

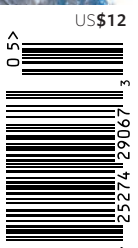
NAUTILUS

48 **CHAOS**
Out of order

49 **THE ABSURD**
Beyond reason



From Us to Them
RETHINKING CONFLICT p.20



MAY/JUNE 2017

Science Connected

NAUTIL.US



THE FARTHEST

VOYAGER IN SPACE

PREMIERES **WEDNESDAY AUGUST 23** 9/8c
ENCORE WEDNESDAY SEPTEMBER 13 10/9c



pbs.org/farthest #FarthestPBS



An Old Problem

IT HAS BECOME ALARMINGLY EASY to paint a dystopian picture of the world and its future,” a recent Amnesty International report on human rights declared. In 2016, it said, “the very notion of a human family [came] under vigorous and relentless assault from powerful narratives of blame, fear, and scapegoating.”

It’s hard to disagree with the report. The recent past has revived old divisions and sowed new ones at a pace that can seem unprecedented—a word which the report uses five times. Similarly, CNN Politics’ first-ever book on the United States presidential election is titled *Unprecedented*, as are a smattering of new books on everything from U.S. politics to the suppression of the Falun Gong.

This may be a step too far.

In this issue’s cover story, primatologist Robert Sapolsky reminds us of the long view of the “us” and “them.” It wasn’t invented by Trump or Clinton. It is not an unfortunate byproduct of the modern age. What it is, is one of the hardest social engineering problems we have ever encountered.

Our brains are us/them machines, and always have been. Subconscious interpretations formed at lightning speeds recruit even arbitrary details to reinforce group identity. We rely on ingroup cues and rewards to shape our decisions. In a time of conflict, these tendencies are barriers. But they also open up possibilities.

While an us/them division is difficult to dissolve, its axis can be rotated from something pernicious, like race, to something benign, like a shared experience. Skepticism for the other can also be redirected to the self, as Erika Weisz and Jamil Zaki argue in their essay on page 36. This can weaken ingroup bonds in favor of outgroup empathy.

There is, after all, something unprecedented here: We have never understood our own mental machinery so well. Now it’s time to get to work.

Welcome to the May/June 2017 *Nautilus* print edition.

—Michael Segal
Editor in Chief



NO REACTION NO PROGRESS

**We can't simply hope that reason will prevail,
we have to stand together and act.**

**Join the American Association for the
Advancement of Science.**

Contents



Preludes

- 14 *The U.S. president's language; how stress can help; and our battle with distraction*

Themes

Each print edition identifies different themes in science and explores them from multiple perspectives.

Cover Story

- 20 **PSYCHOLOGY**
Why Your Brain Hates Other People
And how to make it think differently
BY ROBERT SAPOLSKY

- 34 **Chaos**
Out of order

- 62 **The Absurd**
Beyond reason

- THE LAST WORD**
108 **Sarah Bakewell**
The author of At the Existentialist Café reflects on the themes in Nautilus

COVER Ignacio Serrano
BACK COVER Yuko Shimizu

48

Chaos

“As Murray Gell-Mann once quipped, in physics, ‘Everything not forbidden is compulsory.’ Including, it seems, the universe itself.”

—Amanda Gefter, p. 42

SOCIOLOGY

36 The Case for Less Solidarity

The surprising effects of reducing empathy for your own ingroup

BY ERIKA WEISZ & JAMIL ZAKI

PHYSICS

42 The Inflated Debate Over Cosmic Inflation

Why the majority of physicists are on one side of a recent exchange of letters

BY AMANDA GEFTER

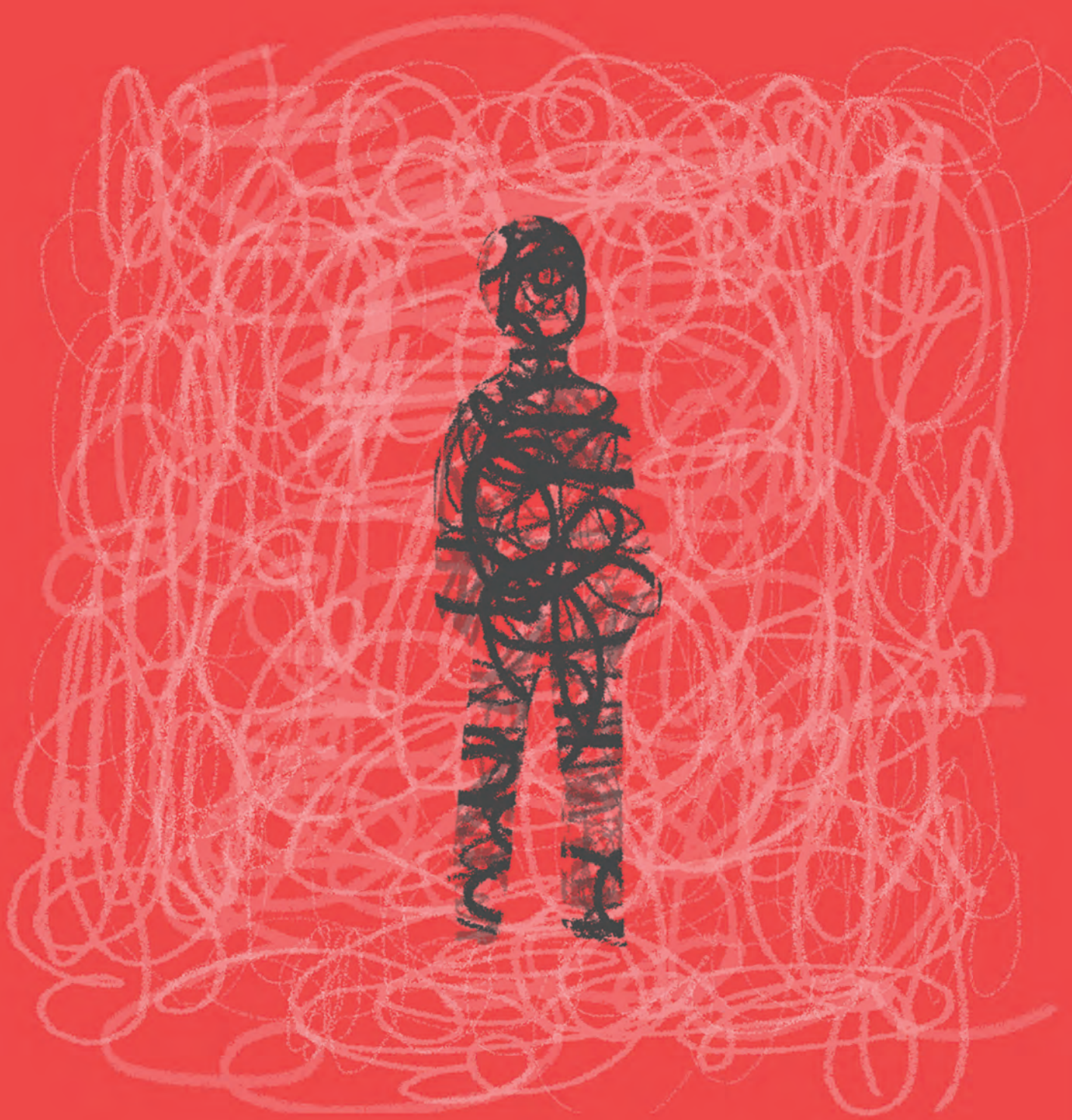
SOCIOLOGY

52 The Hidden Sexism of How We Think About Risk

If men take more risks than women, it's not because of biology

BY CORDELIA FINE

THEME ART Francesco Izzo



49

The Absurd

“On closer inspection, what had looked like a square wasn’t quite a square.”

—Evelyn Lamb p. 64

MATH

64 The Impossible Mathematics of the Real World

Near-miss math provides exact representations of almost-right answers

BY EVELYN LAMB

HISTORY

72 The Multiverse of 1686

Speculation on multiple universes goes back farther than you might think

BY STEVEN NADLER & BEN NADLER

NEUROSCIENCE

88 When Neurology Becomes Theology

A neurologist’s perspective on research into consciousness

BY ROBERT A. BURTON

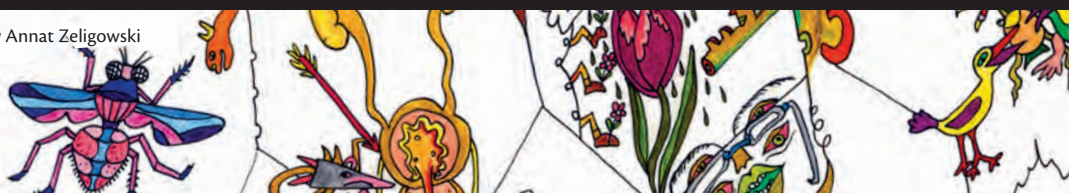
THEME ART Francesco Izzo





Searching for order in the complexity of evolving worlds

www.santafe.edu





NAUTILUS

EDITORIAL

Publisher & Editorial Director
John Steele

Editor in Chief
Michael Segal

Features Editor
Kevin Berger

Art Director
Francesco Izzo

Managing Editor
Liz Peterson

Blog Editor
Brian Gallagher

Assistant Editor, Social Media
Madeline Gressel

Contributing Editor
George Musser

Editor at Large
Regan Penaluna

Assistant Editor/Video Production
Yvonne Bang

Editorial Fellow
Jordana Cepelewicz

Editorial Interns
Natalie Coleman
Sabrina Imbler

Finance Manager
Renata Guyfner

Marketing Intern
Chikaodili Okaneme

Design & Creative Consultants
Point Five Design

BOARD OF ADVISORS

David Agus *Professor of Medicine and Engineering, University of Southern California*

