THE FUTURE OF MEDICINE

SPECIAL REPORT **CLIMATE CHANGE AND A NEW ERA OF INFECTIOUS DISEASE** PAGE 42

SCIENTIFIC AMERICAN

HOW THE DINOSAURS GOT LUCKY

They were confined to a few corners of the world for millions of years—until they caught some breaks

PLUS

DEEP-SEA MINING
Can we both exploit and protect the ocean floor? PAGE 72

MULTIMESSENGER ASTRONOMY
Light particles plus gravitational waves give a new view PAGE 36

OUR STUFF, OURSELVES
Why we get attached to possessions PAGE 66

ScientificAmerican.com

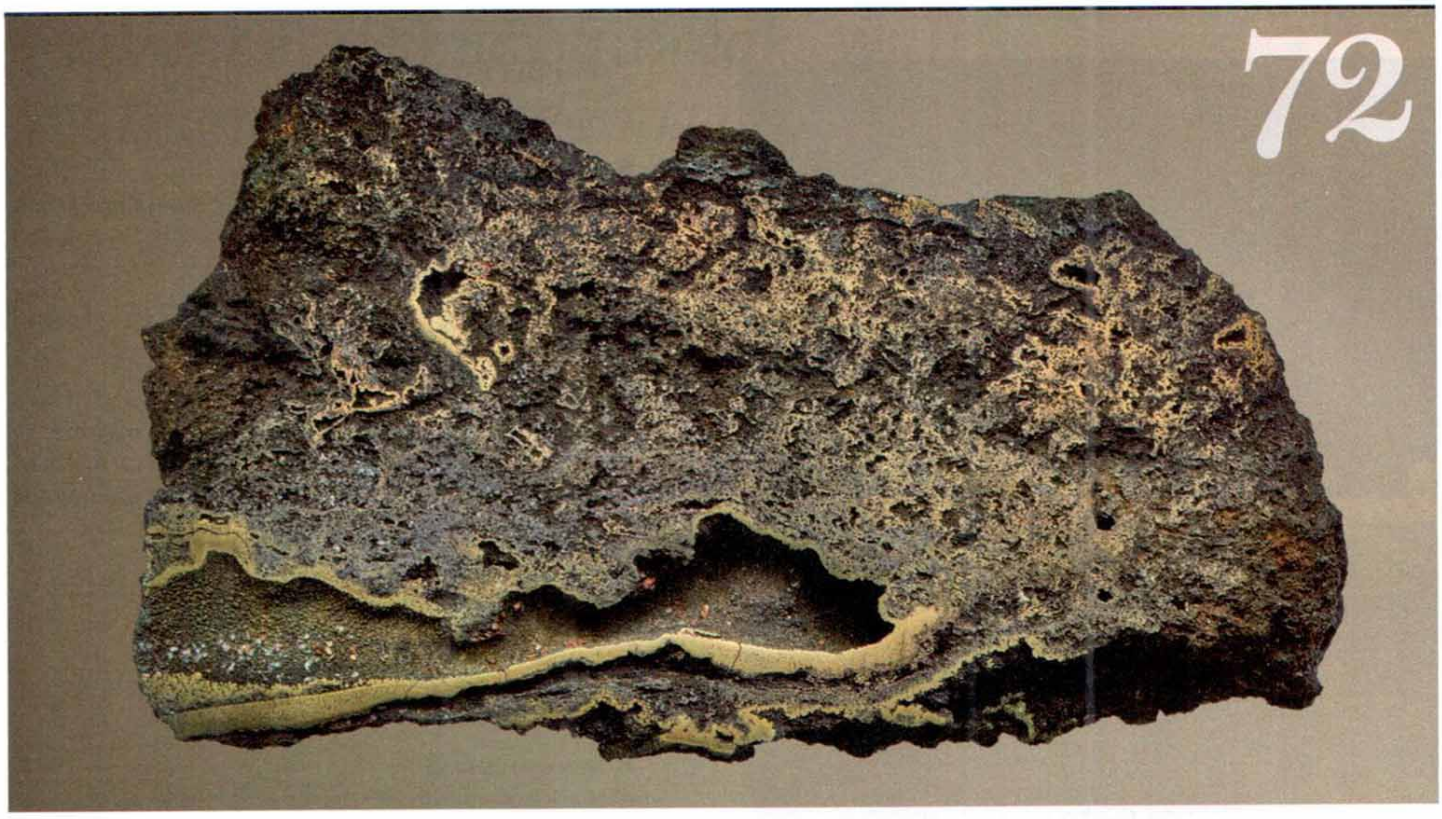
$6.99 U.S.

