteroid, pos-

sibly one named 2008 EV5; remove a boulder weighing more than ten tons; and maneuver the boulder to the Moon's orbit. An astronaut crew will fly to the boulder and collect samples for examination on Earth.

By the 2030s, Newman says, NASA should be poised. "We'll get to Martian orbit first, safe to say," she suggests, or perhaps to a Martian moon, "and then the absolute goal is boots on Mars." For such a voyage, measured in years, astronauts will have to become Earth-independent, devising ways to make fuel, water, oxygen and building materials with whatever resources the Red Planet offers. If that seems as fantastical as Matt Damon growing potatoes in *The Martian*, Newman shrugs: Astronauts have dined on lettuce and peppers grown aboard the space station.

"Successful exploration in human history—that's how it's been accomplished," she said. "You take what you can with you, but you have to make things and be self-sustaining." O

SCI-FI GETS real

HOME AWAY FROM HOME

A Nevada real estate magnate has poured $290 million into a wild dream of being a landlord in outer space. His first tenant: NASA

BY CHARLES FISHMAN

PHOTOGRAPHS BY DAN WINTERS

Bigelow's mock-up of the Olympus, an expandable module with twice the interior space of the International Space Station.

Robert Bigelow is rocked back in a sleek office chair. He's in a dark room with a double-high ceiling, his face illuminated by the glow from two walls of video monitors, each wall three screens wide and three screens tall. This whisper-quiet space is Bigelow's mission control. The real deal. Four of the nine screens on the front

wall are tracking his first two spacecraft as they orbit Earth—each more than 300 miles high, each moving 4.7 miles a second, a brisk 16,990 miles an hour. Those two spacecraft are unlike anything launched before they went into orbit a decade ago—or since.

To go with his mission control, Bigelow has a network of ground tracking stations. He's got an immaculate factory with room for three production lines, ready to crank out spacecraft.

Bigelow has a mane of swooping silver hair, a face well-worn by seven decades of living in the Nevada desert, and a quietly nurtured obsession with space. Bigelow has hundreds of millions of dollars to spend, and he's got technology that's so proprietary his staff keeps active sections of the factory curtained off so visitors don't walk off with any secrets.

Bigelow has a NASA contract and a spacecraft scheduled to be bolted into place on the International Space Station at the end of May.

Robert Bigelow is ready for you to live in space.

He's even got a rack rate: Want one-third of a Bigelow space station for a month? $30 million, a million bucks a day. If you want more than a month, if you want the whole module, he can give you a better deal. In fact, Bigelow lacks just one thing. "Right now," he says, "we have no customers. None. And that's very frustrating."

Bigelow is a step ahead of much higher-profile space entrepreneurs, a step ahead of Elon Musk and SpaceX, of Jeff Bezos and Blue Origin, of Boeing and even a step ahead of NASA. He's ready to create space destinations—laboratory? observatory? factory? transit hub? resort? What he lacks is a good way for people to get to those destinations. So he's waiting. "I do have patience," he says impatiently. "I can exercise substantial patience when I need to."

There's a lot of talk about how Musk or Bezos will soon revolutionize space, but two things are true: They're just working on the transportation part, and their technology isn't going to fundamentally change the way we go to space. It will just change who we pay for the ride, how much it costs, and—Bigelow is sure hoping—who can afford to go for a ride. Bigelow is a better bet to trigger a much more fundamental revolution—changing how we live and work in space, who can afford to set up an outpost, what there is room to do.

Bigelow is a surprising character to shake up the half-century-old world of space travel. He's not an engineer or a scientist. He was born in Las Vegas in 1944, around the time the city was opening its first casinos, and he's lived there ever since. He's got a sinewy self-sufficiency that carries an air of the frontier. He seems more likely to be introduced as a sheriff in rural Nevada than an aerospace innovator.

As a young man, Bigelow began building a real estate empire focused on short-term lodging for the waves of people moving west. He founded a low-priced extended-stay motel chain called Budget Suites of America, and he owns thousands of apartment units across Nevada, Arizona and Texas. His real estate business is still active, though he sold 4,500 units in 2005, 2006 and 2007, cashing out of a huge slice of his portfolio just before the crash, which hit Nevada particularly hard.

Why'd he get out right then?

There is the hint of a smile. "People were going berserk trying to throw money at you and buy your properties. It tore me up—I just couldn't bear the distraught expressions on their faces. I sold out of the goodness of my heart."

Bigelow likes to be immersed in the details of his business. Off the top of his head, he knows the average time people live in his 7,158 remaining apartment units: "One year and three months." The buildings, the facilities belong to Bigelow. The customers come and go.

Around 1999, Bigelow read a magazine article about the TransHab, a soft-sided spacecraft that had been defunded by Congress, apparently for a combination of budgetary and political reasons. Bigelow had been looking for a way into the space business. He tracked down the people at NASA who had worked on TransHab and started to figure out how he could license the technology. "I thought, my God, this is an incredible idea," he recalls. "All we have now are metal cans that are no larger than the rockets they were launched in. That is so antiquated by comparison."

At the moment he saw the technology, he also saw the business: an extension of the one he was already in. Here were spacecraft inexpensive enough but also robust enough to open a whole new vista: room for lease, in space. "What I understand," he says, "is the marketing of volume and time."

Bigelow knew he wanted to go into the space exploration business by the time he was 12 years old. Although he has no formal scientific training, in the last decade he has been awarded about ten patents related to aerospace technology.



Bigelow is convinced that soft-sided spacecraft will play as important a role in commercializing space as rockets themselves. In the history of space travel, only a dozen nonprofessional astronauts have been to space, most rich businesspeople looking for a one-of-a-kind experience. Bigelow Aerospace's modules could finally make living and working in space so affordable that countries and companies would start sending up ordinary staff with a few weeks of training. The company is even planning to provide its own professional support-staff astronauts.

These days, Bigelow spends 95 percent of his time on Bigelow Aerospace. He has 140 employees there. "I'm lucky," he says, "that the real estate business has been able to supply the money that the aerospace company requires."

As pragmatic as he is, a streak of eccentricity runs through Bigelow's story. For years, he quietly funded research into extraterrestrial experiences and other kinds of psychic phenomena. Today, he hands out Bigelow Aerospace coasters with the Bigelow Aerospace logo on them—a rocket substituting for the "i"—and much larger, the artful image of a classic extraterrestrial, the wide, lidless eyes, the noseless face, the perfectly round head. That alien logo also appears on the side of the security vehicles at Bigelow Aerospace and on the outside of some of the factory buildings. Bigelow calls it his "mascot."

It isn't quite serious and it isn't quite a joke, either. Bigelow genuinely believes in extraterrestrial visitors. In a story he has told many times, his maternal grandparents had an encounter in the Nevada desert with a fast-moving, oval-shaped, glowing red object that forced them off the road. From 1995 to 2004, Bigelow funded something called the National Institute for Discovery Science, employing researchers to study a range of unexplained phenomena, including UFOs. "I look at the extraterrestrial subject as phenomenally interesting," he says, volunteering nothing more. Does he know something about extraterrestrials that typical people don't? "I've spent a lot of money doing extensive research. I've spent a lot of time doing extensive research. I hope I have information the average person does not possess."

Does the federal government know what he knows? "Absolutely."

Why doesn't he talk more expansively about extraterrestrials? "Because I don't have an agenda to publish this information, to expose it. And I have information that people

provided to me in confidence, and that has to be respected."

Still, compared with his serious efforts to build space outposts, those interests seem like the avocations of a man with enough money to give his curiosity a little running room. Bigelow might well have been a billionaire—until he spent $290 million developing the space modules. He launched the first two, paying the Russians to put them into orbit aboard intercontinental ballistic missiles that may have once been aimed at the United States, and built a factory to be ready to make modules to meet demand.

