NOVEMBER 2020
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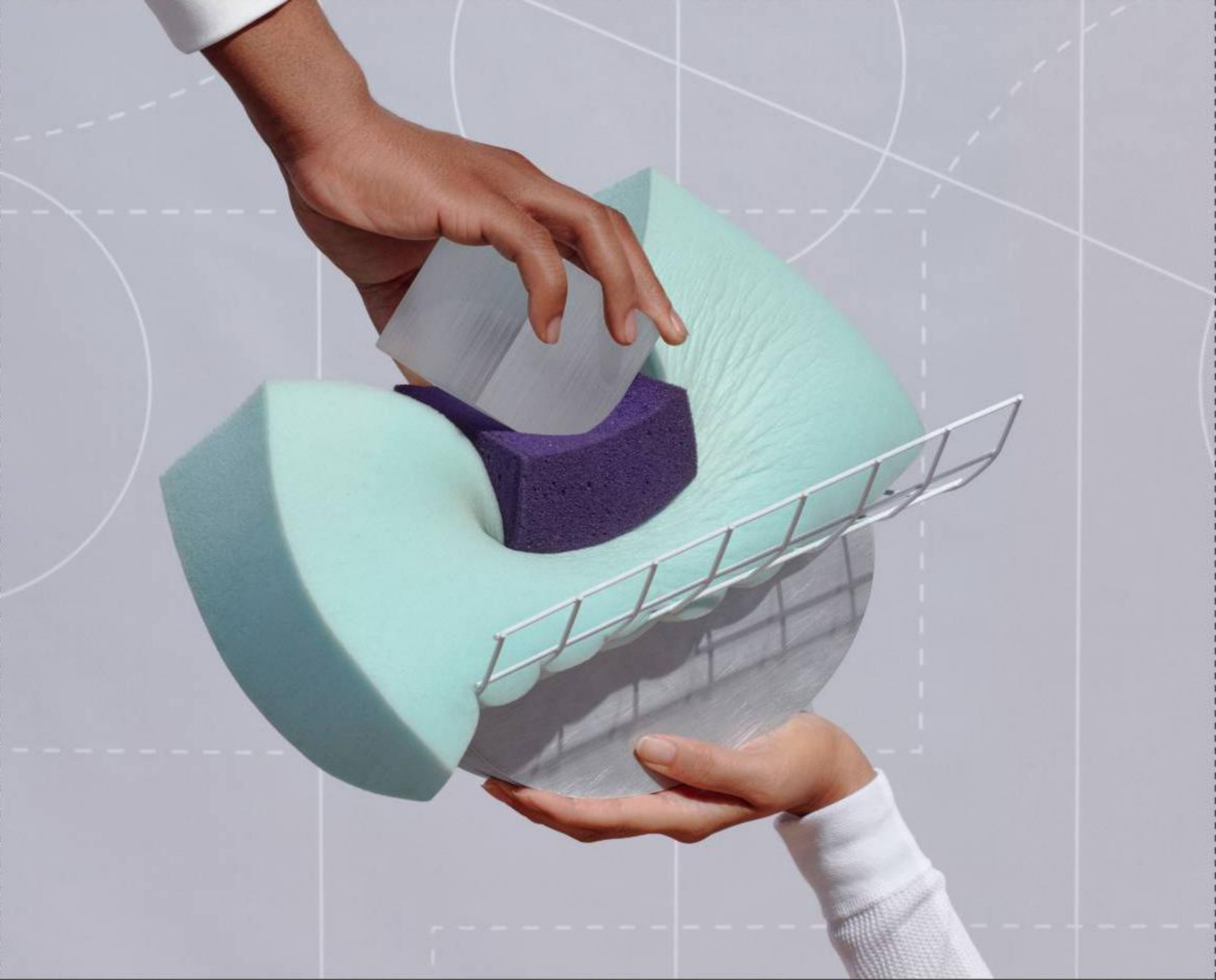
CONFRONTING MISINFORMATION

How to protect society from fear, lies and division



NOVEMBER 2020

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SCIENTIFIC AMERICAN

CONFRONTING ! MISINFORMATION

GETTY IMAGES (*Blackburnian warbler*)

ON THE COVER
Uncertainty creates conditions for misinformation to flourish—and flourish it has. As the world continues to grapple with the pandemic and the U.S. faces a high-stakes election season, how can society be less fragile to toxic media manipulation, whether it is from the highest levels of governments or homegrown?
Illustration by Hanna Barczyk.