Bob Bazell *Adjunct Professor of Molecular, Cellular, and Developmental Biology, Yale University*

Christina Beck *Head of Science & Corporate Communications, The Max Planck Society*

Sean Carroll *Senior Research Associate, Department of Physics, California Institute of Technology*

Jennifer Dunne *Professor and V.P. for Science, Santa Fe Institute*

Josh Empson *Managing Director, Providence Equity Partners*

Bran Ferren *Co-Chairman, Applied Minds, Inc.*

Stuart Firestein *Chairman of the Department of Biological Sciences, Columbia University*

David Fitzpatrick *Scientific Director & C.E.O., Max Planck Florida Institute for Neuroscience*

Jessica Flack *Professor and Director, Collective Computation Group, Santa Fe Institute*

Peter Galison *Pellegrino University Professor in History of Science and Physics, Harvard University*

Thomas Campbell Jackson *Venture Partner, Easton Capital Investment Group*

Beth Jacobs *Managing Partner, Excellentia Global Partners*

David Kaiser *Germeshausen Professor of the History of Science, MIT*

Lisa Kaltenegger *Associate Professor of Astronomy, Cornell University and Director of the Carl Sagan Institute*

Sep Kamvar *LG Associate Professor of Media Arts and Sciences, MIT; Director of the Social Computing Group, MIT Media Lab*

David Krakauer *President, Santa Fe Institute*

Barnaby Marsh *Senior Advisor to the President, John Templeton Foundation*

Gayil Nalls *Artist, Philosopher, and Writer*

Elisa New *Powell M. Cabot Professor of American Literature, Harvard University*

Gerry Ohrstrom *Private Investor and Producer; Former Chairman of G.L. Ohrstrom & Co. and the Ohrstrom Foundation*

Jerry Sabloff *External Professor and Past President, Santa Fe Institute*

Paula Sabloff *External Professor, Santa Fe Institute*

Caleb Scharf *Director of Astrobiology, Columbia University*

Ian Tattersall *Curator Emeritus, American Museum of Natural History*

Nautilus has received financial support from:



Published by:



NAUTILUS think

Copyright © 2017. All rights reserved.

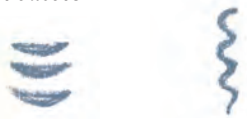
Letters

Reader responses to the Mar/Apr 2017 print edition.

“THE KEKULÉ PROBLEM”

McCarthy says language was extremely useful but did not fulfill a “need.” Can someone explain to me the difference? Anything that is useful is fulfilling a need of some sort. The fact that 5,000 other mammals do fine without it is irrelevant. A human is not a squirrel. A human is not a dog. Humans have human “needs” without which we are not “human.” Artistic expression is a human need. Even amidst the most dire survival situations humans have felt the need to leave a symbolic/artistic record. A human race absent artistic expression would be something else entirely.

—Rob Jacobs



I appreciate McCarthy’s attempt to discuss the presence and influence of the mysterious forces of the unconscious, but it’s difficult not to feel that, ironically, the discussion gives undue weight and influence to language and human consciousness. McCarthy seems to fall into the trap of making the unconscious a more sophisticated version of human consciousness.

—Patrick Horn

“A BRIEF HISTORY OF THE GRAND UNIFIED THEORY OF PHYSICS”

A marvelous recap of 50 years of theoretical physics—a dramatic

tale of spilled GUTs, twisted strings, and broken symmetries. What a strange world we live in! Under those nested layers of increasingly inaccessible explanations, what will we find? More layers? More puzzles? An infinite recursion of theory upon theory? This has to be a discouraging time in the field. Perhaps we need to learn to embrace paradox and admit that our reality and existence is, in some sense, truly miraculous. This does not mean we should stop trying to pierce the veil, but it does call for humility and the admission that we are, after all, merely finite human beings.

—George Gantz

“THE FIFTH FORCE OF PHYSICS IS HANGING BY A THREAD”

Love the fact that Eötvös was testing things like “snake-wood and suet.” Ah, that we could return to the spirit of 19th-century science, with its reverence for particular processes, its massive leaps of imagination, and its willingness to cast its empirical skill-set widely.

—Margaret Wertheim

“WHAT MY STROKE TAUGHT ME”

Fascinating. I wonder how the author’s experience compares to the world as it is perceived by, say, our dogs and cats, or even



human infants and toddlers while they are still non-verbal. Perhaps perceptions are more immediate and redolent without the distracting “background noise” of symbolic language. I’d also like to know how the author experienced music. Perhaps that is treated in her book, which I am eager to read!

—P. Edgar

Nautilus welcomes reader responses.

Please email letters@nautil.us.

All letters are subject to editing.

CONTACT

25 Broadway, 9th Floor

New York, NY 10004

212 221 3870

info@nautil.us

SUBSCRIPTIONS

Visit subscribe.nautil.us



Our global network of
more than 40,000 oncology professionals
works to conquer cancer
and create a world where
cancer is prevented or cured,
and every survivor is healthy.