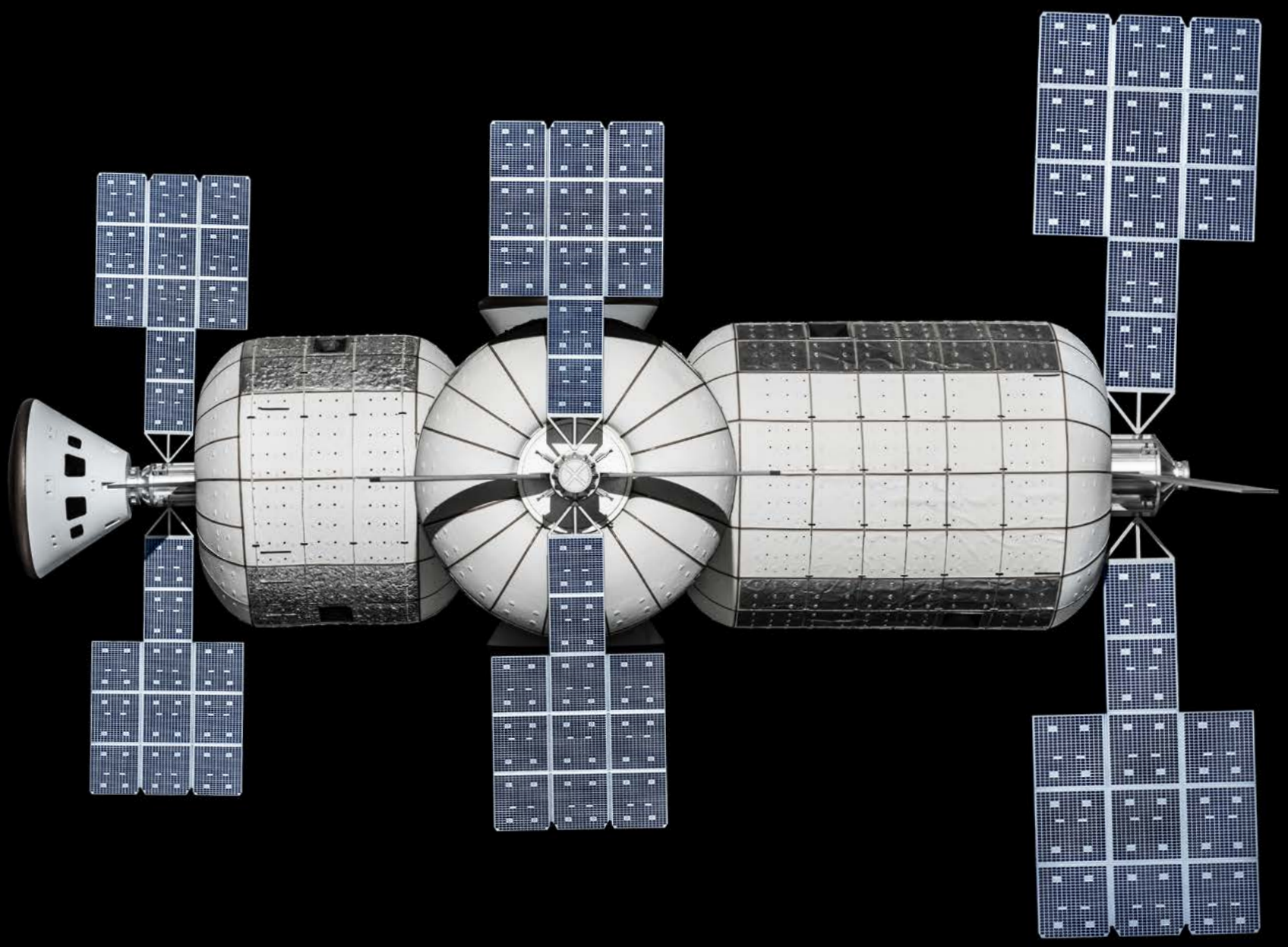
"He didn't talk too much about the extraterrestrials," says William Schneider, an engineer who started working at NASA in 1962 and who led development of expandable space modules inside NASA. After he retired in 2000 to teach at Texas A&M, Schneider helped Bigelow develop the first flight modules, including the two that are still in orbit. Schneider is impressed with Bigelow's focus. "He zeroed in on getting the engineering done—he was absolutely serious about that."

Schneider hasn't worked with Bigelow for years, but he's convinced expandable space modules will become a key element of space life. "It's the coming of the future. And Bigelow is the one gutsy enough to get on it, to put money on it and make it go."

In the earliest days of the space program, long before TransHab came along, NASA launched two inflatable satellites, Echo 1 and 2, which brilliantly illustrated the virtues of what were then called inflatable spacecraft. At liftoff, the Echo satellites fit into a pod little bigger than a modern recycling bin. In orbit, they blossomed into sparkling spherical satellites 100 and 135 feet across, each wider than two city buses and easily visible from the ground. Small weight, small space on launch, big volume in orbit.

But the Echo satellites were made of Mylar, which has all the durability of a birthday party balloon. They lasted years in orbit, but they were reflective satellites—they didn't need to hold pressure and temperature to protect equipment and people. In the 1960s, fabrics as thin as canvas but as tough as steel were a decade or two away. NASA, and the Soviet Union, focused engineering and imagination on hard-sided spacecraft, and "inflatables" were left on the shelf with other not-quite-practical ideas.

Fifty years into the era of space travel, we have an image of space vehicles: Sleek. Crisp. Engineered. Even the International Space



An artist's rendering of three interlinked B330s. Bigelow envisions joining these expandable modules together to create expansive space stations where people can live and work.

Station has a gangly geometry to it. You could draw it with a ruler.

So Bigelow Aerospace's soft-sided spacecraft—known as the B330—takes some getting used to. The exterior surface looks a little marshmallowy. Photos from orbit of Bigelow's first two spacecraft, Genesis I and II, show exteriors that look like rumpled white quilts. In the artist renderings and factory models of the B330, there's not an exterior edge anywhere—it's all curves and gleaming white fabric, with the look and feel of sailcloth.

Even NASA refers to the kind of spacecraft Bigelow is developing as "soft-sided" or as "soft goods." In fact, nothing could be more misleading. The spacecraft Bigelow Aerospace is engineering are pillowy the way a fully inflated football is pillowy. They are soft the way the tires on a 450-ton 747 gliding onto a runway at 180 miles an hour are soft. Says Glenn Miller, the

principal investigator for Bigelow's technology at NASA, "It's 'inflatable,' but it's not like a kid's bouncy castle."

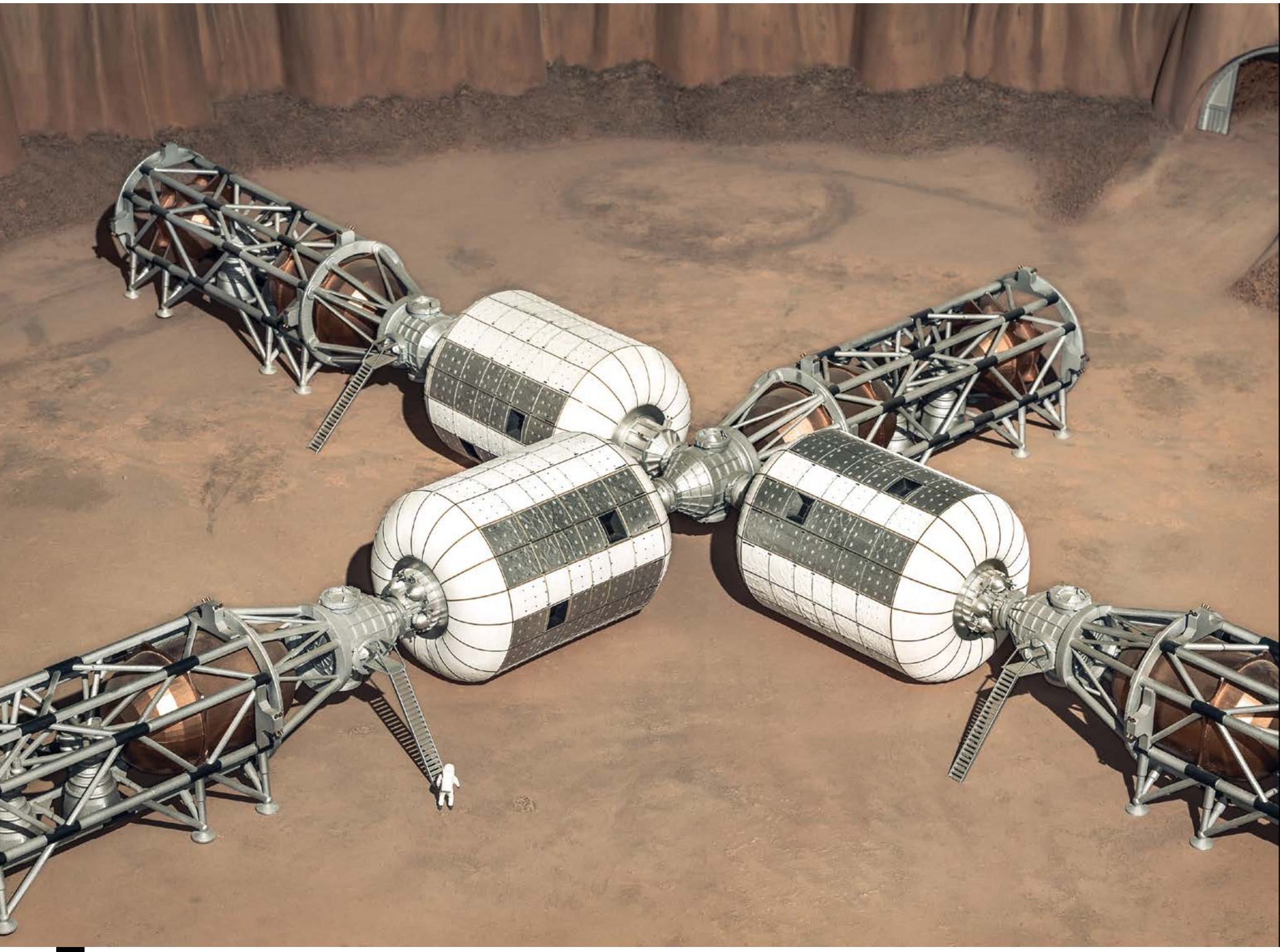
"If you were to float into one of these modules in orbit and rap on the interior with your knuckles, it would feel like you were rapping on the inside of a fiberglass boat hull," says George Zamka, a former Marine combat pilot who flew space shuttle Discovery in 2007 and commanded space shuttle Endeavor in 2010. He worked for Bigelow for 14 months, developing training and procedures for the people who might ultimately staff Bigelow space modules. If the Bigelow space modules don't look like what we think of as "space-age" habitats and vehicles, says Zamka, "it's just because it's not what we're used to seeing."