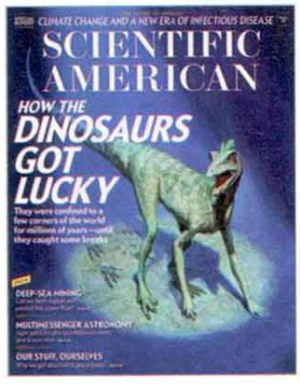
MAY 2018

MAY 2018

VOLUME 318, NUMBER 5

SCIENTIFIC AMERICAN





ON THE COVER

Prorotodactylus, a protodinosaur that was about the size of a house cat, steps onto the world stage in this artist's conception. The animal is known from 250-million-year-old fossilized footprints found in the Holy Cross Mountains in Poland.
Illustration by James Gurney.

Photograph by Brett Stevens

SCIENTIFIC AMERICAN


14


78


82

ON THE WEB

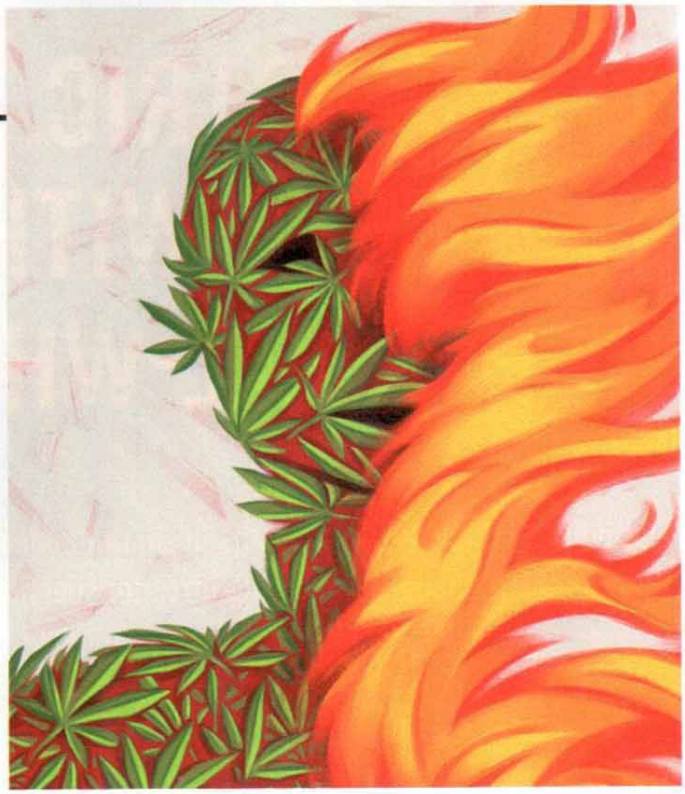
Earthquake Warnings
Scientific American explores how geologists track vibrations in the earth's crust to warn people seconds to minutes before tremors strike.
Go to www.ScientificAmerican.com/may2018/quakes

Scientific American (ISSN 0036-8733), Volume 318, Number 5, May 2018, published monthly by Scientific American, a division of Nature America, Inc., 1 New York Plaza, Suite 4500, New York, N.Y. 10004-1562. Periodicals postage paid at New York, N.Y., and at additional mailing offices. Canada Post International Publications Mail (Canadian Distribution) Sales Agreement No. 40012504. Canadian BN No. 127387652RT; TVQ1218059275 TQ0001. Publication Mail Agreement #40012504. Return undeliverable mail to Scientific American, P.O. Box 819, Stn Main, Markham, ON L3P 8A2. **Individual Subscription rates:** 1 year $49.99 (USD), Canada $59.99 (USD), International $69.99 (USD). **Institutional Subscription rates:** Schools and Public Libraries: 1 year $84 (USD), Canada $89 (USD), International $96 (USD). Businesses and Colleges/Universities: 1 year $399 (USD), Canada $405 (USD), International $411 (USD). Postmaster: Send address changes to Scientific American, Box 3187, Harlan, Iowa 51537. **Reprints available:** write Reprint Department, Scientific American, 1 New York Plaza, Suite 4500, New York, N.Y. 10004-1562; fax: 646-563-7138; reprints@SciAm.com. **Subscription inquiries: U.S. and Canada (800) 333-1199; other (515) 248-7684. Send e-mail to scacustserv@cdsfulfillment.com.** Printed in U.S.A.