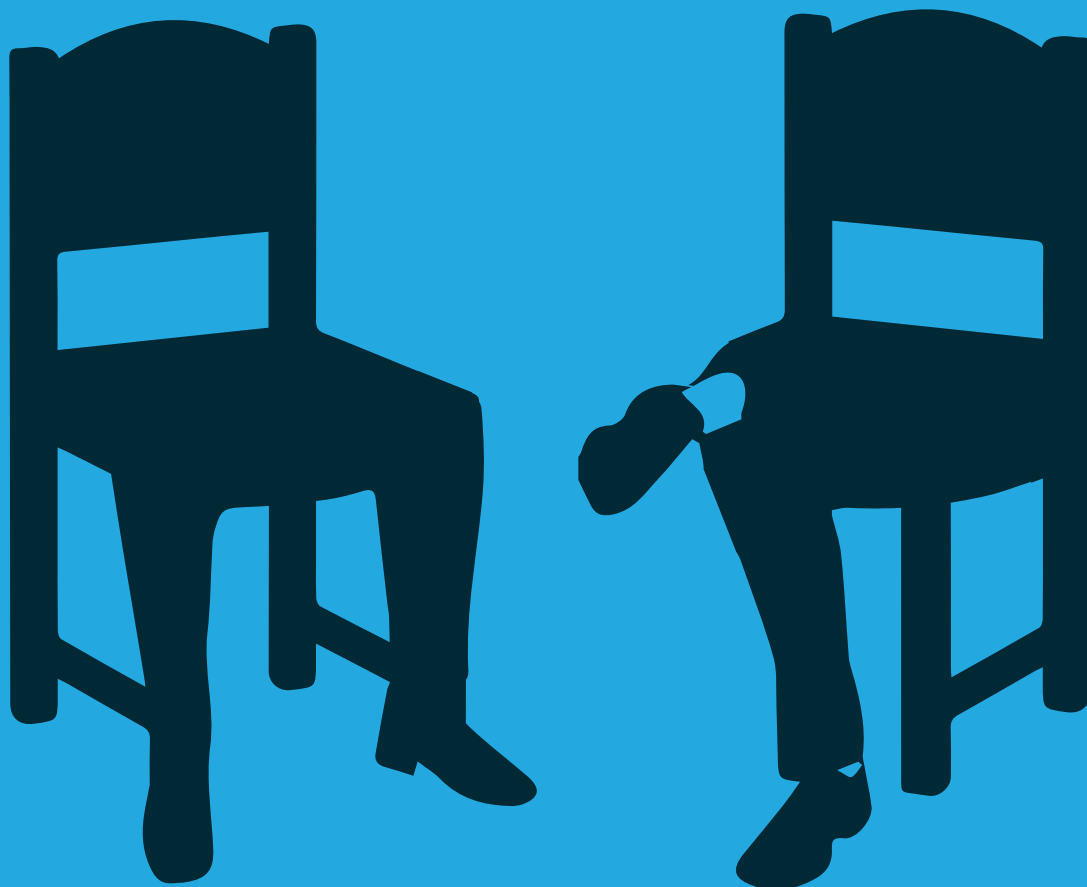
Learn more at asco.org



American Society of Clinical Oncology

Making a world of difference in cancer care

understanding**understanding**

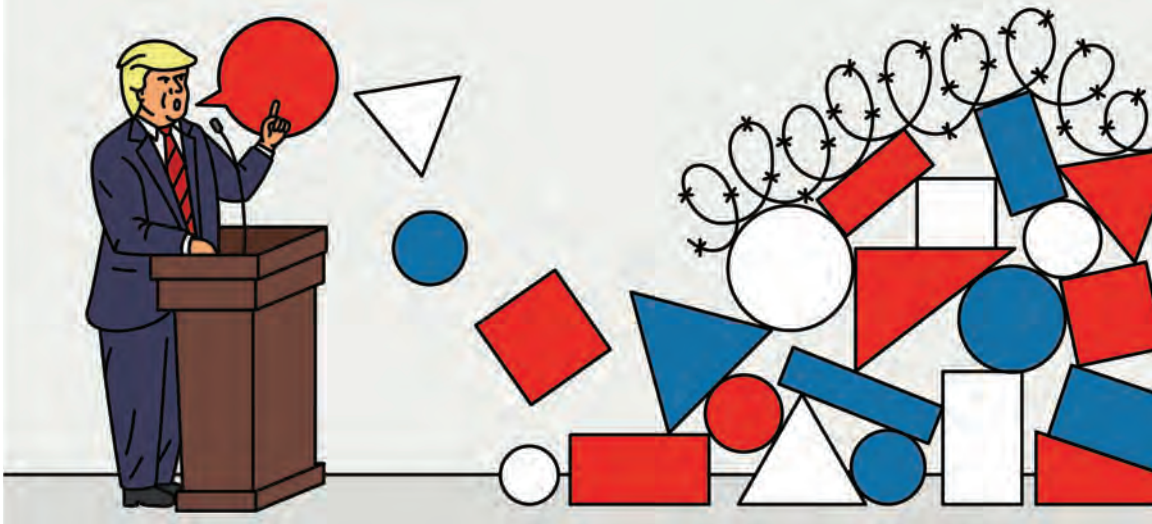


SEPTEMBER 14-17
NANTUCKET, MA

The Nantucket Project is about what matters
in our noisy, messy world. We bring fresh ideas to
curious audiences in live talks, short original films,
and unforgettable experiences.

the **nantucket** project

Preludes



LINGUISTICS

What Trump's Simplified Language Means

I WAS SURPRISED WHEN A PANEL called “The Press and President Trump,” held at the Columbia Journalism School in April, didn’t broach the subject of mental illness. At a recent psychiatry conference at Yale, a group of attendees announced that Trump has a “dangerous mental illness.”

Trump isn’t the first presidential figure to receive psychiatric scrutiny. In 1964, the magazine *Fact* polled psychiatrists on whether Barry Goldwater was psychologically fit for the presidency. “Warped,” “impulsive,” and “paranoid schizophrenic” was how over 1,000 psychiatrists described him. Goldwater successfully sued for libel, and the American Psychiatric Association added the “Goldwater rule” to its ethics code. It forbade making diagnoses without an in-person examination and permission to publicly discuss the results.

“With regard to Trump, however, the rule has been broken repeatedly” by psychotherapists and psychiatrists, Evan Osnos wrote in *The New Yorker*. The story

Trump’s language borders on incapacity.

claims that journalistic coverage of Trump’s mental health doesn’t have to be a flimsy or biased exercise in discerning his thoughts. Over 50,000 mental-health physicians, Osnos notes, have signed a petition declaring Trump, based on copious observational data, is “too seriously mentally ill to perform the duties of president and should be removed” under the 25th Amendment to the Constitution, which says a president can be removed if a congressionally appointed body judges him or her to be “unable to discharge the powers and duties of office.” John Gartner, the psychiatrist who started the petition, said, “The psychiatric interview is hardly

the gold standard, by the way. If you have massive amounts of information about a person's behavior, that can be more accurate. And we have that. If the question is whether we can form a diagnosis from that information, I think it's clear that we can."

Trump's use, or misuse, of language has also been disturbing to experts of constitutional law. Take Laurence Tribe, a Harvard law professor. He said, according to Osnos, "Trump's language borders on incapacity." When asked to explain his reversal on branding China a currency manipulator, Trump said, "No. 1, he's not, since my time. You know, very specific formula. You would think it's like generalities, it's not. They have—they've actually—their currency's gone up. So it's a very, very specific formula." This response could be seen as "gross and pathological inattention or indifference to, or failure to understand" the mandatory duties of the president, Tribe said.

To psycholinguist Julie Sedivy, it's not Trump's rambling language that's worrisome, it's his regular usage. "I think we have rarely had a president who uses such simple and simplifying language," she recently told *Nautilus*.

"There's some interesting research that's looked at the correlation between simple language and the tendency of U.S. presidents to behave in authoritarian ways," Sedivy said. "There is a predictive relationship that speeches expressed using very simple basic language tend to precede very authoritarian acts like the use of executive orders ... That certainly plays out in the

use of the heavy reliance on simple notions like amazing, sad, bad, unfair. These strip away a lot of the complexities that are behind them. They reduce information into very gross impressions. The simplification of points of view, of the good and the bad, and even just the conveyance that, 'We're going to make good deals,' for example. 'It's going to be great.' That this is a simple problem just waiting for someone with the right instincts to come along and solve this, is absolutely pervasive in Trump's language."

And what is the downside of that kind of usage? "The big downside is

that it's false. The world is a complex place. It's not a simple environment. There are many forces interacting simultaneously that elude simple explanations or simple solutions. I've become very aware, through being a scientist, that for every simple, elegant explanation or theory we come up with, we have discovered that the truth is actually not simple or elegant. It's messy, noisy, complex."

By reducing complexity to simplified language, Sedivy said, "we're essentially lying about the nature of the world."

—Brian Gallagher

PSYCHOLOGY

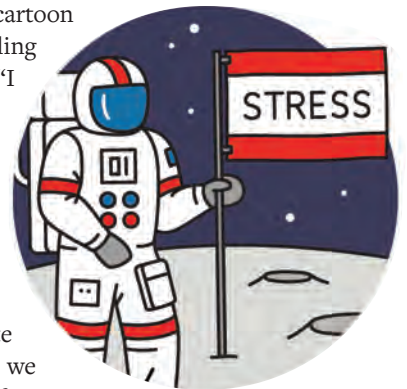
Do You Actually Need More Stress?

THERE'S A *NEW YORKER* cartoon that shows a doctor telling the patient lying in bed, "I don't think you're getting enough stress."

The cartoon is funny because it plays on the idea that stress is bad—how absurd is it that a doctor would prescribe more of it? Why not just offer the patient poison?

But stress—at least in moderate amounts—may not be as harmful as we think. Stress can be beneficial: It focuses our attention, motivates us to perform at our best, and helps us anticipate and overcome problems. In fact, some of our negative experience of stress may have less to do with the nature of stress itself than in how we think about it.

For example, research led by psychologist Alia Crum at Stanford University suggests that people with a "stress-is-enhancing mindset" perform better under pressure and have fewer health



complaints than those with a “stress-is-debilitating mindset.”

In one experiment, she and her colleagues recruited 350 employees who faced the stress of impending layoffs. Some employees watched short videos that emphasized positive aspects of stress, including its ability to help the body cope with difficult tasks, and sharpen cognitive functioning.

Other employees watched videos that showed the downsides of stress: depression, anxiety, distraction. A control group didn’t see any videos. Afterward, employees in the first group reported better work performance and mental health.

Other studies have shown that people who believe stress is harmful suffer more serious health problems. An analysis of data from a 29-year study of thousands of London-based civil servants found that those who believed stress affected their health “a lot or extremely” had a 50 percent greater risk than their less-concerned peers of dying from a heart attack—even after researchers adjusted for biological, behavioral, and psychological risk factors.

So rather than try to rid our lives of stress entirely, we may be better off changing our view of it. According to Harvard Business School professor Alison Wood Brooks, people often tell themselves—or are told—to calm down before an anxiety-producing event such as a performance or test. But because stress is an automatic response, she says, suppressing or hiding anxious feelings is ineffective and can make you feel even more freaked out. She advises to instead reframe anxiety

as excitement. “Whereas anxiety is a negative, aversive emotion that harms performances,” Brooks writes, “excitement is a positive, pleasant emotion that can improve performance.”

Kelly McGonigal, author of *The Upside of Stress*, argues that we can improve our relationship to stress by reminding ourselves that embracing it requires tolerating ambiguity and uncertainty in our lives, and that it is “something that everyone deals with, and not something that proves how uniquely

screwed up you or your life is.”

That’s not to say we should ignore that stress can be destructive, too. “Choosing to see the upside of stress isn’t about denying the fact that stress can be harmful,” McGonigal told the Stanford News Service. “It’s about trying to balance your mindset so that you feel less overwhelmed.”

Stress can be a privilege, allowing us to take risks, to innovate and to explore. All we have to do is believe it.

—Alina Tugend

PSYCHOLOGY

Are You a Self-Interrupter?

MEDIA MULTITASKING—which is accomplished by your brain not performing two tasks simultaneously but instead rapidly switching from one task to another—occurs in every sphere of our world, including home, school, workplace, and our leisure life. *And this is not just limited to the younger generation.* A recent study followed a group of young adults and a group of older adults who wore biometric belts with embedded eyeglass cameras for more than 300 hours of leisure time. While the younger adults switched from task to task 27 times per hour—once every two minutes—the older adults were not all that great at maintaining their attention either, switching tasks 17 times per hour, or once every three to four minutes. Former Microsoft executive Linda Stone dubbed this constant multitasking “continuous partial attention.”