For launch, a B330 can be compacted to ride on an Atlas rocket. How spacious is it? It took 41 shuttle launches to put into orbit the hardware for the International Space Station. The station has 900 cubic meters of interior space. Each B330 has a habitable volume of 330 cubic meters. In other words: Launch three, fully assembled, aboard inexpensive Atlas rockets, and you've got more working and living space than aboard the $100 billion station, which took a decade and 159 spacewalks to construct. That's the prospect that captivated Bigelow.

The holdup, for now, is finding rockets to launch paying passengers into space reliably and inexpensively. Except for the Russian Soyuz—which is dependable, but expensive, inconvenient and mostly booked—there are no rockets available to put people into orbit. The shuttles are in museums, NASA hasn't successfully replaced them, and SpaceX and Boeing have yet to launch astronauts on their new rockets. Is there any point building destinations if there is no way to get to them?

"At this point," he says, "Bigelow Aerospace is close to philanthropy." When he started the company, he was 55. The way things look now, SpaceX may not have routine crew transportation available until he's 75. Bigelow has brought onboard his granddaughter, Blair, a freshly graduated MBA from Southern Methodist University, to learn the business. "She's my retirement plan," he says.

Bigelow's impatience is visible in the sprawling 365,000-square-foot factory space of Bigelow Aerospace in North Las Vegas. Here's a robotic metal fabricating machine methodically cutting a space-rated bulkhead for a B330 module out



Bigelow wants to see his modules used to travel through space and then converted into habitats. This rendering shows a base created from B330 modules lowered to the surface of Mars.

of a disk of aluminum 12 feet across. Why is Bigelow making expensive, highly engineered components for a space habitat no one will need until at least 2018? Practice.

"We're going to make all these parts several times, so we know how to do it," says Bigelow. They make parts, they test them, they break them, they make more parts.

"When someone wants a B330," he says, "we will have made them. We'll know what we're doing."

The materials used to make the spacecraft hulls are high-tech, and the engineers at Bigelow Aerospace have spent a decade fine-tuning how to layer them to provide shape and structural firmness, and protection from micrometeorites and radiation, while they remain workable. The company has never released even a schematic diagram showing a cutaway of the

layers in the fabric. “Proprietary,” says Bigelow. “We know more about this material, these techniques than anyone in the world,” he says. He’s not giving those hard-won insights away.

Some of the layers of fabric—there are about 20 of various materials, he says—have to be stitched together by hand. And what about the packing? How do you fold all that high-tech fabric so it fits in a rocket and then unpacks into a fully ready space station when you get in orbit?

“I’m not going to talk about the folding,” says Bigelow. “Proprietary.” He’s got the expression of a man who has tried to figure out how to roll up his high-tech tent and get it in the stuff-sack, unsuccessfully, many times.

“We’ve been working on the folding since 1999.”

When NASA first developed the TransHab, it was tackling a very specific problem. “We were asked to develop something that could go to Mars,” says Schneider. The requirement was 600 cubic meters of space, enough for six people and their supplies. The size was only part of the issue. Whatever you send into space has to be strong enough to endure the incredible forces of launch. That means giving walls a thickness and stiffness that add a huge amount of weight. “To make something that big out of aluminum, it gets so heavy, you need a whole other vehicle to launch it,” says Schneider.

Schneider says it took his team of ten people about six weeks to come up with the expandable concept: An interior core, like a horizontal elevator shaft made of aluminum trusses, would contain all the spacecraft’s vital electronics and systems, and an inflatable exterior shell would expand on orbit. The group’s first testing at the Johnson Space Center showed that, even with the materials available 16 years ago, their layered fabric was more resistant to micrometeorite punctures than the aluminum skin of the current space station modules.

In the decade and a half since Bigelow Aerospace licensed the technology from NASA, its engineers have been awarded more than a dozen patents for their own development work. NASA is now paying Bigelow $17.8 million for a custom-designed mini-module called BEAM (Bigelow Expandable Activity Module) and launching it to the International Space Station on a SpaceX Dragon rocket. One of the big reasons

NASA is docking this module to the space station is to find out exactly how durable it turns out to be in space—in terms of micrometeorites, but also in terms of radiation, temperature and pressure.

BEAM is about one-twentieth the size of a B330—its interior volume is about twice that of a Honda minivan. It will fly to space almost completely bare on the interior—no windows, no avionics, no electrical or life support systems, no pre-installed lights and no temperature control, just some air ducts, foot restraints and the insulation provided by BEAM's six-inch-thick layered hull.

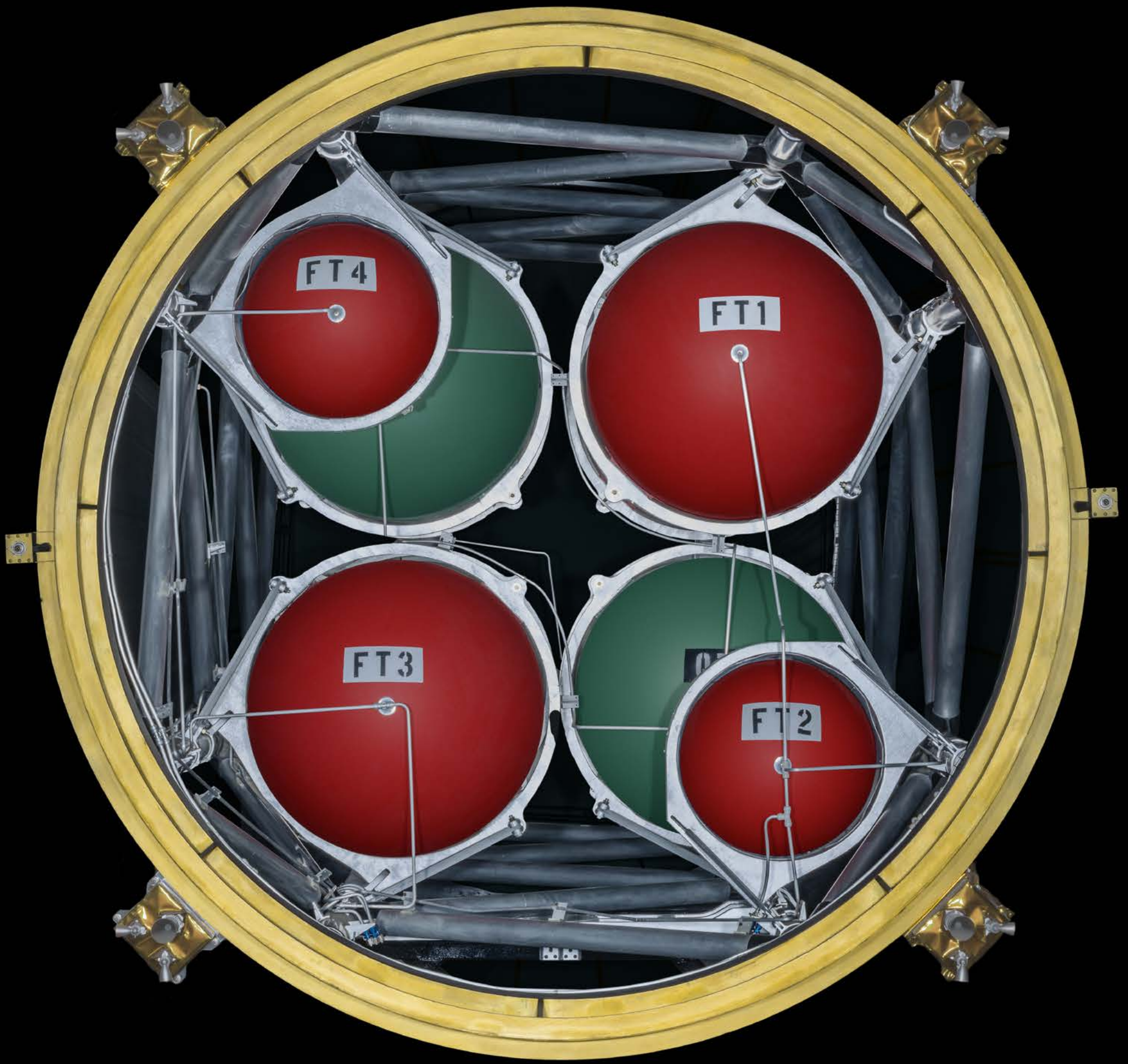
NASA is very careful about flight hardware that will be used by people. For now, its scientists just want to see how the main structure performs under real spaceflight conditions. BEAM will be the only working module attached to the station in 15 years to be kept sealed—not to actually be used, just tested. "If something happens," says Rajib Dasgupta, NASA's BEAM project manager, "if there's a catastrophic leak, those two air circulation valves close automatically. And we could jettison it immediately."