End the War on Weed

Federal marijuana laws are counterproductive and overly harsh

By the Editors



Cannabis—marijuana—is the world's most commonly used illicit drug. Polls suggest that one in eight U.S. adults smoke it, and more than 40 percent of them have tried the drug at some point in their lifetime. A majority of states allow some form of medical marijuana use, and nine states and Washington, D.C., have now legalized recreational use. Although the substance is illegal under U.S. federal law, in 2013 the Justice Department under President Barack Obama guided U.S. attorneys away from prosecuting personal marijuana use in states where it is legal. But in January, Attorney General Jeff Sessions reversed those guidelines, giving U.S. attorneys renewed authority to press criminal charges.

Like the failed Nixon-era War on Drugs, this resurgent war on marijuana is ill informed and misguided. Evidence suggests that cannabis—though not without its risks—is less harmful than legal substances such as alcohol and nicotine. And despite similar marijuana use among blacks and whites, a disproportionate number of blacks are arrested for it. By allowing states to regulate marijuana without federal interference, we can ensure better safety and control while allowing for greater research into its possible harms and benefits.

In 1970 the Controlled Substances Act established marijuana as a Schedule I drug, "with no currently accepted medical use and a high potential for abuse." This is the same category that includes heroin and MDMA (ecstasy). Yet marijuana is far less dangerous than many other drugs, and cannabis or its derivatives have been used to treat everything from chronic pain to post-traumatic stress disorder to childhood epilepsy. A 2015 study that compared the toxicological threshold of marijuana for risk to human health with that of other drugs found that alcohol posed the highest risk, followed by heroin, cocaine and nicotine. Marijuana was among the lowest. In addition, there is some evidence that pot may serve as a safe alternative to other drugs of abuse, including heroin and other opioids.

That does not mean that marijuana is entirely benign. Studies suggest it can impair driving, and a subset of users develops a form of dependence called marijuana use disorder. Other research indicates that teenage marijuana use may adversely impact the developing brain: it has been linked to changes in neural structure and function, including lower IQ, as well as an increased risk of psychosis in vulnerable individuals. But some of these findings have been challenged. A pair of longitudinal twin studies, for example, found no significant link between marijuana use and IQ. Moreover, people with these brain characteristics may simply be more likely to use marijuana in the first place.

We are not advocating for unfettered access to marijuana, especially by adolescents. More large-scale, randomized controlled studies are needed to tease out the risks and benefits. But to do these kinds of studies, scientists must have access to the drug, and until very recently, the federal government has had a monopoly on growing cannabis for research purposes. We also need more research on the various, often more potent, marijuana strains grown for recreational use. As long as the federal government continues to crack down on state-level legal marijuana, it will be difficult to carry out such studies.

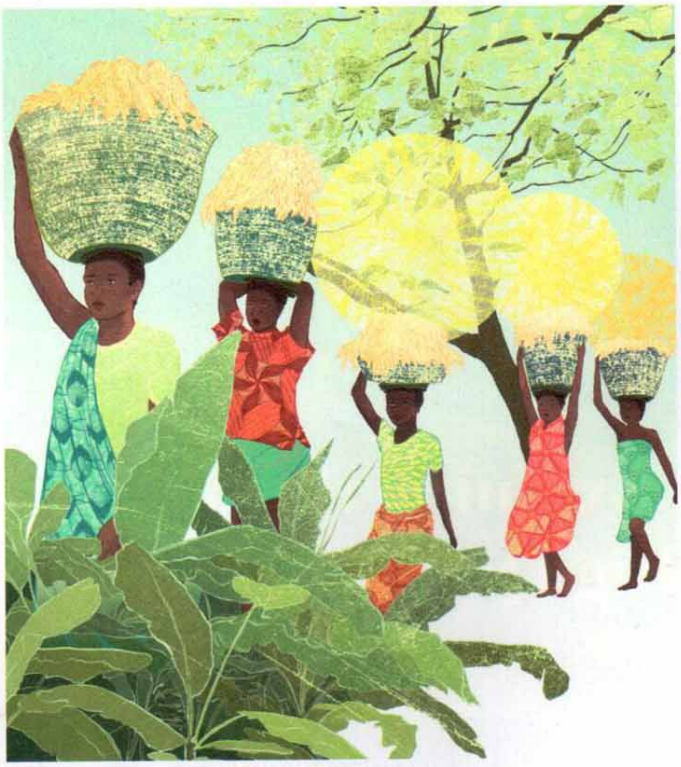
Even those who oppose cannabis use should reconsider the efficacy of criminalizing it. One of the most compelling cases for easing restrictions comes from Portugal, which decriminalized all drugs in 2001. Drug usage has remained the same or decreased as a result, and drug-related deaths and sexually transmitted diseases have dropped significantly. Portugal's experience may not translate directly to the U.S., but its success is worth noting. A 2014 study found that medical marijuana legalization in the U.S. has not increased crime and may actually be linked to lower assault and homicide rates. Even a limited version of federal reform, such as downgrading cannabis to a Schedule II or III drug—categories considered less harmful—could prove beneficial.