Unless you monitor someone’s computer as well as his or her smartphone and all his or her other devices, it is difficult to know how much task switching is truly occurring. However, several studies have used different research tools to try to assess real-world task switching. For example, in a recent study Larry Rosen’s lab

We appear to have lost the ability to simply be alone with our thoughts.

observed students—ranging from middle school to college age—studying for 15 minutes in an area where they normally study. Shockingly, students could not focus for more than three to five minutes *even when they were told to study something very important.*

Other researchers have asked people to keep detailed diaries of their daily media and technology use; one particular study of 3,048 13- to 65-year-old Dutch teens and adults found that people of all ages multitasked at least a quarter of the time—with teens dual tasking 31 percent of their day—although their most common combinations were different. While 13- to 16-year-olds preferred to combine listening to music with being online, engaging in social media, or viewing online videos, young adults (25 to 29) preferred combining email, watching television, and visiting websites, and older people (50 to 65) preferred combining more traditional media activities such as email and radio, television, and visiting websites.

One interesting aspect of this penchant for combining tasks is that we seem to have lost the ability to *single task*. Glance around a restaurant, look at people walking on a city street, pay attention to people waiting in line for a movie or the theater, and you will see busily tapping fingers. We act as though we are no longer interested in or able to stay idle and simply do nothing. We appear to care more about the people who are available through our devices than those who are right in front of our faces. And perhaps more critically, we appear to

have lost the ability to simply be alone with our thoughts.

Rosen's lab has been studying this phenomenon for the past decade and has seen a constant increase across generations in how often people check in with their devices. The vast majority of young people check their smartphones every 15 minutes or less and 3 out of 4 young adults sleep with their phones nearby with the ringer on or on vibrate so as not to miss a nighttime alert. While the typical college student owns an average of seven tech devices, older adults are not far behind. Where we used to read, we now skim. Where we used to write, we now use shortened fragments. Write a letter? It's

much easier to zip off a brief text or an email message. When Twitter first appeared we used to shake our head at the impossibility of putting our thoughts into "only" 140 characters. Now this appears normal and fits our task-switching lifestyle.

We are most certainly impatient, which you can verify by watching a group of people all checking their phones every three to five minutes regardless of what they are doing at the time or who they are with. A recent study from University of Massachusetts, Amherst, and Akamai Technologies demonstrated our collective impatience by collecting server data from 23 million online video views; the data showed that average viewers begin

ONE QUESTION



"Is John Milton's cosmology of chaos more modern than it seems?"

Ed Simon

Associate Editor at *The Marginalia Review of Books*, a channel of *The Los Angeles Review of Books*

John Milton, whose epic poem *Paradise Lost* turns 350 this year, is often presented as a doctrinaire Christian conservative. In fact, he was familiar with astronomy (having met Galileo) and ended up going against orthodoxy, entertaining a radical cosmology of chaos. "The Womb of nature, and perhaps her Grave," he called it. "But all these in their pregnant causes mixt / Confusedly, and which thus must ever fight." This vision—the universe born out of an eternal undifferentiated chaos—is different from the traditional Christian understanding of creation *ex nihilo*. *Paradise Lost* depicts Lucifer's travels through chaos, a region where neither he nor God seem to have full dominion. Chaos is therefore a field of potentiality, where the providential determinism of God is unclear, but where order can still seemingly arise—a shockingly modern concept, recalling the indeterminism of a fluctuating quantum field with its virtual particles. Milton offers us an alternate cosmology from the earliest days of science, and a fuller understanding of the part chaos has (and hasn't) played in our myths.

to abandon a video if it takes more than two seconds to buffer, and 6 percent more click on something else for every additional second of buffering. Even a brief 10-second delay in starting a video provokes nearly two-thirds of viewers to leave that screen for another source of information. These quantitative data, collected without the knowledge of the viewers, corroborate survey and experimental data highlighting what was originally dubbed the “four-second rule,” referring to the time that an average online shopper is likely to leave a website for another if it does not download.



For those of us who work with technology, interference has become the norm. We are constantly interrupted by others dropping by our desk to chat or attempting to connect with us through a variety of technological communication modalities, including the most popular workplace tool—email. A study by Judy Wajcman, a sociology professor at the London School of Economics, highlighted this phenomenon by shadowing 18 employees of an Australian telecommunications company during their entire workday. Wajcman selected this company because it was designed to facilitate interactions between workers with open-plan offices and other external distractors, including many large television screens mounted around the office. The employees in this study spent only half their workday on actual “work episodes,” which included any and all work-related activities. Strikingly, most of these work episodes lasted 10 minutes or less, with an average of just three minutes per work episode. And even more interesting, nearly two-thirds of the work episode interruptions were self-generated, and most of those involved some form of mediated communication using a technological device.

Whether directed externally via an alert or notification or internally by an unseen process, it appears that in the work environment email and other communication modalities bear a major responsibility for interruptions. One field study that followed workers for two weeks discovered that they were interrupted 4.28 times per hour by email and an additional 3.21

times by instant message communications. And these communications appeared to have a strong draw for the employees, since 41 percent of them responded to the email immediately and 71 percent responded to an instant message immediately. On average, the workers spent 10 minutes dealing with the alerts and then took an additional 10 to 15 minutes to return to their appointed task.

A study out of Loughborough University in England found that people are responding like Pavlov’s dogs to incoming email communication, waiting only an average of one minute and 44 seconds to open that message. Strikingly, 70 percent of those alerts were attended to within six seconds, which is about the time it takes a phone to ring three times. And yet another study found that even without an alert, while one in three people claimed to check their email every 15 minutes, they actually checked it about every five minutes. We are self-interrupting and not even aware of how often we are diverting our attention from our main task—in this case, our job—to another task that may be completely unrelated to work.

—Adam Gazzaley & Larry D. Rosen

Where we used to read, we now skim. Where we used to write, we now use shortened fragments.

Adapted from *The Distracted Mind* with permission of MIT Press.

Animals

by Howard Altmann

It happened in broad daylight.
A museum of world renown was exhibiting
the facts on behalf of the people when
animals stole their way past the absurdists
and the realists with the acclaimed collection.
Disagreement persists as to which animal
is now running with the facts and whether
the perpetrator is the ultimate beneficiary.
If collusion among the species was at play,
one could say the entire kingdom is up for grabs.
If it were one beast acting on its own accord,
friends and family have not come forward
with any clues. On one matter, however,
a consensus remains: the facts will never be
the same. To say they are being dragged
through the mud would be an oversimplification.
To argue that they are being chewed to pieces
suggests that they could be broken down.
And to assume they could even be held
in the jaws of one callous creature is simply grist
for the mill. The reality is that most people
never viewed the facts when they were mounted
or before they were purchased by a family trust
for an undisclosed sum. Only a privileged
few actually held the facts in their hands;
and they are all deceased. While a visit

to their burial sites has been recommended
by a committee of volunteers, access
has been denied, as the pursuit of the facts
has been deemed to be no spiritual matter. And
though roads, bridges, and tunnels have been
sealed off, conventional wisdom has determined
that whatever four-legged species committed
the crime, it is now a flock of birds careening
out of control with the weight of biblical dimension
crushing its wings. Thus all bodies of water
have been summoned back to land, and all
clouds and patches of blue sky are passing through
routine inspection. What has emerged
is a kind of dinosaur, that without the constitution
to breathe in another medium, will not survive.
And so fact-checkers, the world over, have since
been caught lying on their backs, holding
their breath; for this time to pass.

HOWARD ALTMANN is the author of two collections of poetry,
Who Collects the Days and *In This House*.

This poem first appeared in *In This House*, published by Turtle Point
Press in 2010.

Why Your Brain Hates Other People

And how to make it think differently

BY ROBERT SAPOLSKY

AS A KID, I saw the 1968 version of *Planet of the Apes*. As a future primatologist, I was mesmerized. Years later I discovered an anecdote about its filming: At lunchtime, the people playing chimps and those playing gorillas ate in separate groups.

It's been said, "There are two kinds of people in the world: those who divide the world into two kinds of people and those who don't." In reality, there's lots more of the former. And it can be vastly consequential when people are divided into Us and Them, ingroup and outgroup, "the people" (i.e., our kind) and the Others.

Humans universally make Us/Them dichotomies along lines of race, ethnicity, gender, language group, religion, age, socioeconomic status, and so on. And it's not a pretty picture. We do so with remarkable speed and neurobiological efficiency; have complex taxonomies and classifications of ways in which we denigrate Them; do so with a versatility that ranges from the minutest of microaggression to bloodbaths of savagery; and regularly decide what is inferior about Them based on pure emotion, followed by primitive rationalizations that we mistake for rationality. Pretty depressing.

But crucially, there is room for optimism. Much of that is grounded in something definedly human, which is that we all carry multiple Us/Them divisions in our heads. A Them in one case can be an Us in another, and it

ILLUSTRATION BY IGNACIO SERRANO



can only take an instant for that identity to flip. Thus, there is hope that, with science's help, clannishness and xenophobia can lessen, perhaps even so much so that Hollywood-extra chimps and gorillas can break bread together.

THE STRENGTH OF US VERSUS THEM

Considerable evidence suggests that dividing the world into Us and Them is deeply hard-wired in our brains, with an ancient evolutionary legacy. For starters, we detect Us/Them differences with stunning speed. Stick someone in a “functional MRI”—a brain scanner that indicates activity in various brain regions under particular circumstances. Flash up pictures of faces for 50 milliseconds—a 20th of a second—barely at the level of detection. And remarkably, with even such minimal exposure, the brain processes faces of Thems differently than Us-es.