BIG QUESTIONS FROM… ONDREJ KRIVANEK

A pioneer in electron optics, Ondrej Krivanek discusses the fascinating possibilities now that electron microscopes can distinguish atoms, including energy-conserving computers, clean-burning hydrogen fuel, and the chance to peer inside cells to track the chemistry of life.

When Ondrej Krivanek first considered building a device to boost the resolution of electron microscopes, he asked about funding from the U.S. Department of Energy. "The response was not positive," he says, laughing. He heard through the grapevine that the administrator who held the purse strings declared that the project would be funded "over his dead body."

"People just felt it was too complicated, and that nobody would ever make it work," says Krivanek. But he tried anyway. After all, he says, "If everyone expects you to fail, you can only exceed expectations."

The correctors that Krivanek, Niklas Dellby, and other colleagues subsequently designed for the scanning transmission electron microscope did exceed expectations. They focus the microscope's electron beam, which scans back and forth across the sample like a spotlight, and makes it possible to distinguish individual atoms and to conduct chemical analysis within a sample. For his pioneering efforts, Krivanek shared The Kavli Prize in Nanoscience with the German scientists Harald Rose, Maximilian Haider, and Knut Urban, who independently developed correctors for conventional transmission electron microscopes, in which a broad stationary beam illuminates the entire sample at once.

Electron microscopes, invented in 1931, long promised unprecedented clarity, and in theory could resolve objects a hundredth the size of an atom. But in practice they rarely get close because the electromagnetic lenses they use to focus electrons deflected them in ways that distorted and blurred the resulting images.

The aberration correctors designed by both Krivanek's team and the German scientists deploy a series of electromagnetic fields, applied in multiple planes and different directions, to redirect and focus wayward electrons. "Modern correctors contain more than 100 optical elements and have software that automatically quantifies and fixes 25 different types of aberrations," says Krivanek, who co-founded a company called Nion to develop and commercialize the technology.

That level of fine-tuning allows microscopists to fix their sights on some important pursuits, such as producing smaller and more energy-efficient computers, analyzing biological samples without incinerating them, and being able to detect hydrogen, the lightest element and a potential clean-burning fuel.

Can electron microscopes help build energy-sipping computers?

We are making all kinds of fun atomic-scale devices that would minimize the energy needed for a logic operation. Computing on a much lower power budget is a frontier that people are exploring: How many gigaflops can you get per microwatt? What we're waiting for is a 10-atom transistor built out of foreign atoms incorporated in boron nitride. I'm sure that's going to come one of these days, because you can move atoms around with the electron beam in these two-dimensional materials. Then the only problem will be trying to connect it to other transistors in the device.

Could microscopy lead to eco-friendly power sources, like hydrogen or solar cells?

Hydrogen fuel cells would be wonderful. It's one of the most abundant elements, and when you combine hydrogen with oxygen in the air, there's no pollution because what you're producing is water. If you could store hydrogen in a storage tank without having to keep it under huge pressure, you could put enough of it in your car. But to put hydrogen into the storage cell and cycle it in and out, you need to be able to see what the hydrogen is doing, where it is sitting, and to what it is bonded. That is the province of electron microscopes and their spectrometers, which tell you which elements are where. For solar cells, the issue tends to be efficiency and cost. With silicon solar cells, you get something like 20% efficiency, and you have to grow and slice and polish the silicon crystals, so it can get expensive. Can you make something cheaper and with higher efficiency? What if you could just spray a material as a thin film on a piece of plastic and get good efficiency? When you try to do that, you introduce defects called grain boundaries, because you don't have a single crystal. There was some nice work from the SuperSEM Laboratory in the U.K. showing how grain boundaries in thin-film solar cells affect their efficiency, and what you can do about it. Microscopy helps us see how we can arrange the internal structure of the material so it gives us the properties we want from an electrical point of view.