It is time to stop treating marijuana like a deadly drug, when science and public opinion agree that it is relatively safe for adult recreational use. The last thing we need is another expensive and ineffective war on a substance like cannabis—especially when there are far more serious drug problems to tackle.

JOIN THE CONVERSATION ONLINE
Visit *Scientific American* on Facebook and Twitter or send a letter to the editor: editors@sciam.com

Illustration by Tangmo Cecchini

Lisa Einstein is a physics educator with the Peace Corps' Let Girls Learn program in Guinea, West Africa.



The Suns in Our Daughters

Unleashing the energy trapped within undereducated girls

By Lisa Einstein

The question on the physics quiz seemed simple enough: "What is the smallest piece of matter that makes up everything in the universe?"

Binta's response: "Binta."

I laughed out loud. You would too if you saw tiny Binta, who is one of my smartest seventh graders. Surely she knew the correct answer is "atom." Yet, I mused, a famous equation governing atoms could also apply to her.

$E = mc^2$. The equation says that under the right conditions, mass can become energy, and vice versa. Because light moves so fast, an atom at rest—even with a small mass—contains a great deal of energy. A walnut has enough energy locked in it to power a small city. Mass from the sun radiates as light that warms the earth from 93 million miles away. Tiny masses hide astronomical energy. One look at Binta's effulgent smile proves that.

Reflecting on Binta's lesson as I walk home through the village, I am almost knocked over by Aissatou's exuberant tackle-hug. A magical six-year-old with a spirit too big to fit her child's body, Aissatou is further evidence of the small but powerful. A year into my Peace Corps service in Guinea, my young neighbor has become my local language teacher, running partner, closest friend and inspiration. I've watched her lead friends through dances she created, make bandages from spare fabric for her injured four-year-old sister and fashion a rope extension so our bucket can reach the bottom of our dried-up well. Aissatou is a designer: she builds, plays and imagines. I observe her ingenuity with awe.

I see Aissatou the way my parents saw me: filled with unlimited potential. My parents called their four kids "their greatest collaboration" and helped us grow into our fullest selves. Knowing the challenges facing young women in physics, Dad went out of his way to fuel my passion. Once he drove me six hours to a lecture by a female physicist. His encouragement emboldened me to dive into a challenging field dominated by men.

Aissatou, on the other hand, has been taught that she should be dominated by men. When male visitors arrive at her house, the jubilant builder I know transforms into a meek and submissive servant, bowing as she acquiesces to their every request.

The difference? I won the lottery at birth: time, place and parents who gave me the chance to develop my passions. I am on a mission to give Aissatou and Binta the chance to do the same.

I think about the untapped potential of millions of girls like Aissatou and Binta, who lack opportunities because of custom, poverty, laws or terrorist threats. The gifted young women I've taught as a Peace Corps volunteer implementing the Let Girls Learn program have strengthened my conviction that it is possible for them to fulfill their promise through education. And educating girls is not only morally right but also provides a cornerstone of achieving a peaceful and prosperous future.

I wonder if Binta intended to leave me the clue to a brighter world in her quiz. After all, I reflected on moral metaphors in science when I was her age.

"What exciting thing did you learn today?" my Dad would ask.

"We should all be like ideal gases," I responded one day after an exciting physics class. "They expand to fill whatever containers they occupy, so we can make the most of every situation too."

He smiled knowingly. "You know, gases with enough energy can even break open their containers."

When I see Aissatou squeal joyously on the improvised roller coaster she built from tree branches, I know that with the right support she could burst through her cultural container. If anyone has enough energy, she does.