Astronauts are set to visit the interior of BEAM to check sensors and download data twice every six months. They might, in fact, find BEAM to be an appealing, quiet hideaway spot—free of the noisy fans and the always-on video cameras in the rest of the station. And that would be fine, says Dasgupta, but it wouldn't be encouraged. "It's a temporary habitat," he says. "A demonstration habitat. It doesn't have any circulating fans, it doesn't have any fire protection."

According to Jason Crusan, the director of advanced exploration systems for NASA, "Our entire effort with BEAM is to bring our level of knowledge up on soft-sided structures as close to parity as possible on a single flight."

Already, BEAM has presented unexpected complexity. Space is the land of pure Newtonian mechanics and BEAM is being launched folded to one-quarter its flight volume. When air pressure expands it to full size, it will push against the International Space Station, potentially putting all that load on the docking port connection. "When we analyzed the rate at which the gas would come out of the tanks," says Dasgupta, "it was imparting a lot of load to the space station." Now, BEAM will be inflated more slowly and the module will be outfitted with shock absorbers.

The core of the never-launched Genesis III. “It was a backup,” says Bigelow. “I wasn’t expecting success with Genesis I and II.”



For Bigelow, BEAM could be regarded as a step backward. The expandable space modules he launched a decade ago—the Genesis I and II—weren't designed for human use, but they were autonomous, with solar cells, and filled with avionics and equipment. Comparatively, BEAM is an empty shell—after a decade of work and waiting.

Except for two things. Bigelow says his engineers have reworked and improved the layering. The BEAM hull has layers of Kevlar, the fabric strong enough to stop bullets, and Vectran, another artificial fabric, which is two times as strong as Kevlar. Vectran was used for the airbags that cushioned Mars rovers when they landed on the Martian surface. BEAM's hull is six inches thick; the shell for the B330 modules is 18 inches thick.

The second thing that is different now is NASA. If you're aiming to provide orbiting Moon stations, if you envision providing a soft-sided, roomy spaceship for the trip to Mars, NASA is going to have to be very comfortable with your competence and rigor. Robert Bigelow has no trouble being blunt—he thinks the nation's space program is adrift. "It's at a crossroads," Bigelow says. "It needs to acquire a strong direction." But asked about BEAM, he is nothing but grateful. "We got the opportunity to work with NASA on a spacecraft," says Bigelow. "We made a lot of friends, we worked with people we have come to highly respect. And we hope to be working with them on other programs.

"If things work out," he adds, "we're going to be the landlord on a lot of future systems. The point for us is to allow NASA to get comfortable with it."

Bigelow is hoping that expandable space modules prove to be a turning point—liberating people from what has for half a century been a frankly cramped, tunnel-like space-travel experience.

There is a perfect if slightly inverted comparison. A hundred years ago, steel girders permitted the construction of spacious skyscrapers. That's what Bigelow thinks expandable spacecraft will do for extraterrestrial landscapes—create structures that make it routine to live and work outside Earth's atmosphere. He wants us to finally stop camping in space and really move there. He has a very clear plan in mind. He's not planning to sell B330s. "We want to lease them," he says. "It's just like if you build an office building." He may launch them in linked units of

If Bigelow's modules don't look "space age," says one former employee, "it's just because it's not what we're used to seeing."

two or three, running them like an office park. The key, he says, "is, we don't want you to have to write a big check."

In some ways, he imagines B330s being run like sophisticated research vessels. He'll provide the platform and also an onboard crew to operate the space station; you'll lease space to do whatever work you want to do.

Beyond NASA and the corporate world, Bigelow has his eye on the literally dozens of countries that would like some kind of presence in space, but don't have rockets or the money to create spacecraft. Seventy nations claim to have a space program, though "most of those have never flown anybody," says Bigelow. But at $1 million a day, almost any country could have a space presence.

And Bigelow has adopted the original goal of Schneider's TransHab development at NASA: He wants the B330, or its successors, to be used for transportation to the Moon and to Mars. Once there, he wants them to be immediately repurposed as initial habitats. "You get the modules into low-Earth orbit," says Bigelow, "and then you can assemble metal frameworks around them. You attach propulsion tugs to the metal frameworks, and you can send them to the Moon or to Mars as if they were rockets."

Getting the B330s safely onto the surface will require retro rockets and internal floors. But none of that requires technology, or even assembly techniques, that haven't already been developed.

Inside the Bigelow Aerospace buildings, for instance, the models of Moon modules have tubes draped across them. "Those tubes are filled with regolith," says Bigelow. Regolith

is simply the sand on the surface of the Moon. He envisions astronauts filling the empty tubes with regolith, protecting the spacecraft like low-tech Moon sandbags. “They are a great insulator, and also provide radiation shielding,” he adds. He has a patent on the idea.

All in all, the man who wants to be the first space landlord is frustrated but not discouraged. “I’m a businessman,” he says. “The future of space is going to be commerce. It has to be. Like everything else in the world, if space is going to be sustainable, it has to be commercially viable.”

The success of people like Elon Musk and Jeff Bezos, he says, is the key. Space travel is waiting for the equivalent of its Model T Ford—or its minivan. “Then space can really be the kind of thing that writers have imagined for decades and decades, where we have thousands of people out there.” All paying rent to Robert Bigelow.