This has been studied extensively with the inflammatory Us/Them of race. Briefly flash up the face of someone of a different race (compared with a same-race face) and, on average, there is preferential activation of the amygdala, a brain region associated with fear, anxiety, and aggression. Moreover, other-race faces cause less activation than do same-race faces in the fusiform cortex, a region specializing in facial recognition; along with that comes less accuracy at remembering other-race faces. Watching a film of a hand being poked with a needle causes an “iso-

morphic reflex,” where the part of the motor cortex corresponding to your own hand activates, and your hand clenches—unless the hand is of another race, in which case less of this effect is produced.

The brain's fault lines dividing Us from Them are also shown with the hormone oxytocin. It's famed for its pro-social effects—oxytocin prompts people to be more trusting, cooperative, and generous. But, crucially, this is how oxytocin influences behavior toward members of your *own* group. When it comes to out-group members, it does the opposite.

The automatic, unconscious nature of Us/Them-ing attests to its depth. This can be demonstrated with the fiendishly clever Implicit Association Test. Suppose you're deeply prejudiced against trolls, consider them inferior to humans. To simplify, this can be revealed with the Implicit Association Test, where subjects look at pictures of humans or trolls, coupled with words with positive or negative connotations. The couplings can support the direction of your biases (e.g., a human face and the word “honest,” a troll face and the word “deceitful”), or can run counter to your biases. And people take slightly longer, a fraction of a second, to process discordant



pairings. It's automatic—you're not fuming about clannish troll business practices or troll brutality in the Battle of Somewhere in 1523. You're processing words and pictures, and your anti-troll bias makes you unconsciously pause, stopped by the dissonance linking troll with "lovely," or human with "malodorous."

We're not alone in Us/Them-ing. It's no news that other primates can make violent Us/Them distinctions; after all, chimps band together and systematically kill the males in a neighboring group.

Recent work, adapting the Implicit Association Test to another species, suggests that even other primates have implicit negative associations with Others. Rhesus monkeys would look at pictures either of members of their own group or strangers, coupled with pictures of things with positive or negative connotations. And monkeys would look longer at pairings discordant with their biases (e.g., pictures of members of their own group with pictures of spiders). These monkeys don't just fight neighbors over resources. They have negative associations about them—"Those guys are like yucky spiders, but us, us, we're like luscious fruit."

Thus, the strength of Us/Them-ing is shown by the: speed and minimal sensory stimuli required for the brain to process group differences; tendency to group according to arbitrary differences, and then imbue those differences with supposedly rational power; unconscious automaticity of such processes; and rudiments of it in other primates. As we'll see now, we tend to think of Us, but not Them, fairly straightforwardly.

THE NATURE OF US

Across cultures and throughout history, people who comprise Us are viewed in similarly self-congratulatory ways—We are more correct, wise, moral, and worthy. Us-ness also involves inflating the merits of our arbitrary markers, which can take some work—rationalizing why our food is tastier, our music more moving, our language more logical or poetic.

Us-ness also carries obligations toward the other guy—for example, in studies in sports stadiums, a researcher posing as a fan, complete with sweatshirt supporting one of the teams and in need of help with something, is more likely to be helped by a fellow fan than by an opposing one.

Ingroup favoritism raises a key question—at our core, do we want Us to do "well" by maximizing absolute levels of well being, or merely "better than," by maximizing the gap between Us and Them?

We typically claim to wish for the former, but can smolder with desire

The core of Us/ Them-ing is emotional and automatic.

for the latter. This can be benign—in a tight pennant race, a loss for the hated rival to a third party is as good as a win for the home team, and for sectarian sports fans, both outcomes similarly activate brain pathways associated with reward and the neurotransmitter dopamine. But sometimes, choosing “better than” over “well” can be disastrous. It’s not a great mindset to think you’ve won World War III if afterward Us have two mud huts and three fire sticks and They have only one of each.

Among the most pro-social things we do for ingroup members is readily forgive them for transgressions. When a Them does something wrong, it reflects essentialism—that’s the way They are, always have been, always will be. When an Us is in the wrong, however, the pull is toward situational interpretations—we’re not usually like that, and here’s the extenuating circumstance to explain why he did this. Situational explanations for misdeeds are the reason why defense lawyers want jurors who will view the defendant as an Us.

Something interesting and different can happen when someone’s transgression airs Us’s dirty laundry, affirming a negative stereotype. Ingroup shame can provoke intense punishment for the benefit of outsiders. Consider Rudy Giuliani, growing up in Brooklyn in an Italian-American enclave dominated by organized crime (Giuliani’s father served time for armed robbery and then worked for a mob loan shark). Giuliani gained prominence in 1985 as the attorney prosecuting the “Five Families” in the Mafia Commission Trial, effectively destroying them. He was strongly motivated to counter the stereotype of “Italian-American” as synonymous with organized crime—“If [the successful prosecution is] not enough to remove the Mafia prejudice, then there probably could not be anything you could do to remove it.” If you want someone to ferociously prosecute Mafiosi, get a proud Italian-American outraged by the

stereotypes generated by the mob.

Thus, being an Us carries an array of ingroup expectations and obligations. Is it possible to switch from one category of Us to another? That’s easy in, say, sports—when a player is traded he doesn’t serve as a fifth column, throwing games in his new uniform to benefit his old team. The core of such a contractual relationship is the fungibility of employer and employee.

At the other extreme are Us memberships that are not fungible, transcending negotiation. People aren’t traded from the Shiites to the Sunnis, or from the Iraqi Kurds to the Sami herders in Finland. It’s

Dividing the world into Us and Them is deeply hard-wired.

a rare Kurd who wants to be Sami, and her ancestors would likely turn over in their graves when she nuzzled her first reindeer. Converts are often subject to retribution by those they left—consider Meriam Ibrahim, sentenced to death in Sudan in 2014 for converting to Christianity—and suspicion from those they joined.

THE NATURE OF THEM

Do we think or feel our way toward disliking Them?

Us/Them-ing is readily framed cognitively. Ruling classes do cognitive cartwheels to justify the status quo. Likewise, it's a cognitive challenge to accommodate the celebrity Them, the neighborly Them who has saved our keister—"Ah, this Them is different."

Viewing Thems in certain threatening ways requires cognitive subtlety. Being afraid that some Them will rob you is rife with affect and particularism. But fearing that those Thems will take our jobs, manipulate the banks, dilute our bloodlines, etc., requires thoughts about economics, sociology, and pseudoscience.

Despite that role of cognition, the core of Us/Them-ing is emotional and automatic, as summarized by when we say, "I can't put my finger on why, but it's just wrong when They do that." Jonathan Haidt of New York University has shown that often, cognitions are post-hoc justifications for feelings and intuitions, to convince ourselves that we have indeed rationally put our finger on why.

This can be shown with neuroimaging studies. As noted, when fleetingly seeing the face of a Them, the amygdala activates. Critically, this comes long before (on the time scale of brain processing) more cognitive, cortical regions are processing the Them. The emotions come first.

The strongest evidence that abrasive Them-ing originates in emotional, automatic processes is that supposed rational cognitions about Thems can be unconsciously manipulated. Just consider this array of findings: Show subjects slides about some obscure country; afterward, they will have more negative attitudes toward the place if, between slides, pictures of faces with expressions of fear appeared at subliminal speeds. Sitting near smelly garbage makes people more socially conservative about outgroup issues (e.g., attitudes toward gay marriage among heterosexuals). Christians express more negative attitudes toward non-Christians if they've just walked past a church. In another study, commuters at train stations in predominantly white suburbs filled out questionnaires about political views. Then, at half the stations, a pair of young Mexicans, conservatively dressed and chatting quietly, appeared daily on the platform for two weeks. Then commuters filled out second questionnaires. Remarkably, the presence of such pairs made people more supportive of decreasing *legal* immigration from Mexico and making English the official language, and more opposed to amnesty for undocumented immigrants (without changing attitudes about Asian-Americans, African-Americans or Middle Easterners). Women, when ovulating, have



IT'S NEGOTIABLE When a Confederate general was wounded during the U.S. Civil War, he gave a secret Masonic sign that was recognized by a Union officer, who protected him and took him to a Union hospital.

more negative attitudes about outgroup men.

In other words, our visceral, emotional views of Them are shaped by subterranean forces we'd never suspect. And then our cognitions sprint to catch up with our affective selves, generating the minute factoid or plausible fabrication that explains why we hate Them. It's a kind of confirmation bias: remembering supportive better than opposing evidence; testing things in ways that can support but not negate your hypothesis; skeptically probing outcomes you don't like more than ones you do.

THE HETEROGENEITY OF THEM

Of course, different types of Them evoke different feelings (and different neurobiological responses). Most common is to view Them as threatening, angry, and untrustworthy. In economic games people implicitly treat other-race individuals as less trustworthy or reciprocating. Whites judge African-American faces as angrier than white faces, and are more likely to categorize racially ambiguous angry faces as the other race.

But Them's do not solely evoke a sense of menace; sometimes, it's disgust. This brings up one fascinating brain region, the insula. In mammals, it responds to the taste or smell of something rotten, and triggers stomach lurching and gag reflexes. In other words, it protects animals from poisonous food. Crucially, in humans the insula not only mediates such sensory disgust, but also moral disgust—have subjects recount

something rotten they've done, show them pictures of morally appalling things (e.g., a lynching), and the insula activates. It's why it's not just metaphorical that sufficiently morally disgusting material makes us feel sick to our stomachs. And Thems that typically evoke a sense of disgust (e.g. drug addicts) activate the insula at least as much as the amygdala.