Do you want to know something exciting I learned? Mass-energy equivalence means that the solar energy striking the earth each second equals only four pounds of mass. That means a small girl of 40 pounds could unleash the energy of 10 suns shining on the earth in a second. Take the 132 million girls who are not in school, and we have 1.32 billion suns in our daughters.

How will we help them rise? ■

JOIN THE CONVERSATION ONLINE
Visit *Scientific American* on Facebook and Twitter or send a letter to the editor: editors@sciam.com

Illustration by Cat O'Neil

ADVANCES

Mexican free-tailed bats have been migrating north earlier—possibly because of the warming climate.

David Pogue is the anchor columnist for Yahoo Tech and host of several *NOVA* miniseries on PBS.

Weirdest Hardware Product Ever?

Google's new camera decides what to photograph, based on AI algorithms

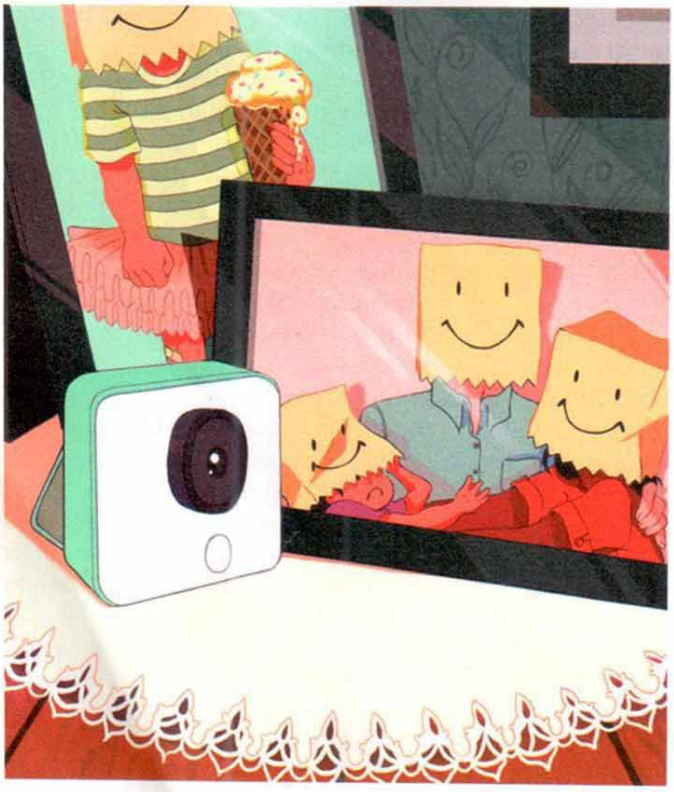
By David Pogue

Google's Clips camera is a tiny sliver of a camera, the size of two Wheat Thins crackers. You can set it down anywhere or clip it to anything. Once you turn it on, you don't have to press a button or use a self-timer to take pictures. The *camera* decides when to snap, based on Google's artificial-intelligence algorithms.

The Clips's heart is in the right place. It solves some real problems for its target audience, which is parents (of kids or of pets).

First, if you're in that category, you're probably never in any of your own photographs, because you're always behind the camera. Second, babies and young children often stop whatever cute thing they're doing the moment you pull out your phone. They get distracted by it or feel self-conscious. But the Clips avoids that problem because it's unobtrusive and because you're not holding it between your face and the kid's.

Truth is, I suspect the Clips will probably flop. The camera isn't very impressive next to those in some smartphones, and $250 is a steep price for a one-trick pony. But its central idea—AI as photographer—is fascinating.



AI isn't organic. It has to be *programmed*—taught or coded by engineers. In other words, the AI doesn't ultimately decide what makes a good picture; its programmers, informed by photography experts, do.

Some of the AI's decision making in the Clips is obvious. It looks for scenes of activity. It favors familiar subjects—people whose faces it sees most often. It avoids capturing an image when something is blocking the lens, like your fingers or your grabby baby's hands. It prefers good lighting. It takes its best shots three to eight feet away.

But here's where things get more complicated: The camera is also designed to wait for happy facial expressions. It tends not to capture anybody who is sad, angry, sleepy, bored or crying.

That AI rule, unfortunately, rules out a lot of great picture taking. Let's face it—a young child's life is full of micro tragicomic moments that might be worth recording, even if they produce brief bursts of tears. You know: His ice cream falls off the cone onto the floor. A puppy licks her face a little too energetically. A well-meaning clown scares him.