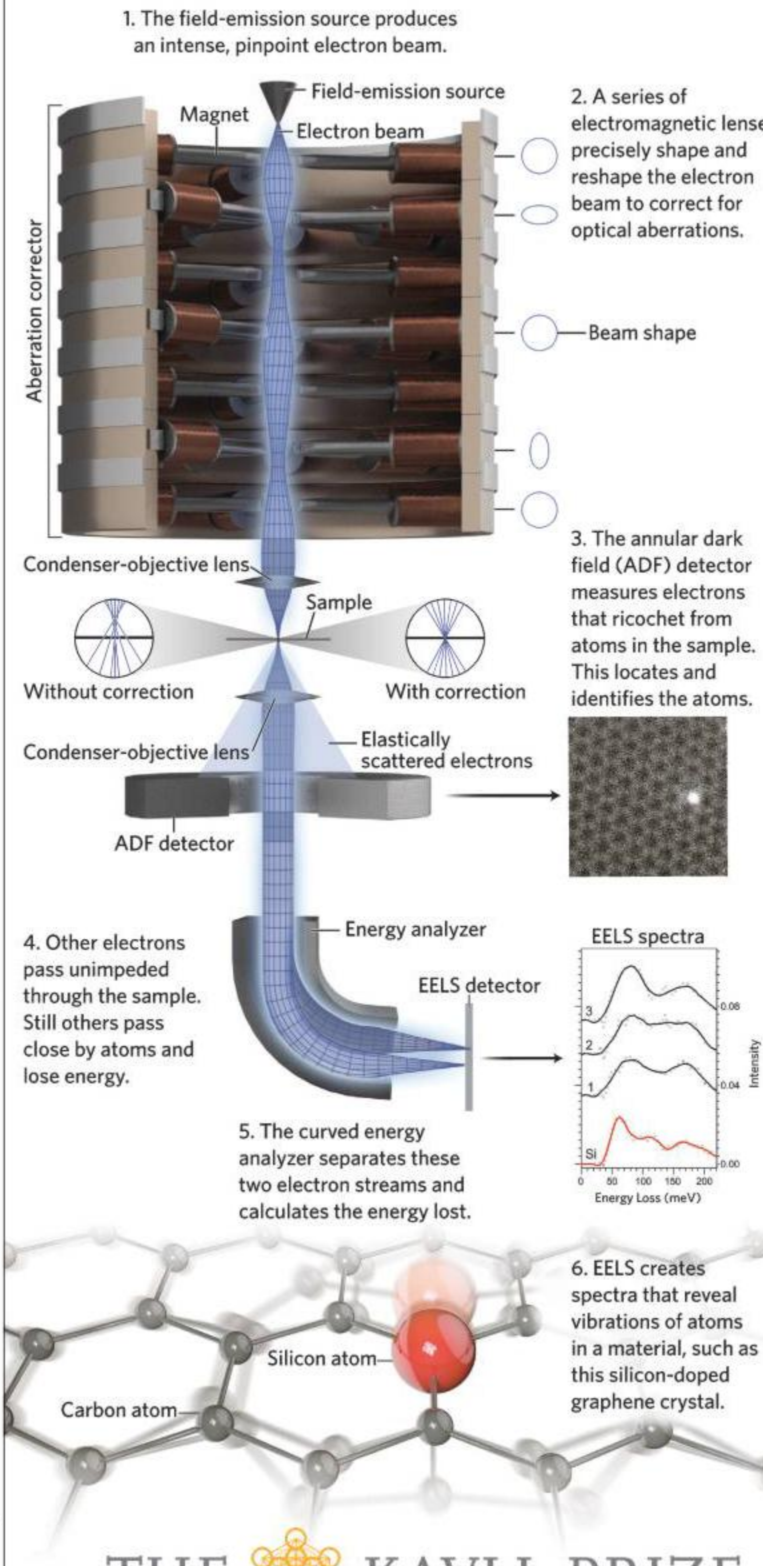
How can enhanced resolution advance the study of biological materials?