Having viscerally negative feelings about abstract features of Thems is challenging; being disgusted by another group's abstract beliefs isn't easy for the insula. Us/Them markers provide a stepping-stone. Feeling disgusted by Them because they eat repulsive, sacred, or adorable things, slather themselves with rancid scents, dress in scandalous ways—this the insula can sink its teeth into. In the words of the psychologist Paul Rozin of the University of Pennsylvania, "Disgust serves as an ethnic or outgroup marker." Deciding that They eat disgusting things facilitates deciding that They also have disgusting ideas about, say, deontological ethics.

Then there are Thems who are ridiculous, i.e., subject to ridicule, humor as hostility. Outgroups mocking the ingroup is a weapon of the weak, lessening the sting of subordination. But when an ingroup mocks an outgroup, it solidifies negative stereotypes and reifies the hierarchy.

Thems are also frequently viewed as more homogeneous than Us, with simpler emotions and less sensitivity to pain. For example, whether in ancient Rome, medieval England, imperial China, or the antebellum South, the elite had system-justifying stereotypes of slaves as simple, childlike, and incapable of independence.

Thus, different Thems come in different flavors with immutable, icky essences—threatening and angry, disgusting and repellent, ridiculous, primitive, and undifferentiated.

COLD AND/OR INCOMPETENT

Important work by Susan Fiske of Princeton University explores the taxonomies of Thems we carry in our heads. She finds that we tend to categorize Thems along two axes: "warmth" (is the individual or group a friend or foe, benevolent or malevolent?) and "competence" (how effectively can the individual or group carry out their intentions?).

The axes are independent. Ask subjects to assess someone; priming them with cues about the person's status alters ratings of competence but not of warmth. Priming about the person's competitiveness does

Between envy and disgust are our most hostile urges.

the opposite. These two axes produce a matrix with four corners. We rate ourselves as high in both warmth and competence (H/H), naturally. Americans typically rate good Christians, African-American professionals, and the middle class this way.

There's the other extreme, low in both warmth and competence (L/L). Such ratings go to the homeless or addicts.

Then there's the high-warmth/low-competence (H/L) realm—the mentally disabled, people with handicaps, infirm elderly. Low warmth/high competence (L/H) is how people in the developing world tend to view the Europeans who colonized them (“competence” here is not about skill at rocket science, but rather the efficacy those people had when getting it into their heads to, say, steal your ancestral lands), and how many minority Americans view whites. It's the hostile stereotype of Asian-Americans by white America, of Jews in Europe, of Indo-Pakistanis in East Africa, of Lebanese in West Africa, of ethnic Chinese in Indonesia, and of the rich by the poor most everywhere—they're cold, greedy, clannish but, dang, go to one who is a doctor if you're seriously sick.

Each extreme tends to evoke consistent feelings. For H/H (i.e., Us), there's pride. L/H—envy and resentment. H/L—pity. L/L—disgust. Viewing pictures of L/L people activates the amygdala and insula, but not the fusiform face area; this is the same profile evoked by a picture of, say, a maggot-infested wound. In contrast, viewing L/H or H/L individuals activates emotional and cognitive parts of the frontal cortex.

The places between the extremes evoke their own characteristic responses. Individuals who evoke a reaction between pity and pride evoke a desire to help. Floating between pity and disgust is a desire to exclude and demean. Between pride and envy is a desire to associate, to derive benefits from. And between envy and disgust are our most hostile urges to attack.

What fascinates me is when someone's categorization changes. Most straightforward are shifts from high-warmth/high-competence (H/H) status:

H/H to H/L: A parent declining into dementia, evoking poignant protectiveness.

H/H to L/H: The business partner who turns out to have embezzled for decades. Betrayal.

H/H to L/L: The rare instance of that successful acquaintance, where “something happened” and now he's homeless. Disgust mingled with bafflement—what went wrong?

Then there's L/L to L/H. When I was a kid in the '60s, the parochial American view of Japan was the former—World War II's shadow generating dislike and contempt, and “Made in Japan” was about cheap plastic gewgaws. Then, suddenly, “Made in Japan” meant outcompeting

American automakers.

When a homeless guy does cartwheels to return someone's lost wallet—and you realize he's more decent than your friends—that's L/L to H/L.

Most interesting to me is L/H to L/L, which invokes gleeful gloating, helping to explain why persecution of L/H groups usually involves degrading and humiliating them to L/L status. During China's Cultural Revolution, resented elites were first paraded in dunce caps before exile to labor camps. Nazis eliminated the mentally ill, already viewed as L/L, by unceremoniously murdering them; in contrast, pre-murder treatment of the L/H Jews involved forcing them to wear degrading yellow armbands, cutting one another's beards, scrubbing sidewalks with toothbrushes before jeering crowds. When Idi Amin expelled tens of thousands of L/H Indo-Pakistani citizens from Uganda in the 1970s, he first invited his army to rob, beat, and rape them. Turning L/H Them into L/L Them accounts for some of our worst savagery.

Complexities in our categorization of Them abound. There's the phenomenon of the grudging respect, even a sense of camaraderie with an enemy, the perhaps apocryphal picture of World War I flying aces, where a glimmer of Us-ness is shared with someone trying to kill you ("Ah, monsieur, if it were another time, I would delight in discussing aeronautics with you over some good wine." "Baron, it is an honor that it is you who shoots me out of the sky"). And there's the intricacies of differing feelings about economic versus cultural enemies, new versus ancient ones, or the distant alien enemy versus the familiar one next door (consider Ho Chi Minh, rejecting the offer of help from Chinese troops during the Vietnam War, stating to the effect of "The Americans will leave in a year or a decade, but the Chinese will stay for a thousand years if we let them in").

And then there is the profoundly strange phenomenon of the self-hating _____ (take your pick of the outgroup member), who has bought into the negative stereotypes and favors the ingroup. This was shown by psychologists Kenneth and Mamie Clark in their heart-breaking "doll studies," in the 1940s, demonstrating how African-American children, along with white children, preferred playing with white dolls over black ones, ascribing more positive attributes to them (e.g., nice, pretty). That this effect was most pronounced in black kids in segregated schools was cited in *Brown v. Board of Education*. Or consider the scenario of the strident crusader against gay rights who turns out to be closeted—the Mobius strip



pathology of accepting that you are an inferior Them. We put monkeys, even with their complexities of associating alien monkeys with spiders, to shame when it comes to the psychological vagaries of dividing the world into Us and Them.

MULTIPLE US-ES

We also recognize that other individuals belong to multiple categories, and shift which we consider most relevant. Not surprisingly, lots of that literature concerns race, exploring whether it is an Us/Them categorization that trumps all others.

The primacy of race has folk-intuition appeal. First, race is a biological attribute, a conspicuous fixed identity that readily prompts essentialist thinking. Moreover, humans evolved under conditions where different skin color conspicuously signals that someone is a distant Them. Furthermore, a large percentage of cultures, long before Western contact, make status distinctions by skin color.

And yet, evidence is to the contrary. First, while there are obvious biological contributions to racial differences, “race” is a biological continuum rather than discrete categories—for example, unless you cherry-pick the data, genetic variation within race is generally as great as between races. And this really is no surprise when looking at the range of variation within a racial rubric—go compare, say, Sicilians with Swedes.

Moreover, race fails as a fixed classification system. At various times in U.S. census history, “Mexican” and “Armenian” were considered races; southern Italians and northern Europeans were classified differently; someone with one black great-grandparent and seven white ones was “white” in Oregon but not Florida. This is race as a cultural construct.

So it’s not surprising that racial Us/Them dichotomies are frequently trumped by other classifications. In one study, subjects saw pictures of individuals, each black or white, each associated with a statement, and then had to recall which face went with which statement. There was

automatic racial categorization—if subjects misattributed a quote, the correct and incorrect faces were likely to be of the same race. Next, half the blacks and whites pictured wore the same distinctive yellow shirt; the other half wore gray. Now subjects most often confused statements by shirt color. Furthermore, gender reclassification particularly overrides unconscious racial categorization. After all, while races have evolved relatively recently in hominid history (probably over the course of just a few

There are Us/ Thems that I would kill or die for.

tens of thousands of years), our ancestors, almost all the way back to when they were paramécia, cared about Boy or Girl.

Important research by Mary Wheeler along with Fiske showed how categorization is shifted, studying other-race/amygdala activation. When subjects are instructed to look for a distinctive dot in each picture, other-race faces don't activate the amygdala; face-ness wasn't being processed. Judging whether each face looked older than some age wasn't a recategorization that could eliminate the other-race amygdaloid response. But for a third group of subjects, a vegetable was displayed before each face; subjects judged whether the person liked that vegetable. And the amygdala didn't respond to other-race faces.

Why? You look at the Them, thinking about what food she'd like. You picture her shopping, or ordering a meal in a restaurant. Best case scenario, you decide you and she share some vegetable preference—a smidgen of Us-ness. Worst case, you decide you two differ, a relatively benign Them—history is not stained with blood spilled by animosities between partisans for broccoli versus cauliflower. Most importantly, as you imagine her sitting at dinner, enjoying that food, you are thinking of her as an *individual*, the surest way to weaken automatic categorization of someone as a Them.