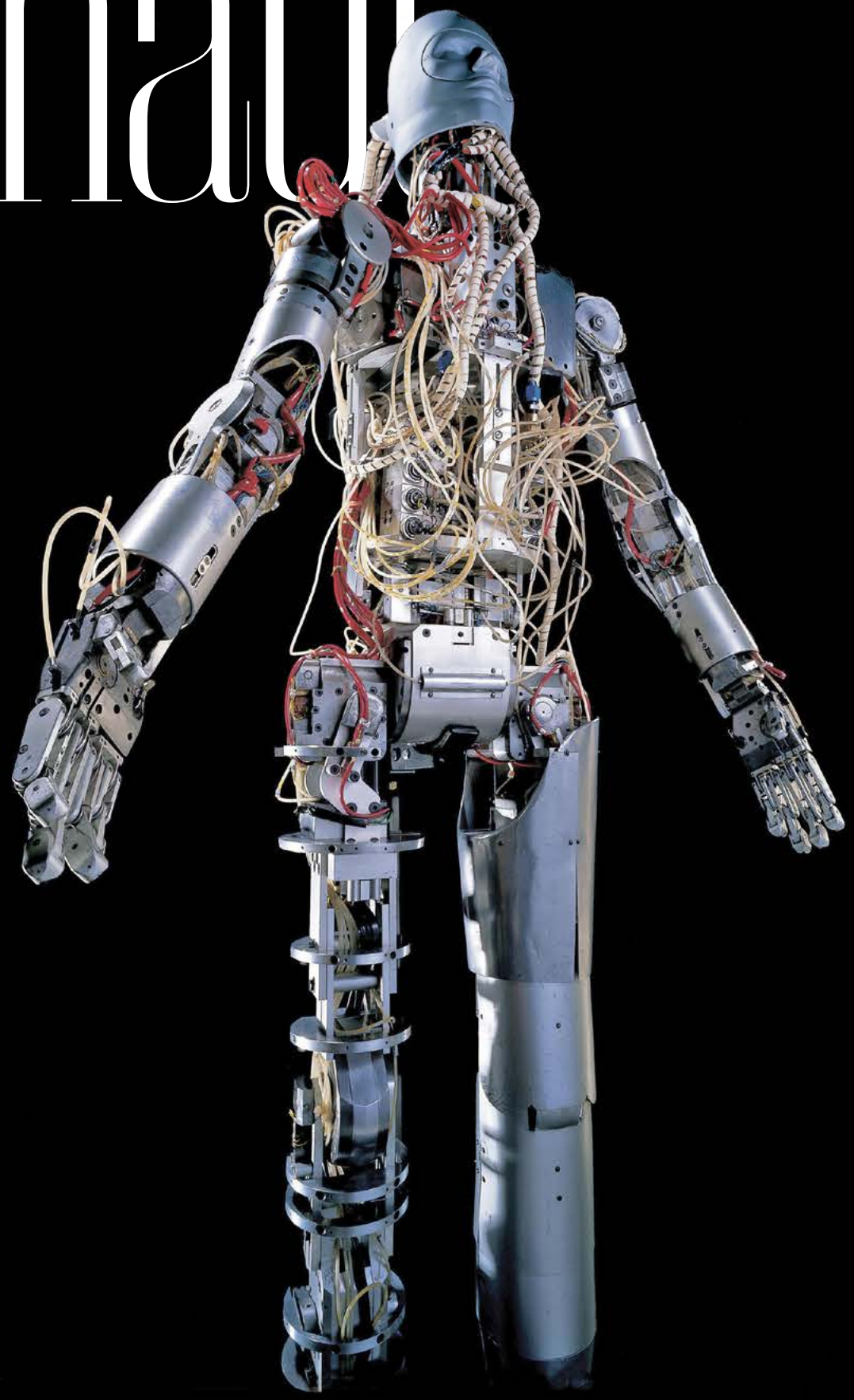
National Treasure

Model Astronaut

A cautionary tale about the android who just wasn't suited for the job

by Andrew Chaikin

PHOTOGRAPH BY
Eric Long



FROM THE SMITHSONIAN NATIONAL AIR AND SPACE MUSEUM

It looks so much like an intelligent robot that it hardly seems fair to call it a dummy. For decades it languished in a warehouse at the National Air and Space Museum's Paul E. Garber storage facility in Suitland, Maryland, and no one knew what it was. "It used to sit, covered with dust and filthy, in a sort of homemade chair, for years and years," says NASM curator Paul Ceruzzi. "Everybody, every day would walk past it and sort of chuckle at it. And it's like, 'What are we doing with this thing?' "

The mystery was solved when Mike Slowik, a businessman in suburban Chicago, contacted Ceruzzi. In the early 1960s, Slowik's late father, Joe, an engineer at the Illinois Institute of Technology in Chicago, created an articulated dummy for NASA, to test astronaut spacesuits. "From that moment on," Ceruzzi recalls, "I said, well, gee, this is actually pretty important."

In the early years of the Apollo program, NASA needed an objective way of evaluating different spacesuit designs. The problem was a human subject could offer only subjective impressions, says Joe Kosmo, a retired NASA suit engineer. "I can get in a spacesuit and say, 'Yeah, it's a little hard to move . . . to flex the elbow takes a little more force than that other suit that had the different elbow.' But I couldn't give you numbers. I couldn't tell you the range of the motion and the degrees."

Joe Slowik's creation was a hydraulically powered figure weighing 230 pounds, its height adjustable from 5 feet 6 inches to 6 feet 2 inches. Under its aluminum skin a network of nylon tubes circulated oil at a pressure of 1,000 pounds per square inch. The high fluid pressure powered the dummy's hydraulic activators to move the joints. During testing at NASA's Manned Spacecraft Center in Houston the dummy was suspended from the ceiling. Standing at a nearby console, an operator could turn knobs to make the dummy's 36 joints execute remarkably lifelike actions. Sensors measured the precise motion and amount of force exerted by each joint.

"It was impressive on the motions it could make, very humanlike motions," Kosmo recalls. In a filmed demonstration, viewable on YouTube, the android performs leg lifts and arm raises, runs in place, and swivels its hips like a slow-motion

Elvis Presley. It could even shake hands. But there was one nagging problem: It leaked. One of the great technical challenges had been that hydraulic valves small enough to use in the dummy couldn't be made sufficiently strong to handle the fluid pressure required to move the joints of a pressurized spacesuit. To contain the leaking oil, Kosmo dressed the dummy in a scuba diver's wet suit. But the problem was never solved, and the dummy never got to do its job.

"You couldn't place the dummy inside a one-of-a-kind spacesuit," says Kosmo. "Leaking oil would contaminate the suit. We didn't want to risk ruining a suit." (A single spacesuit would cost the equivalent of $750,000 today.) Kosmo believes that a solution could have been found. But under the looming end-of-the-decade deadline for sending humans to the moon, he explains, NASA's focus was, "how do you build a better spacesuit, not how do you build a better robot." Kosmo says NASA had already spent an amount equaling almost $2 million today on the project, and "you've got to draw the line somewhere." Sometime in 1967 Kosmo's boss told him, "Get rid of it."

But there was still hope for Joe Slowik's dummy to reach its full potential. By 1968 it had found a new home at Ohio's Wright-Patterson Air Force Base, where researchers in the bionics branch wanted to use it to create a true android. They planned to replace the dummy's hydraulic actuators with electronic ones. Most intriguing, they wanted to hook it up to a computer to create what they called a "learning machine." We'll never know whether they would have succeeded; the bionics branch was disbanded in late 1968. The dummy was later purchased at auction and donated to NASM in 1986.

If Joe Slowik was frustrated by the fate of his creation, he didn't let on. "He was very proud of it," his son Mike says. "In our family we referred to him as our long-lost brother, because my dad spent so much time working on the darned thing we hardly saw him for a year or so." Today, with a humanoid robot—NASA's Robonaut 2—aboard the International Space Station, it seems as if the descendants of Joe Slowik's articulated dummy are hard at work in the real world. ○

SCI-FI GETS real

READY FOR TAKEOFF

Drones and autonomous cars are fueling a transportation revolution. Your flying car is around the corner

BY JACK HITT

PHOTOGRAPHS BY JOHN LEE

In the last hangar off the runway in Prineville, Oregon, Sam Bousfield locked down one of the wings to his flying car. His engineer was busy burnishing the parabolic slope of the carbon-fiber finish. Bousfield handed me half a tail wing. It floated in my hand, light



A 1/4-scale model of the Switchblade flying car from Samson Motor Works. Its designer, Sam Bousfield, plans to take the vehicle into the air in June.



Bousfield (in a mock-up of the Switchblade) worked with Boeing engineers refining wind-tunnel construction before launching Samson Motorworks.

as balsa wood. “Eight pounds,” he said, which, for a structural component of an airplane, is almost nothing. Off in the far side of the hangar sat his original wooden mock-up of the chassis, a three-wheeled aerodynamic lozenge right out of a manga enthusiast’s idea of a speed racer. He encouraged me to climb in and get a feel for the feng shui of the driver’s seat, the view out the windshield, the sense of balance. But what he really wanted me to see was that this thing was real—that the flying car is no longer in that jetpack realm of promising technology that never quite arrives. “I expect to take this car into the air in June,” he said.

The idea of flying cars has lingered in the back of people’s minds for decades, thanks to synapses permanently fused upon first seeing the opening credits of “The Jetsons.” The fantasy has been stymied by a handful of problems. Or, as the former vice chairman of GM, Bob Lutz, told me: “It’s the eternal dream, and nobody has ever been able to make it work.” Lutz is a smart,

“Twenty years from now, I’d say, fully autonomous electric modules will be standardized so that they can be linked together,” says Lutz.

hilarious, cigar-smoking, gruff, anti-romantic skeptic whose view of this whole scene is why the English language has words in it like “harrumph.” He added, “You end up with the combination of a lousy car when it’s on the road and a lousier plane when it flies.”

But inventors like Bousfield are showing that they’ve begun to puzzle through some of the more vexing design problems that have kept this idea on the drawing board for decades. For instance, how do you stow the wings when you’re driving around town and yet keep your origami’d airplane from bulking up like some vehicular armadillo? In his first design, Bousfield engineered a retractable telescoping wing. But there was always that old problem: With lots of collapsing or folding, the smooth aerodynamic surface of the wing is compromised. Making it “roadable,” as flying car junkies call it, resulted in Lutz’s lousy plane. So working off the swing-wing design of an F-111 supersonic fighter bomber, Bousfield developed a full, aerodynamically sleek wing on a pivot that stows neatly and safely beneath the length of the vehicle. As a result, the prototype of Bousfield’s company, Samson Motorworks, looks like a supercool race car, with wings that spring outward from beneath the body at the press of a button, hence the name: the Switchblade.