When you look at an individual cell, you want to understand what type of chemical substances sit at different places, and how they travel in the cell. How are they synthesized, and how are they metabolized into something different? I'm hoping that aberration-corrected vibrational spectroscopy will be able to answer these types of questions. Biological microscopy has typically been a race between extracting useful information from the sample and destroying it with the same beam that you're using for imaging. In vibrational spectroscopy, you don't aim the electron beam to the place you're examining; you direct it nearby. This avoids radiation damage, and allows closer examination of the samples. We can now do this in scanning transmission electron microscopes with remarkable energy and spatial resolution. I was doing a sabbatical at Humboldt University in Berlin, concentrating on precisely this, but I had to finish it prematurely because the university was shutting down due to COVID-19. Hopefully, when the world returns to normal, I'll go back to Germany, and I'll be able to say this project worked out great—or, it was a crazy idea and didn't work at all. If you know how it's going to turn out, then it's engineering. If you don't have any idea, then it's called research. And that's what we're doing right now.

To learn more about the work of Kavli Prize laureates, visit kavliprize.org.

ATOMIC VISUALIZATION

Scanning transmission electron microscopes can now resolve and identify individual atoms, thanks to electron optics advances. Adding an energy electron loss spectrometer (EELS) can even help visualize how atoms jostle and vibrate.



SOURCE: STEM-EELS mechanism: O. Krivanek; EELS spectra: F. Hage et al., Science 367, 1124-1127 (2020). Reprinted with permission from AAAS.

THE KAVLI PRIZE

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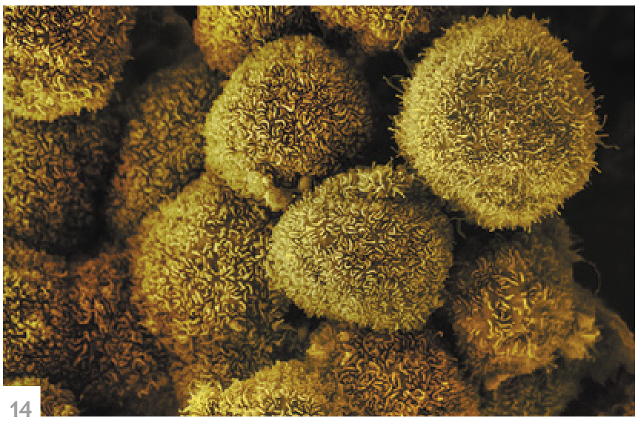
12



14

78

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Laura Helmuth is editor in chief of *Scientific American.* Follow her on Twitter @laurahelmuth

True Reality

This month I learned that senior editor Jen Schwartz is an evil genius at media manipulation. She produced our cover package about misinformation (starting on page 28), including a story about her own role in an Election Day drill in which she demonstrated how easily bad actors can disrupt honest news coverage. It's funny and chilling and a little too real for comfort, and I'm more grateful than ever that she is working for the side of truth and reality rather than disinformation.

Misinformation is one of the hottest areas of research right now—unfortunately because there's just so much to study. With the pandemic, election season, trolls who weaponize confusion and the massive influence of social media platforms, conspiracy theories and quackery are spreading more quickly and widely than ever. We hope that understanding the science of misinformation will help us all tell sense from nonsense and find the best ways to resist and debunk dangerous myths.

During the pandemic shutdown, lots of people are discovering the joy of watching birds. Senior editor Kate Wong was inspired by the goldfinches at her feeder to look into how birds evolved such spectacular diversity (*page 44*). As a longtime birder, I'm delighted to see this hobby becoming more popular. It's now hawk migration season, so when you're outdoors, look up, and you might see raptors heading south in a hurry.