Google is aware of the problem and plans to add a new preference setting—not a check box called "Include Misery" but an option that makes the camera watch for *changes* in facial expression. In the meantime, the Clips's preference for joyous moments tends to exaggerate two happiness filters we already put on our lives.

First, we already self-edit our video and photographic memories simply by choosing what to shoot. Most people, most of the time, record high points such as celebrations and travel. Your collection probably contains very few pics of you fighting with your spouse, depressed by your job or in pain from an injury.

Second, we further curate our recordings by choosing which to post online. At this point, we don't just risk deceiving *ourselves* about the overall happiness balance in our lives; we're explicitly trying to paint a picture of a wonderful life for our followers. We become brand ambassadors for our supposedly flawless lives.

Studies have shown that the result of all this happy filtering can sadden *other* people on social media, who develop "Facebook envy."

You begin to wonder why we take pictures and videos in the first place. What's the purpose of those acts? Is it to create a faithful record of our lives, both high and low moments? Is there anything wrong with immortalizing only the bright spots, permitting the darker stuff to fade out of view—and maybe out of memory?

Answering those questions depends, in part, on who your audience is. An older you? Your descendants? Your Facebook friends?

There's no right answer. We all take and curate pictures—or don't—for different reasons. If Google's Clips camera achieves nothing more than throwing those questions into sharper focus, its invention won't have been in vain.

SCIENTIFIC AMERICAN ONLINE
READ MORE ABOUT "FACEBOOK ENVY":
scientificamerican.com/may2018/pogue