And Bousfield’s not alone in searching for solutions to the problem. A century after Glenn Curtiss patented the Model 11 Autoplane (it never actually flew), around a dozen start-ups have jumped into the flying car competition. Sure, a few are little more than websites with vaporous computer-generated im-



With wings that slide beneath the body, Samson's Switchblade outperformed a Jaguar in acceleration road tests.



agery. But most have real venture capital, prototypes and marketing plans. One of them, Terrafugia, founded by former MIT aerospace engineers and based in Massachusetts, is already taking orders on its flight-tested Transition model—a 20-foot-long aircraft with a steering wheel, gas and brake pedals for driving, and a stick and rudders for flying. The Transition's wings fold up, as does part of the tail—it's a foot shorter on the road—and the whole thing will fit into a standard house garage. Still, you'll need a pilot's license to take it aloft, along with at least 20 hours of flight training. Although it looks quite at home in the sky, on the ground it suffers the bulked-out problem, ambling down the road like some monster cricket escaping Chernobyl.

Still, in the larger realm of the things that get us around town, everyone is suddenly busy—from garage inventors to Detroit designers to bike mechanics to Google programmers. It is safe to say that we are living through the most intense frenzy of transportation creativity since the 1890s, when brothers Charles and Frank Duryea's gas-powered buggy and Thomas Jeffery's Rambler began spooking horses in Manhattan. Back then, one might happen upon all manner of experiments on any street corner. In 1900, the gas-fueled combustion engine was just one more concept car. About half the automobiles were steam-powered, and most of the taxis in Manhattan were electric.

Likewise, today we find ourselves in the midst of a Cambrian explosion of experimentation, with self-driving vehicles, hoverboards, maglev trains, biomass-mobiles, electric bicycles, hydrogen-powered vans, flying car prototypes and manned drones. Hardly a week passes without a gee-whiz story about a new steppingstone to our transformed future: Uber's new R&D facility in Pittsburgh for autonomous vehicles, or a robotic new feature



Terrafugia's TF-X will fold helicopter rotors into the car's body for an aerodynamic update to its Transition model.

on a standard Detroit model ("adaptive cruise control," say, a combination of radar and engine control that maintains a car's position in traffic and keeps it in its lane) or some kind of sci-fi public transportation, like Elon Musk's fantasy of a "hyperloop" train that would propel passengers at speeds up to 760 miles per hour via outsized pneumatic tubes.

I originally set out to clear a path through the hype by identifying the precise technological hurdles standing between us and a flying car. But I immediately stumbled over a presumption that most of us make—that the current flurry of inventions is on some linear track of improvement that will gradually take us past our souped-up combustion engine cars, on to robotic electric vehicles, and then to the flying car.

After spending time in inventors' hangars, on the proving grounds of autonomous vehicles and even on my back, beneath a junker VW Cabrio I'd bought, I found that the contours of this revolution resemble a sort of traffic circle. So much depends on whether and when there are break-

throughs in artificial intelligence or energy efficiency or battery technology or even drone regulation. Any one of these off-ramps takes our transportation future onto a new path, and each involves a distinct set of philosophical dilemmas, cultural shifts and basic questions about how crowded we wish to see the roads around us and the sky above.

A few years back, I met a professor at Gateway Community College, where I live in New Haven, Connecticut. Tony Rish teaches vehicle engineering with an emphasis on alternative energy sources. I asked him how hard it would be to tear the combustion engine out of my crummy old VW Cabrio, replace it with an electric motor, power it with lithium batteries and charge those off solar panels on the roof of my house. In other words: Could I build a car fueled entirely off sunshine? "That's easy," he said. "More or less."

Rish is a mortar shell of a man, stout and ripped with the same weaponized head as Michael Chiklis of the TV show "The Shield." He radiates an amicably infectious passion for cars. So, one chill weekend afternoon in Rish's backyard garage in Middletown, Connecticut, we braked and chalked my Cabrio and spent most of a morning unhitching every connection in the engine bay. We wrapped the engine with sling belts and, deploying the magic of a winch, hoisted it out of there.

Afterward, we stood looking into the empty engine bay, ending the first of what became a year of weekends building a DIY energy-efficient electric car. I now run around town in it, and once I put up the solar panels to charge a battery pack—the kind Elon Musk recently announced Tesla will be manufacturing in Nevada—I will own a car powered entirely off daylight. The great American dream: a free ride, as long as you pay no attention to the $23,000 I've invested so far.

But the real reason I wanted to build this car is the same reason Sam Bousfield wants to build his, and, without sounding overly dramatic, it's the underlying desire in all these designs. (Maestro, cue the national anthem.) It's about a sense of freedom.

Bousfield's desire to build a flying car grew out of a collaboration with Steve Fossett, the adventurer and the first man to circumnavigate the planet nonstop in a balloon. They

"Flying cars will first become popular with the super-rich, but in time they'll find other uses—like Lutz's "autonomous, vertical-lift ambulances."

intended to break the land speed record with a Bousfield design, but that project ended tragically when Fossett died in an accident aboard a small plane. "At that point, I had to reset what I was doing," Bousfield said. "And I asked myself, 'What's wrong with aviation?'"

Planes get you places faster than anything else, he thought, but ultimately they're not that useful, "because when you get there, you're kind of stuck at the airport." Bousfield wanted to unchain himself from the prescribed geography of 20th-century air travel. My longing to be free of visits to the gas station and fossil fuels in general brought me back to Rish's backyard every weekend. The day I flopped onto Tony's creeper, rolled under the back end of the car with a reciprocating saw and started chopping out the muffler, I felt as if I were making a break for it, heading to some newfound land. I loved cutting out the big hard plastic gas tank to make more battery room. It resembled some fossilized Jurassic placenta. I dragged the whole heap out to the trash pile. A new car was being born, at whose core was a battery system charged off a regular outlet in my driveway and, soon, by sunshine.

Battery technology is engulfed in its own revolution, marked by routinely breathless press releases announcing new devices capable of storing massive amounts of energy in seconds, of charging wirelessly, of breaking through to holy grail-like technologies (a "lithium-air battery," for instance).

Mention big battery breakthroughs to Lutz, and the caustic exec turns into a tech-drunk evangelist. "Twenty years from now, I'd say, fully autonomous electric modules will be standard-

ized so that they can be linked together," he says. In Lutz's near-future, cars won't need much more than local battery range, because once they get on the freeway, they will automatically be assessed a toll for a charge. "There will be inductive rails embedded in the concrete or asphalt which will power that whole swarm of vehicles continually as they're moving down the freeway," he muses. "After you leave the freeway, your car will go the last 10 miles or 15 miles or 20 miles to your ultimate destination. And when you reach your destination, you get out, and your car will go to some sort of holding barn, where it will be recharged off of inductive current placed under parking spaces."

If the fast-charging hyper-electric vehicle is still a breakthrough away, the cars of today are getting smarter. Nearly every new model from most manufacturers now offers "self-parking," and some argue that new features on Toyota's Lexus GS, with automatic steering and acceleration, smart braking, robotic lane changing and radar monitoring of surrounding traffic, means that the driverless car is effectively among us. Same with Tesla's much-hyped "autopilot" feature, rolled out via a software update to its radar, sensor and camera-equipped Model S cars late last year: Already YouTube is rife with dozens of videos showing the car making its way robotically through real traffic.

Safety standards typically lag behind technology's pioneers, but the U.S. Department of Transportation recently signaled that rules of the road may soon be changing. The proposed budget for federal spending released in January included a near $4 billion line item for real-world testing of automated cars over the next ten years. Anthony Foxx, the Secretary of Transportation, has cited the need to speed up the deployment of autonomous driving and other new technologies that, according to his department's studies, could "eliminate 94 percent of fatal crashes involving human error." In January, he pledged that within six months there will be federal "guidance on the safe deployment and operation of autonomous vehicles," and many states have already legalized testing autonomous cars, including Nevada, California, Michigan, Florida and parts of Virginia.

What's more, younger generations aren't buying cars in the same numbers their parents did, and they don't feel that old 20th-century need to drive. Why buy a car when you can just summon an Uber or, as nervous Detroit executives say, "engage



The Ehang 184 weighs just 440 pounds despite its eight helicopter rotors, partly designed for redundancy.

mobility services"? A generation that can press a button to parallel-park will also see its driving abilities atrophy, and in time, insurance companies could require exorbitant rates for accident-prone manually driven cars, creating a ruthless market force that threatens to stampede old cars into retirement.