You might not expect a story about space war to be … charming? And amusing? Satellites fighting satellites is a serious issue, and science writer Ann Finkbeiner is a serious person, but she also knows how to bring out the absurdity of a situation and get experts to tell us what they really think. Turn to page 50 and enjoy an amazing graphic within.

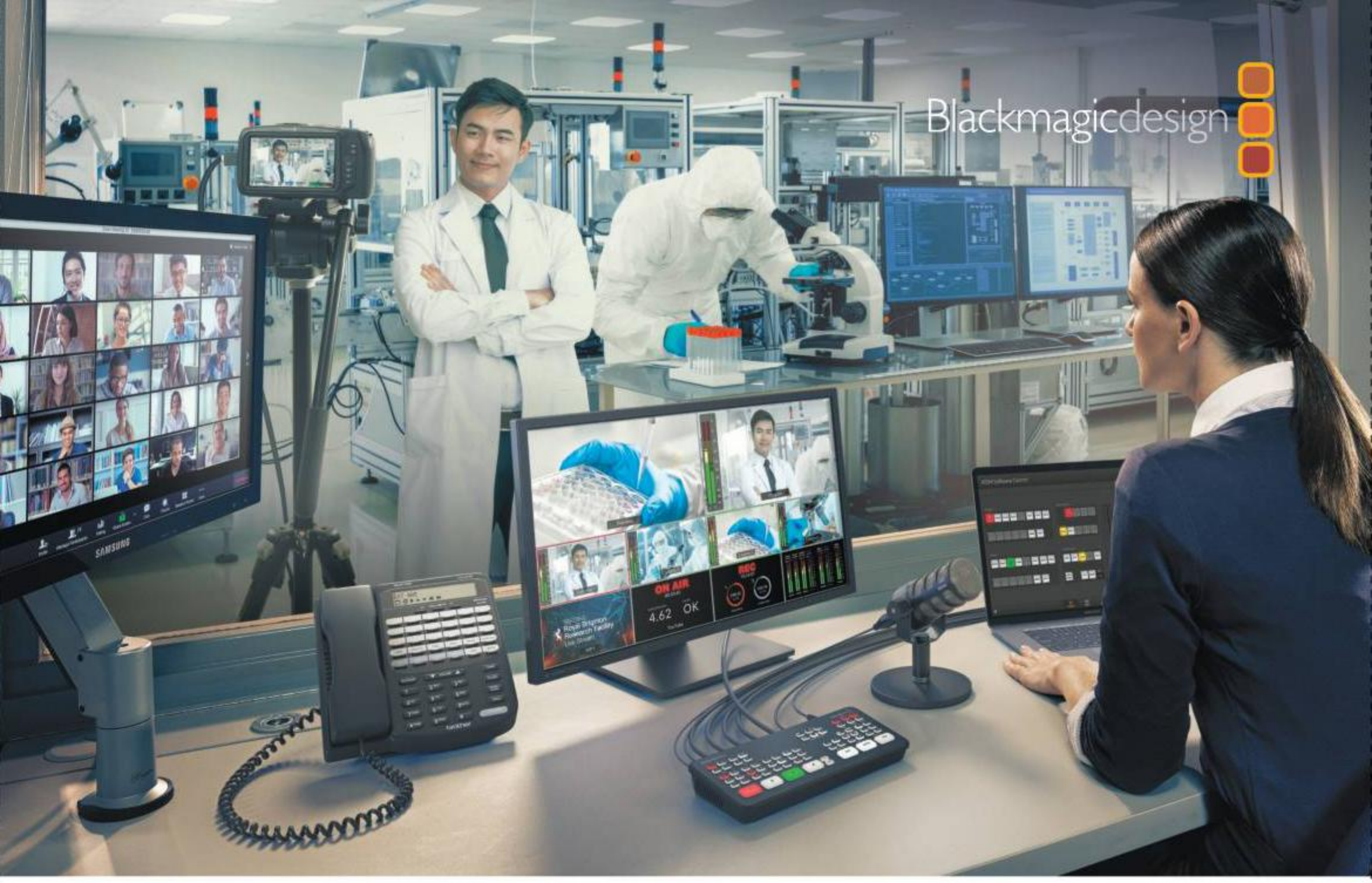
Rocket science may be challenging, but brain science is immeasurably more complicated. Beginning on page 58, journalist Diana Kwon offers a possible explanation for how psychological trauma can cause neurological symptoms in a feedback loop that scientists are just starting to piece together. The mysterious condition is called functional neurological disorder.