Rapid recategorizations can occur in the most brutal, unlikely, and intensely poignant circumstances:

- In the Battle of Gettysburg, Confederate general Lewis Armistead was mortally wounded. As he lay on the battlefield, he gave a secret Masonic sign, hoping it would be recognized by a fellow Mason. It was, by Union officer Hiram Bingham, who protected him, and got him to a Union field hospital. In an instant the Us/Them of Union/Confederate faded before Mason/non-Mason.
- During World War II, British commandos kidnapped German general Heinrich Kreipe in Crete, followed by a dangerous 18-day march to the coast to rendezvous with a British ship. One day the party saw the snows of Crete's highest peak. Kreipe mumbled to himself the first line (in Latin) of an ode by Horace about a snowcapped mountain. At which point the British commander, Patrick Leigh Fermor, continued the recitation. The two men realized that they had, in Leigh Fermor's words, "drunk at the same fountains." A recategorization. Leigh Fermor had Kreipe's wounds treated and personally ensured his safety. The two stayed in touch after the war and were reunited decades later on Greek television. "No hard feelings," said Kreipe, praising their "daring operation."
- And finally there is the World War I Christmas truce, where opposing trench soldiers spent the day singing, praying, and partying together, playing soccer, and exchanging gifts, where soldiers up and down the lines struggled to extend the truce. It took all of one day for British-versus-German to yield to something more important—*all* of us in the trenches versus the officers in the rear who want us to kill each other.

We all have multiple dichotomies in our heads, and ones that seem

inevitable and crucial can, under the right circumstances, evaporate in an instant.

LESSENING THE IMPACT OF US/THEM-ING

So how can we *make* these dichotomies evaporate? Some thoughts:

Contact: The consequences of growing up amid diversity just discussed bring us to the effects of prolonged contact on Us/Theming. In the 1950s the psychologist Gordon Allport proposed “contact theory.” Inaccurate version: bring Us-es and Them-s together (say, teenagers from two hostile nations in a summer camp), animosities disappear, similarities start to outweigh differences, everyone becomes an Us. More accurate version: put Us and Them-s together under narrow circumstances and something sort of resembling that happens, but you can also blow it and worsen things.

Some of the effective narrower circumstances: each side has roughly equal numbers; everyone’s treated equally and unambiguously; contact is lengthy and on neutral territory; there are “superordinate” goals where everyone works together on a meaningful task (say, summer campers turning a meadow into a soccer field).

Even then, effects are typically limited—Us-es and Them-s quickly lose touch, changes are transient and often specific—“I hate those Them-s, but I know one from last summer who’s actually a good guy.” Where contact really causes fundamental change is when it is prolonged. Then we’re making progress.

Approaching the implicit: If you want to lessen an implicit Us/Them response, one good way is priming beforehand with a counter-stereotype (e.g., a reminder of a beloved celebrity Them). Another approach is making the implicit explicit—show people their implicit biases. Another is a powerful cognitive tool—perspective taking. Pretend you’re a Them and explain your grievances. How would you feel? Would your feet hurt after walking a mile in their shoes?

Replace essentialism with individuation: In one study, white subjects were asked about their acceptance of racial inequalities. Half were first primed toward essentialist thinking, being told, “Scientists pinpoint the genetic underpinnings of race.” Half heard an anti-essentialist prime—“Scientists reveal that race has no genetic basis.” The latter made subjects less accepting of inequalities.



Flatten hierarchies: Steep ones sharpen Us/Them differences, as those on top justify their status by denigrating the have-nots, while the latter view the ruling class as low warmth/high competence. For example, the cultural trope that the poor are more carefree, in touch with and able to enjoy life's simple pleasures while the rich are unhappy, stressed, and burdened with responsibility (think of miserable Scrooge and those happy-go-lucky Cratchits). Likewise with the "they're poor but loving" myth of framing the poor as high warmth/low competence. In one study of 37 countries, the greater the income inequality, the more the wealthy held such attitudes.

SOME CONCLUSIONS

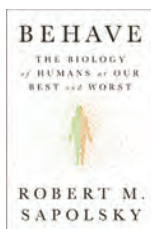
From massive barbarity to pinpricks of microaggression, Us versus Them has produced oceans of pain. Yet, I don't think our goal should be to "cure" us of all Us/Them dichotomizing (separate of it being impossible, unless you have no amygdala).

I'm fairly solitary—I've spent a lot of my life living alone in a tent in Africa, studying another species. Yet some of my most exquisitely happy moments have come from feeling like an Us, feeling accepted, safe, and not alone, feeling part of something large and enveloping, with a sense of being on the right side and doing both well and good. There are even Us/Thems that I—eggheaded, meek, and amorphously pacifistic—would kill or die for.

If we accept that there will always be sides, it's challenging to always be on the side of angels. Distrust essentialism. Remember that supposed rationality is often just rationalization, playing catch-up with subterranean forces we never suspect. Focus on shared goals. Practice perspective taking. Individuate, individuate, individuate. And recall how often, historically, the truly malignant Thems hid themselves while making third parties the fall guy.

Meanwhile, give the right-of-way to people driving cars with the "Mean people suck" bumper sticker, and remind everyone that we're in this together against Lord Voldemort and House Slytherin. ☺

ROBERT SAPOLSKY is a professor of biology, neurology, and neurosurgery at Stanford University, and author of *A Primate's Memoir*, *Why Zebras Don't Get Ulcers*, and *Behave: The Biology of Humans at Our Best and Worst*, his newest book.



From *Behave: The Biology of Humans at Our Best and Worst* by Robert M. Sapolsky, published on May 2, 2017 by Penguin Press, an imprint of Penguin Publishing Group, a division of Penguin Random House, LLC. Copyright © 2017 by Robert M. Sapolsky.

48

WHAT A MAKEOVER chaos has had. In the Bible it is mentioned alongside desolation and destruction. Shakespeare wrote of a “sin-concealing chaos,” and Newton opposed it to the laws of nature.

Then, in the last century, we decided to look more closely. The motivation, at its core, was a simple one: If there is only order and chaos, where else can order come from?

What we found recast the fallow into the fertile. At the borders between chaos and order were seeds for new insights into information, war, physiology, and physics. Structure was not just visible—it was created, transformed, and destroyed.

This strikes a hopeful note: Bits of chaos can be tamed, or at least circumscribed. But are we willing to accept that most of it never will be?

Welcome to “Chaos.”

—MS

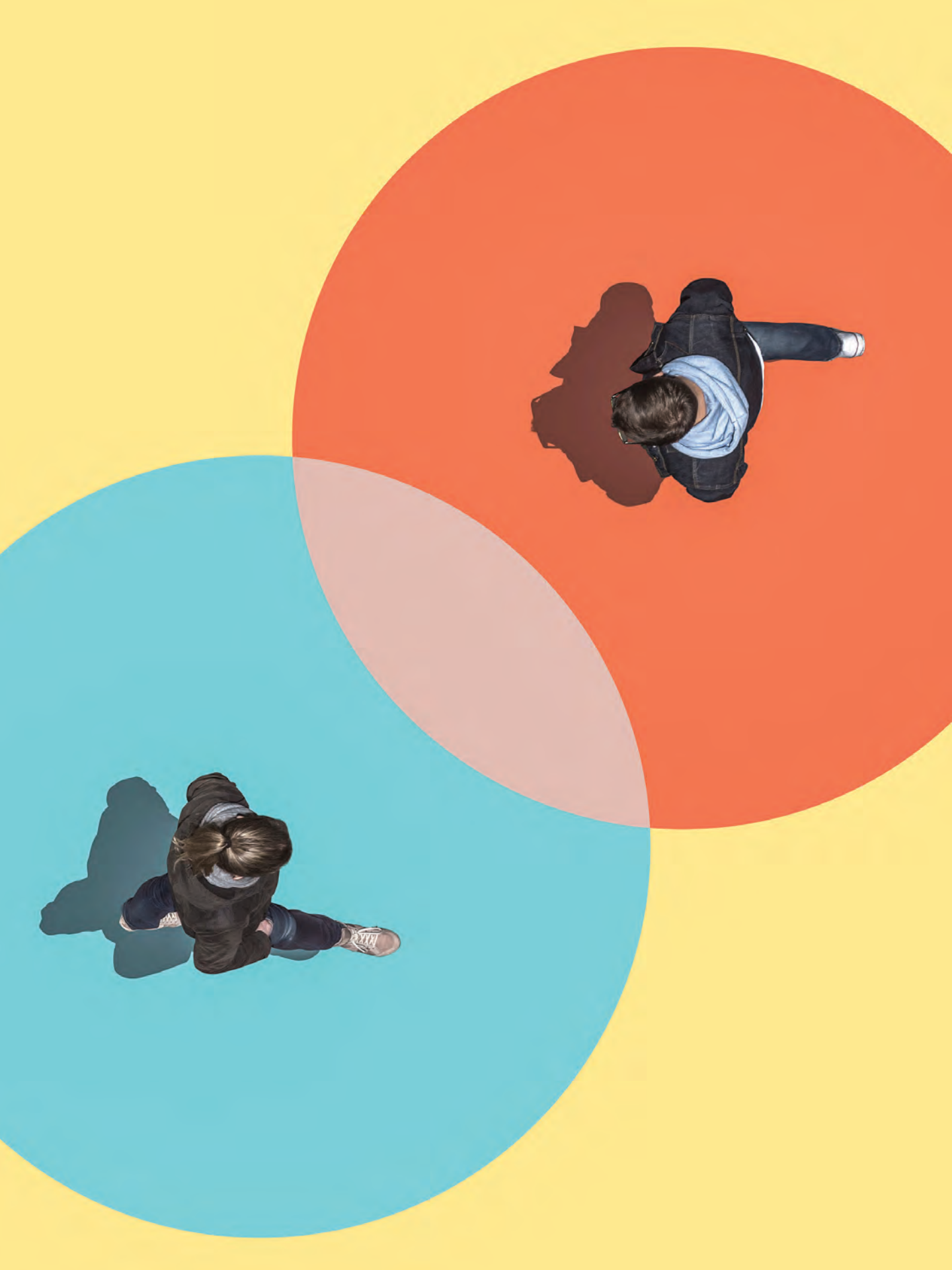
“The best response to social divisions may sometimes involve doing something counterintuitive: lowering empathy for our ingroup and distancing from our own kind.”