And would that be so bad?

In an immaculate car shed at Stanford's Dynamic Design Lab near Palo Alto, Chris Gerdes spends his days shuttling between his test tracks and his computer terminal. Gerdes is one of the leading engineers identifying novel problems facing autonomous driving and writing the code to solve them. He's a tall, cheerful guy with a Buzz Lightyear grin (and chin) who grew up in North Carolina near the Charlotte Motor Speedway. It's instantly clear that this is a guy who loves cars. Even his dad-mobile, a station wagon, is a stick shift. With his zeal for racing, Gerdes has been asking this question: Why not program

autonomous vehicles to maneuver like the finest human car drivers? At his outdoor track, Gerdes studies the skills of race-car professionals and then programs their best instincts into his robot cars' software.

Gerdes is excited to show me his latest acquisition—an all-electric lithium battery conversion car, just like mine, only the installation is not in a beat-up Cabrio but a mint DeLorean so spotless you could probably perform surgery in the motor bay. It also happens to be fully autonomous. "This is Marty," Gerdes says. "Multiple Actuator Research Test bed for Yaw control." Also in the car bay are Shelley and Trudy, robot cars that Gerdes puts on the track to test their outer limits.

Most store-bought cars are built for average drivers and favor stability over control: Many of us, it turns out, would rather have big, heavy clunkers without the maneuverability of light-footed race cars, even if it means we can't quite get around traffic or other obstacles as spryly as we might. "But expert drivers don't have the same hierarchy," Gerdes says. They regularly sacrifice stability for control in order to gain advantage on the road. Certain maneuvers may feel counterintuitive, and dangerous, to us non-daredevils—think of how hard it is to teach "turning into a skid"—but that type of reactive driving is exactly what Gerdes is programming into Marty, Shelley and Trudy. Cars designed with champion-level expertise, Gerdes believes, could eliminate entire categories of accidents.

Just getting down the street under normal conditions provides occasion for new ways of thinking. "Autonomous vehicles don't eliminate human error," Gerdes tells his students. "They shift it from the driver to the programmer." Say you are driving down the road and a child suddenly darts in front of your car. You might hit the child, or you might swerve, hit a tree and hurt or kill a passenger or yourself. Any bad outcome would be tragic, but it would also be chalked up as a "terrible accident." Lacking prior knowledge about the circumstances, you couldn't react on anything except instinct. But "how many of us would like to think about our most stressful driving situations," asks Gerdes, "and instead of solving those behind the wheel, would rather do it by sitting at a desk?" That's both the opportunity, and the burden, of autonomous driving.

The car's wings spring forward from underneath the body at the push of a button.



Part of what Gerdes does is huddle with a team that includes not just engineers and programmers but also moral philosophers, and what has emerged is an ethical framework, or set of decision trees. For instance, instead of asking, "What should a car do in Scenario X?" they ask a broader question: What is the car's responsibility on the road?

"The first rule is that the vehicle should obey the rules of the road and it should not cause an accident with somebody who is following the vehicle codes," he says. Then you have situations where another car is violating the rules of the road. So the next command becomes, "If I'm not going to harm the occupants of the vehicle and I can avoid a collision with other people who are doing the wrong thing, then the car should do that." And so on. Fans of science fiction might be feeling a bit of déjà vu, since, as even Gerdes admits, his programming rules sound a lot like Isaac Asimov's famous Laws of Robotics, written in 1942: "A robot may not injure a human being. . . . "

Still, there will come times when a car will be unprepared for how to react—maybe it unexpectedly encounters what it reads as a herd of elephants, which a person would quickly identify as a parade. Gerdes' current solution is for the car to safely pull itself over and turn over control to the "driver" by voice command or what is called haptic technology—a jiggle in the driver's seat.

That might take some getting used to, as will the entire gestalt of riding in such a car. Wirelessly connected vehicles, for instance, might travel at 90 miles per hour only a few feet apart—and might suddenly brake or accelerate in conjunction with the entire conga line of cars in constant and coordinated communication. Consider how you might react if your car suddenly speeds toward an oncoming vehicle only to veer within two inches of it before performing a Richard Petty-like maneuver to avoid a collision—all because it knew the physics of the moment well enough to save your life.

Ford has already anticipated this scenario, sort of. In March, the company applied for a patent called the Autonomous Vehicle Entertainment System, which darkens the windows, lowers a screen to block the front windshield and shows movies precisely so that occupants don't have to concern themselves with the vehicle's navigation and movement

in any way whatsoever. Gerdes expects people to get used to giving up control fairly quickly. “I doubt that people would necessarily need to get that acclimated,” he said. “If they’re happily in their automated vehicle, playing around with their iPad and the vehicle does something unusual, they might look up and say—‘Hey! What was that?’”

Of course, airplanes have long used “detect and avoid” sys-tems, and unlike cars they have three dimensions in which to maneuver. The objects that an aircraft has to anticipate, once it’s cleared takeoff, are mainly other aircraft, birds and weather. The technology to handle those, says Terrafugia’s co-founder and CEO Carl Dietrich, are practically off-the-shelf.

The more pressing technological hurdle for the flying car is taking off and landing. Terrafugia’s second-generation flying car, called the TF-X, will feature a vertical takeoff with helicopter rotors that lift the plane straight up in the air above tree and building heights to safe airspace, where a rear jet engine will propel it toward its programmed destination.

Instead of seeing human intervention as a mere safety net or transitional necessity, Dietrich has built it into his programming, believing that there are precise situations when quick advice from a human with eyeballs—even one without a pilot’s license—is invaluable. “People are very good at looking out the window and assessing, ‘It’s safe if I land here,’” Dietrich said. “For computers, it can be very hard.” If there’s any outstanding concern, the aircraft would be programmed to default to the nearest airport.

“I’d feel a lot safer in an autonomously piloted vehicle traveling through the air than I would in an autonomously driven vehicle on the road,” said Lutz, the automobile man who, when he was president of Chrysler, famously inspired a generation of dreamers with a concept car that redefined the SUV by driving a then-unheard-of thing called a Jeep Grand Cherokee up the stairs of the 1992 Detroit Auto Show and plowing it through a plate-glass window.

Bousfield, of Samson Motorworks, is already at work on a second generation of his Switchblade, also pilot-free, to adapt a military technique that permits extremely short takeoffs and landings. Using compressed air valves fired across the top of

the wing, the technology gives the plane up to four times more lift capacity, meaning that "you can safely touch down and take off from a parking lot," says Bousfield, who is collaborating on the project with researchers at Georgia Tech.

There is no question that flying cars will be expensive, especially at first, but, as Bousfield points out in his business plan, there are half a million licensed pilots in the United States and more than 800,000 outside of the country. And unpiloted flying cars, according to transportation analyst Roger Lanctot, will first find a keenly interested customer base among the world's growing super-rich, who are already looking for ways to escape the miseries of ever-increasing ground traffic. "Look at São Paulo, Brazil, add in security concerns, and that would be the only way to get around, if you are in a certain strata of society," Lanctot said. "That would be true in parts of the Middle East and India, to say nothing of Los Angeles and New York."

In time, as their novelty wears off and the technology becomes cheaper, flying cars will find all kinds of uses. "Say you have a major catastrophe and you have to get people to a hospital as quickly as possible," Lutz mused. "Wouldn't it be wonderful to have autonomous, vertical-lift ambulances where you could put four or five people on a stretcher, close the glass lid on them and within minutes the thing lands at a hospital?"

If the programming advances that have given us self-parking cars and adaptive cruise control continue apace, our roads may see fleets of autonomous vehicles by the 2020s, and using a smartphone app to fetch a driverless car from a nearby lot and provide door-to-door service will seem as routine as hailing a cab or getting an Uber. Recent documents filed by Google suggest that the electric car the company is developing may feature a work-around for the crummy battery storage of current cars. The company has partnered with Hevo Power, which develops cordless car-charging technology. A car would need only enough juice to get around town and to a designated highway—Lutz's dream—where wireless charging would keep the battery topped off even during a high-speed, driverless trip. If a breakthrough in battery or other energy-source technologies makes *flying* a driverless car over longer distances possible, the market could open up far beyond pilots.