At a time when every conversation eventually turns to the pandemic, it's hard to imagine that we will ever forget it. But collective memory for the catastrophic influenza of 1918–1919, which killed 50 million to 100 million people, was shockingly fleeting. The story, on page 66, is by Scott Hershberger, a summer writing fellow who worked with us through a program from the American Association for the Advancement of Science.

Plenty of other plagues have shaped history, and researchers around the world are extracting pathogens' genetic material from their victims to show which diseases caused the worst mass deaths and how the germs spread around the world. The article by science writer James P. Close begins on page 70. We hope that looking at the history of past plagues can help us understand the COVID-19 pandemic, which will only be ended with science, public health measures and a shared interpretation of reality.

We got more attention than we expected for our editorial in last month's issue endorsing Joe Biden for president. More than 1,000 publications covered the endorsement, and the response was overwhelmingly positive (whew). Thanks very much to everyone who sent supportive messages, including some people who disagree with the decision but respect us for feeling a responsibility to speak up. We hope those who are disappointed in the endorsement will stick with us for everything else we have in common: a desire to understand the world, share knowledge and discoveries, and show that reality is more rich and fascinating than misinformation. SA

Illustration by Nick Higgins



Introducing ATEM Mini

The compact television studio that lets you create training videos and live streams!

Blackmagic Design is a leader in video for the medical industry, and now you can create your own streaming videos with ATEM Mini. Simply connect up to 4 HDMI cameras, computers or even technical equipment. Then push the buttons on the panel to switch video sources just like a professional broadcaster! You can even add titles, picture in picture overlays and mix audio! Then live stream to Zoom, Skype or YouTube!

Create Training and Educational Videos

ATEM Mini's includes everything you need. All the buttons are positioned on the front panel so it's very easy to learn. There are 4 HDMI video inputs for connecting cameras and computers, plus a USB output that looks like a webcam so you can connect to Zoom or Skype. ATEM Software Control for Mac and PC is also included, which allows access to more advanced "broadcast" features!

Use Professional Video Effects

ATEM Mini is really a professional broadcast switcher used by television stations. This means it has professional effects such as a DVE for picture in picture effects commonly used for commentating over a computer slide show. There are titles for presenter names, wipe effects for transitioning between sources and a green screen keyer for replacing backgrounds with graphics!

Live Stream Training and Conferences

The ATEM Mini Pro model has a built in hardware streaming engine for live streaming via its ethernet connection. This means you can live stream to YouTube, Facebook and Twitch in much better quality and with perfectly smooth motion. You can even connect a hard disk or flash storage to the USB connection and record your stream for upload later!

Monitor all Video Inputs!

With so many cameras, computers and effects, things can get busy fast! The ATEM Mini Pro model features a "multiview" that lets you see all cameras, titles and program, plus streaming and recording status all on a single TV or monitor. There are even tally indicators to show when a camera is on air! Only ATEM Mini is a true professional television studio in a small compact design!

ATEM Mini...... **US$295***
ATEM Mini Pro...... **US$595***
ATEM Software Control...... **Free**

Learn more at www.blackmagicdesign.com

ATEM Mini for use in training, conferencing and teaching purposes only.

Blackmagicdesign

July 2020

"As a Black woman and a physician, I have seen the deleterious effects of obesity."

SYLVIA GONSAHN-BOLLIE *VIA E-MAIL*

OBESITY AND PREJUDICE

In "Treating Patients without the Scale," Virginia Sole-Smith describes physician Louise Metz's approach to issues around weight and eating that affect individuals' health. I could not agree more with Metz, whose technique involves encouraging healthier behaviors rather than focusing on weight.