Illustration by Jay Bendt

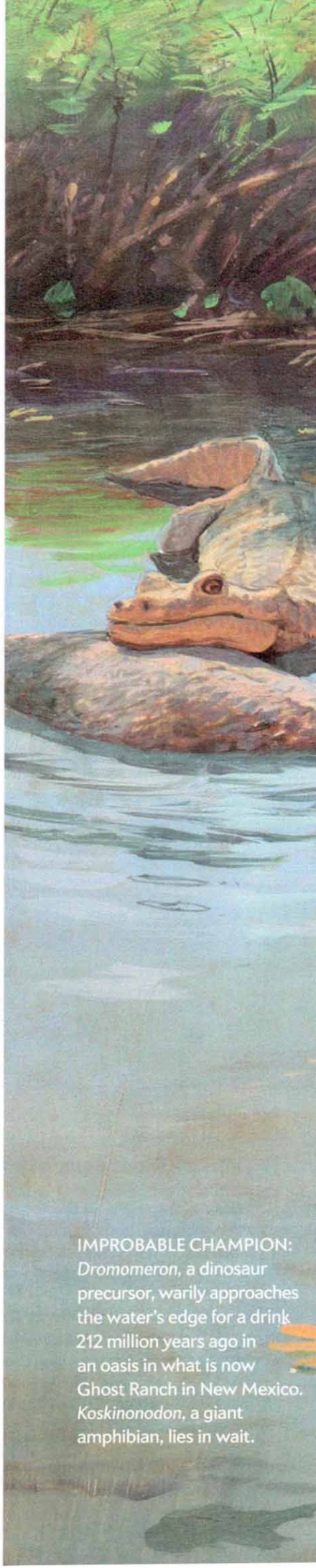
EVOLUTION

THE UNLIKELY TRIUMPH OF DINOSAURS

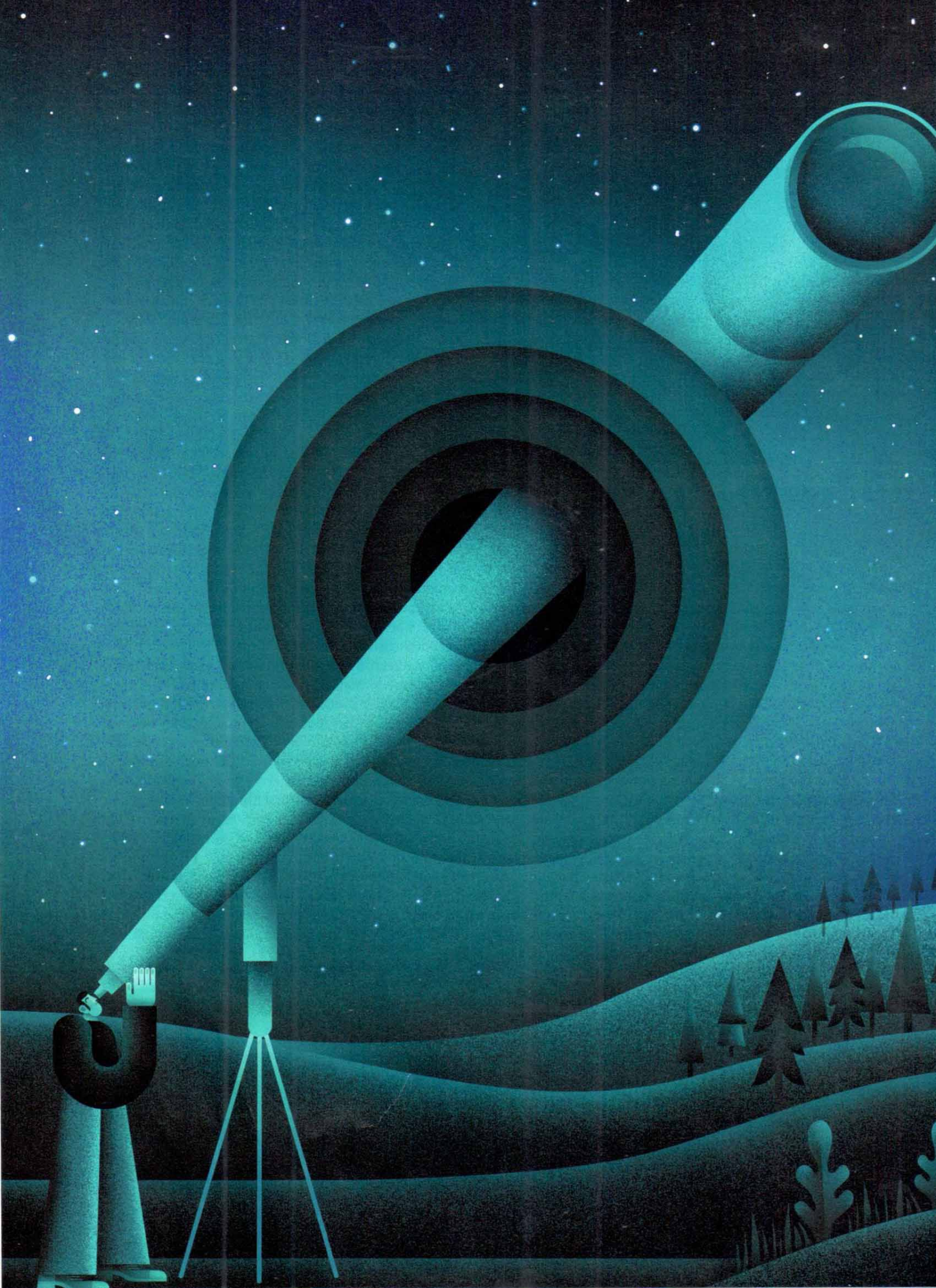
New fossils and analyses topple the long-standing explanation of how dinosaurs came to rule the earth

By Stephen Brusatte

Illustration by James Gurney



IMPROBABLE CHAMPION: *Dromomeron*, a dinosaur precursor, warily approaches the water's edge for a drink 212 million years ago in an oasis in what is now Ghost Ranch in New Mexico. *Koskinonodon*, a giant amphibian, lies in wait.



ASTRONOMY

Astronomers' newfound ability to see the same cosmic events in light, particles and gravitational waves—a synthesis called multimessenger astronomy—gives them a fuller picture of some of the universe's most mysterious phenomena