And this is how the cultural shift happens. In our dreams,

> “Wouldn’t it be wonderful to have autonomous, vertical-lift ambulances where you could put four or five people on a stretcher, close the glass lid on them and within minutes the thing lands at a hospital?”

we civilians like to think in broad-stroke, science fiction terms. We believe the combustion engine car conquered the horse in one swift, technological, cinematic moment. The reality is that it took almost half a century, and happened incrementally, after lots of experimentation with alternative energy sources, early adoption by the wealthy of luxury cars and later by truckers with short-haul goods, and finally once the widespread paving of roads gave the combustion engine the edge over other means of long-distance travel. It’s natural to think of innovation as happening in some instantaneous transformative way, but the transition to our own future will likelier involve a great mix of evolving technologies—a transportation landscape populated with smart cars, autonomous cars and, muses Fernando Suarez, a professor at Northeastern University’s School of Business, “maybe flying cars for some longer distances, and much better public transportation, and a dedicated bike lane, too.” The revolution will come, but you may not notice it until it’s happened.

At the annual Consumer Electronics Show, held in January in Las Vegas, visitors and tech analysts were quick to notice all the vehicles. BMW showed off its AirTouch “gesture control.” The Faraday Future FFZERO1 “electric hypercar” had an iPhone slot in the steering wheel that would personalize the

car to your settings. There was Audi's new E-tron Quattro, with dual electric motors and promises of "piloted driving" via "swarm intelligence." (The electronics show is nothing if not a showcase for new buzzwords.) Mitsubishi had its Emirai, with 3-D display embedded in the windshield, side cameras to provide exterior views and a "telematics" system that uses real-time mapping data to alert the driver to road conditions ahead. VW's electric minivan, called BUDD-e, boasts an improved battery system with a nearly 400-mile range on a single charge. Toyota's FCV Plus has a hydrogen fuel-cell engine. The Aston Martin Rapide S is controlled largely by touch-screen. There was also a basic Chevy Bolt, an electric car with decent range whose most eye-catching feature was its cheap price: under $30,000.

One entry drew special notice this year, a prototype by a Chinese company called Ehang: a single-passenger craft with four quadcopter motors running on batteries. In other words, the first manned drone. Fully charged, the Ehang 184 currently provides 23 minutes of flying, although given the plus-or-minus aspect of any official battery time, I was in a full sweat just reading the specs.

But the Ehang 184 is a concept car, whose entire purpose is to put investors, customers and industry competitors on notice:

Unlike many other developers, Google has banished steering wheels from its autonomous cars—a regulatory obstacle.



A new class of unpiloted flying vehicle has left the drawing board. It's 18 feet long but can be folded up and sidelined in half a parking space. It flies up to 62 mph and can gain altitudes higher than 10,000 feet, far above infrastructural obstacles such as bridges and power lines. Looking at the vehicle made you start to ask questions. How safe is it? Do I want these things flying over my neighborhood? Would I put my child inside one? How much fun would it be to pop across town in an Ehang—how *easy*?

There is no control system, no pilot's joystick, no instrument inside the cockpit save a tablet for a passenger to plug in a destination before being whisked up and away. You could imagine climbing inside the glass bubble, and that's when you realize that the Ehang looks familiar: It's George Jetson's car, only better. You don't have to pilot it at all, and it's not a cartoon.

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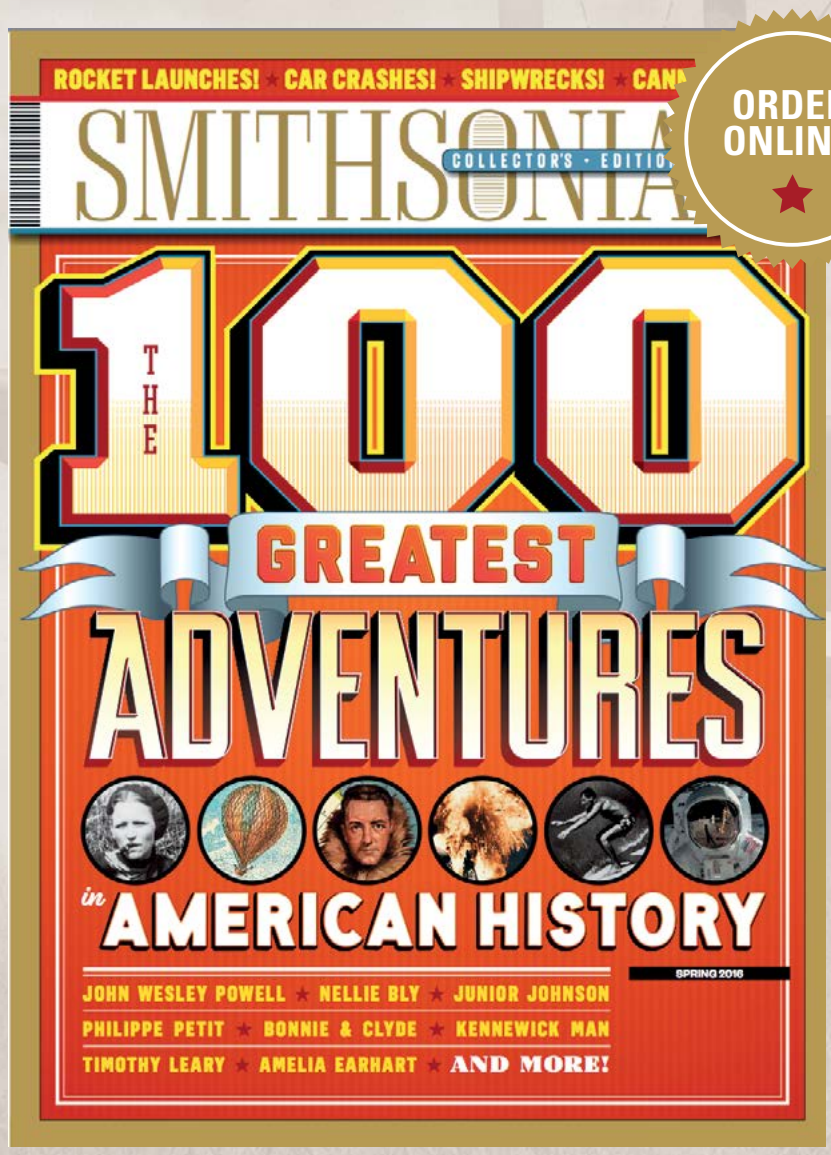

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YOUR QUESTIONS ANSWERED BY OUR EXPERTS

This month we invited former NASA astronaut **TOM JONES** *to be our guest expert. He flew on four space shuttle missions, and on the last one he led three spacewalks to install the U.S. Destiny Laboratory, the centerpiece of the International Space Station's research and command-and-control capabilities. He is the author of* Ask the Astronaut, *just published by Smithsonian Books.*

Which is more exciting—launch or re-entry?

For me, re-entry was unquestionably more exciting visually. During launch, our flight-deck windows were pointed up at the empty sky. During re-entry, these same windows revealed amazing views of the rapidly approaching Earth and the blanket of hot, glowing plasma that engulfed our ship as it collided with air molecules in the Earth's atmosphere. The light show lasted more than 20 minutes. And unlike launch, re-entry was completely silent and almost vibration-free, except for the last five minutes of buffeting as we slowed through the sound barrier.

What does an orbital sunrise look like?

The International Space Station goes around the Earth every 92 minutes or so, meaning astronauts see nearly 16 sunrises and 16 sunsets every 24 hours. Sunrises begin with the appearance of a thin indigo line along Earth's horizon, changing to a robin's-egg blue as the ISS heads toward dawn. A rainbow of colors spreads rapidly along the planet's edge, and then there's a brilliant burst of white light as the Sun's disk crests the atmosphere. The subtly glowing horizon explodes into white-hot sunlight in just about 30 seconds. Even digital cameras have trouble capturing the delicate colors and rapidly changing light levels.

How long does it take to recover from an extended trip to the International Space Station?

It takes four to six weeks to regain prelaunch levels of coordination, stamina and strength. At first, your arms and legs feel like lead; it took nearly all my strength to rise from my seat and exit the orbiter hatch with some welcome help from the ground crew. Balance is particularly challenging—it took about three days to recover my equilibrium. Two days after my Columbia landing, I tried to drive to the space center to review our crew's Earth photography. I made it to the end of my street, three houses down, before I hopped the curb trying to make my first right turn. I parked right there, walked gingerly back to the house, and asked my wife to drive me.

Would you journey to another world in space if you knew you couldn't come back?

Thank goodness that in the time of Columbus, Ferdinand and Isabella, and Queen Elizabeth I, colonists were willing to leave their familiar lives and search for new opportunities in the New World. If a colony on the Moon or Mars offered better opportunities for my family than here on Earth, I would like to think I'd have the courage to make the leap to a new world. In the long run, some of us will need to move to other worlds and colonize them, to ensure that humanity doesn't succumb to a terrible virus or comet impact. To survive, we must become a multi-planet species.

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