During the past 27 years of my practice of internal medicine before my retirement, I treated many hundreds of people with eating disorders whose body mass index (BMI) ranged from malnourished to morbidly obese. They taught me much about how to treat all of my patients. As the article notes, for different racial, cultural, ethnic and socioeconomic groups, there are huge disparities in societal attitudes and acceptance, as well as in treatment received from the medical community. In addition, I believe one of the greatest disparities is manifested in gender: Men are far less likely to experience bias against overweight people than women. Men also have eating disorders that are not as often recognized as they would be in women.

A. LEE TUCKER, JR. *Nashville, Tenn.*

In "The Racist Roots of Fighting Obesity," Sabrina Strings and Lindo Bacon assert that "blaming black women's health conditions on 'obesity' ignores … critically important sociohistorical factors." They also say that prescribing weight loss is ineffective and that "the most effective and ethical approaches … should aim to … [tackle] racism, sexism and weightism." That strategy provides only a partial solution to improve African-American health.

As a Black woman and a physician, I have personally and professionally seen the deleterious effects of obesity that extend beyond subjective aesthetics. I agree that forcing individuals to conform to specific body types that are rooted in racism, classism and sexism is unhealthy and potentially harmful. But given the evidence of the increased all-cause mortality associated with obesity—especially at a BMI greater than 35—it would be a disservice not to address it in African-Americans. The work Strings and Bacon describe does not invalidate the need for obesity treatment in African-American patients with diseases related to the condition. Rather it reemphasizes that such treatment must comprehensively address nutrition, physical activity, behavior and, if needed, medication or bariatric surgery.

Additionally, for Black people globally, it is critical to incorporate the effects of personal and systemic racism, as well as other psychosocial factors, into obesity-treatment planning to truly create lasting weight loss and optimal health.

SYLVIA GONSAHN-BOLLIE *via e-mail*

FLAVOR COMBINATION

"The Darkest Particles," by William Charles Louis and Richard G. Van de Water, describes how neutrinos emanating from the sun transition from one of the three known "flavors" to another en route to Earth. The "Neutrino Flavors" box illustrates how the cumulative contribution of a neutrino's three mass states determines its flavor during the course of its travel. The particle is shown with a sharply defined mass state combination associated with an electron neutrino at its source and one indicating a tau neutrino at its destination. But the graphic seems to suggest that between those points, the neutrino passes through a large number of mass state combinations. Do the three flavors encompass a wide enough range of combinations to account for the entire transit? If not, what is the neutrino when it is not one of them?

ALLAN W. MALINEN
Kingsburg, Nova Scotia

I assume that there is agreement that the tau and electron neutrinos are, respectively, thought to be the most and least massive of the three known flavors. In the "Neutrino Flavors" box, an illustration of the three mass states of the normal hierarchy produces the expected result. Meanwhile the illustration of the inverted hierarchy seems to propose that the electron neutrino's predominant mass state (mass 1) is not the smallest state but the intermediate one.

Yet to maintain the expected rank order of the masses in the inverted hierarchy, the "extremely small mass" must be the electron neutrino's second most prominent mass state (mass 2). If it were mass 3, as the illustration shows, then the tau neutrino—which is dominated by that state—would easily be the least massive of the three flavors. Is the illustration in error?

ERIC M. VAN *via e-mail*

THE AUTHORS REPLY: To answer Malinen: If the neutrino starts out as a pure electron neutrino, then it will be in a superposition of the three known flavors as it travels from its source. Therefore, if the particle is detected downstream from that source, it will have different probabilities of being an electron, muon or tau neutrino. If the sum of these probabilities is measured to be less than one, then that result would be evidence that the neutrino's flavor is the possible fourth "sterile" type that we discuss in our article.

In reply to Van: The figures of the three mass states are correct. As they show, the electron neutrino consists of a superposition of these different states rather than having a single mass. The particle's most dominant mass state is mass 1, followed by mass 2 and then mass 3. Neutrino oscillation experiments have shown that