Messengers from the Sky

By Ann Finkbeiner

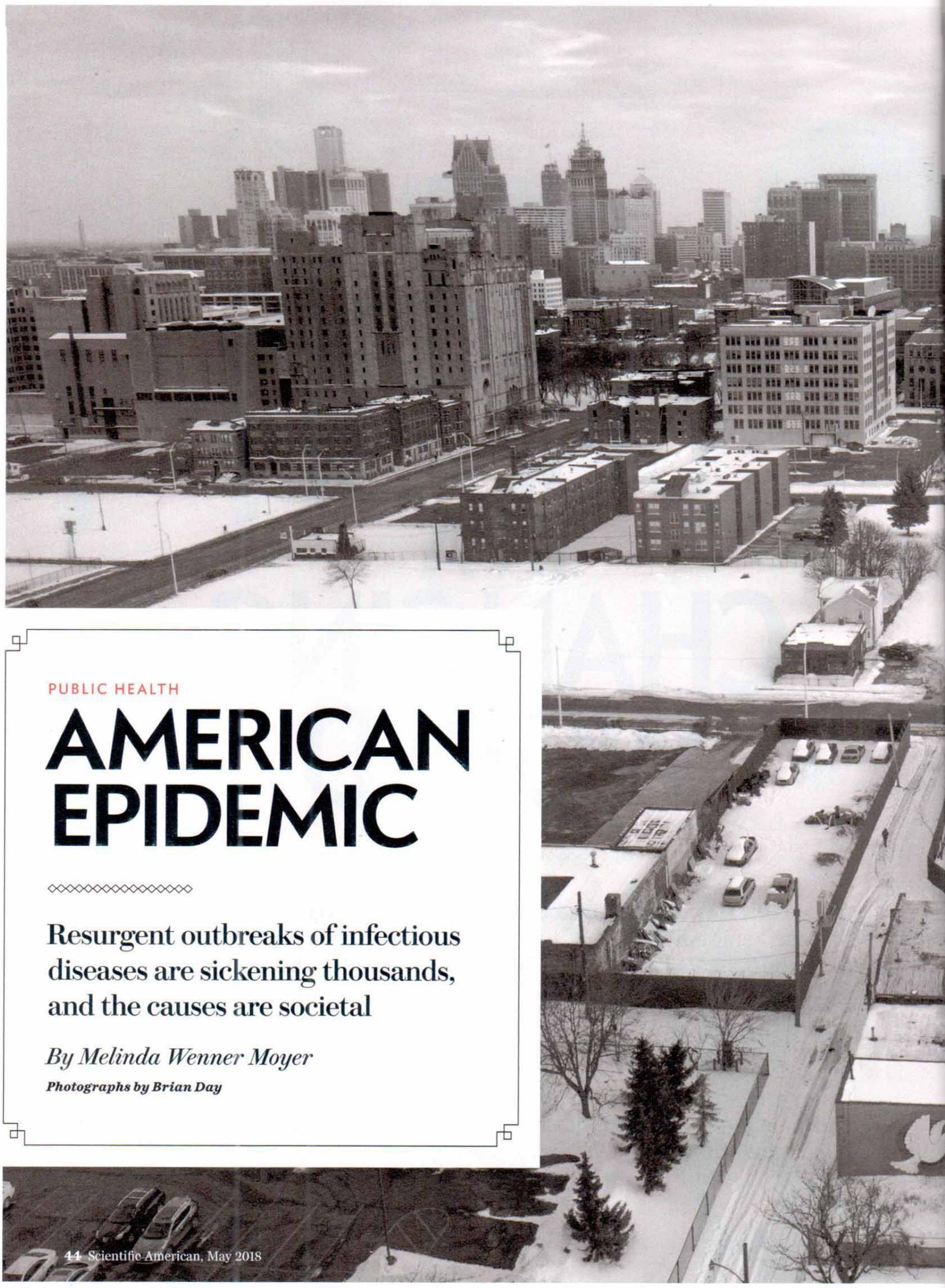
Illustration by Maria Corte Maidagan

THE FUTURE OF MEDICINE 2018

EMERGING DISEASE IN A CHANGING WORLD

"IN AN UNCHANGING WORLD, YOU DON'T SEE A LOT OF EMERGING disease," epidemiologist William Karesh told *Scientific American* contributor Lois Parshley during her reporting for this issue. The world, of course, is changing fast. In the U.S., growing economic inequality is driving a resurgence of deadly hepatitis, Legionnaires' and other infections. Globally, climate change and unchecked urbanization are creating conditions in which diseases emerge faster and spread farther. As the six articles in this special report show, hope resides with interdisciplinary collaborations—epidemiologists, climatologists, ecologists, and others working together to solve medical problems with deep social roots.

Illustrations by Hanna Barczyk



PUBLIC HEALTH

AMERICAN EPIDEMIC

Resurgent outbreaks of infectious diseases are sickening thousands, and the causes are societal

By Melinda Wenner Moyer

Photographs by Brian Day

MIDTOWN DETROIT'S Cass Corridor neighborhood has new construction, as well as a population of sick and homeless people.