ERIKA WEISZ & JAMIL ZAKI

“The Case for Less Solidarity” p.36

Chaos

OUT OF ORDER



The Case for Less Solidarity

The surprising effects of reducing empathy for your own ingroup

BY ERIKA WEISZ & JAMIL ZAKI

THERE'S A LOT OF TALK in this country about the federal deficit," then-Senator Barack Obama said in a 2006 commencement address at Northwestern University. "But I think we should talk more about our empathy deficit." What we need, he said, was the ability to "see the world through those who are different from us."

Since Obama's speech, the phrase "empathy deficit" has gained a foothold, appearing everywhere from academic journals to mainstream media outlets. Among the varied responses to the 2016 United States presidential election were calls for a greater general empathy. Many liberals tried to peer across party lines to understand the motivations of Donald Trump voters, for instance, interviewing Republican constituents and reading books about rural poverty (think J.D. Vance's *Hillbilly Elegy* or Arlie Hochschild's *Strangers in Their Own Land*). But these efforts didn't alleviate tension between parties, which might be because empathy-building efforts don't always work. They can

even backfire in some cases: when people take the perspective of someone they think will act selfishly, they act more selfishly themselves.¹ If empathy deficits fuel social divisions, why doesn't empathy building salve them?

Maybe the problem is not with the remedy, but with the diagnosis. Empathy is not like the volume knob on a stereo, which tunes all frequencies of a piece of music identically; it's more like an equalizer, which boosts different frequencies by different amounts. Rather than empathizing more or less overall—and changing the quantity of a single empathy deficit—we tune our empathy, boosting it for some while lowering it for others. Even people who empathize a lot can still suffer from an empathy *imbalance*—greater empathy for people who look, think, and act like themselves (their ingroup) and reduced empathy for those who don't (their outgroup).

Research suggests that imbalances can be a bigger problem than deficits. This year, psychologists Emile

Bruneau, Mina Cikara, and Rebecca Saxe measured the empathy in three ingroup-outgroup pairs: Americans versus Arabs, Greeks versus Germans, and Hungarians versus refugees. They found that people who empathized more with their ingroup than outgroup—an empathy imbalance—held more negative attitudes toward outsiders, and even a willingness to harm them. In fact, a person’s imbalance mattered more than their overall level of empathy.²

Conflict-resolution programs designed to increase overall empathy could backfire if they increase ingroup empathy in an already imbalanced situation. The more empathy someone feels for their ingroup, the more damage they might be willing to inflict to protect it. The people who are most bound to their own group also tend to be the most biased, unwilling to consider information distasteful to their group’s preference. In one study, psychologist Geoff Cohen showed that in evaluating new laws, people care more about which political party proposed it than the content of the law. What’s more, people aren’t aware of this tendency and maintain that their evaluation reflects personal beliefs and an objective assessment of policy content.³

The best response to social divisions may sometimes involve doing something counterintuitive: lowering empathy for our ingroup and distancing from our own kind.

But is this even possible?

ALTHOUGH THEY MAY BE less apparent, there have also been episodes of ingroup de-empathizing that address empathy imbalances rather than deficits. In January 2017, U.S. senators John McCain and Lindsey Graham publicly criticized Trump’s travel ban preventing people from seven Muslim-majority nations from entering the U.S., calling it a “self-inflicted wound” in the fight against terrorism. McCain, who has since been crowned “Critic in Chief” by *The New York Times*, frequently condemns Trump: He pushed back when Trump called the U.S. military raid in Yemen “a huge success,” and when Trump suggested the U.S. and Russia were moral equals. Despite being a lifelong Republican, McCain regularly speaks out against his own party.

There are similar stories on the left. After Trump’s election, the Anti-Facist (Antifa) movement resurged and, in February, stoked violence while protesting Milo

People can
ignore the
instinct to
follow the
crowd—
particularly
if someone
already has.



A NEW PERSPECTIVE Studies have shown that empathy for outgroups can be boosted when the opinions and practices of ingroups are questioned.

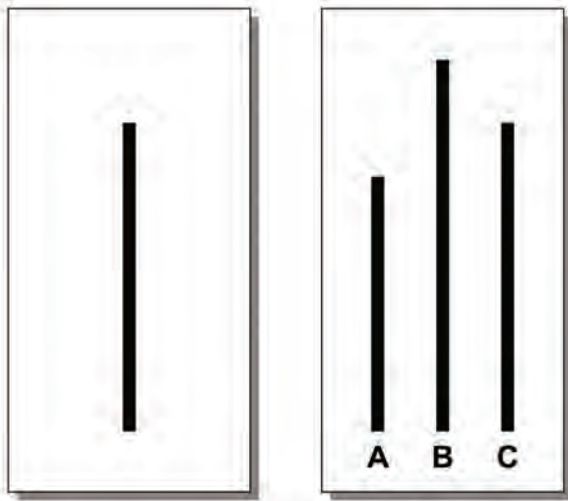
Yiannopolous’s speech at the University of California, Berkeley, breaking windows and launching fireworks at campus buildings. Liberals quickly distanced themselves in response, asserting that this outburst undermined their values. In condemning the edge of their own party, they extended an olive branch across party lines.

Researchers call these acts “emotional compensation:” adjusting one’s own feelings to balance out those of their peers when a person feels their group has gone emotionally awry. For instance, the psychologist Amit Goldenberg finds that individuals express more guilt at social injustice if they see their group as too comfortable with it. He and his colleagues presented Jewish Israelis with a news story about a Palestinian girl who was deported under a new immigration law. He told some people that other Israelis felt little guilt, and others that their group felt a lot of it. The less guilty their group seemed, the more guilt they felt individually.⁴

Rejecting the feelings or actions of one’s own group also plays a role in whistleblowing. The psychologists

Adam Waytz, James Dungan, and Liane Young argue whistleblowing involves a tradeoff between the desire to be fair and the desire to be loyal. These desires clash when an ingroup does something a member deems unethical. Waytz and colleagues asked individuals to write essays about the importance of fairness or of loyalty, then perform an unrelated group-based task (in which they wrote out the numbers 1 to 30 in English). At the end of the experiment, participants were given an opportunity to inform the researchers about a fellow participant’s rule breaking during the task. People who wrote about valuing fairness were more likely to report on ingroup rule breaking, while people who wrote about valuing loyalty were more likely to let bad behavior slide.⁵

Waytz, Dungan, and Young suggest that institutions should promote fairness norms—just and ethical treatment of all persons and groups—and even try to redefine loyalty among members to include the reporting of unethical behavior. This way, whistleblowing—and, potentially, other kinds of emotional



GET IN LINE When asked which of the lines on the right is the same length as the line on the left, participants in Solomon Asch's experiments were easily swayed by the answers of others.

compensation—could come to be seen as a pro-group behavior done to preserve a group's integrity instead of an act of betrayal. Internal disagreement can even come to be celebrated. The American Foreign Service Association, for example, honors employees with Constructive Dissent Awards for challenging departmental policies in non-public forums.

IT CAN BE HARD to distance one's self from one's own group, but ingroup de-empathizing is not just possible—it is common. When used right, it helps resolve conflict when traditional methods fall short, and can encourage groups to engage in a wider self-reflection.

In a famous series of experiments on conformity in the 1950s, psychologist Solomon Asch demonstrated people's extraordinary sensitivity to social influence in deciding on truth claims. Asch assembled a group consisting of study participants mixed with research staff pretending to be study participants. He then asked them to decide whether a set of lines had the same length or not. When the research staff pretended to believe that two lines of different size were actually equal in length, the real participants tended to agree with them, doubting their own judgment. In Asch's experiments, 75 percent of participants agreed with an incorrect answer at least once.⁶

In further studies, Asch showed that such

conformity is not inevitable, and people can ignore the instinct to follow the crowd—particularly if someone already has. When the research staff pretending to be regular participants were not in unanimous agreement, it made it easier for participants to resist the pull of the group, and considerably reduced rates of conformity. Courage is contagious, and when one person speaks out against their group others follow suit. Inside every group member is a potential lone dissenter who can restore a sense of individuality and create a foundation for constructive dissent.

Though it's not easy, distancing ourselves from our own ingroups can help one person become a few people, a few people become a group, and a group become a movement. And that can make all the difference. ☺

ERIKA WEISZ is a doctoral candidate in the Stanford Social Neuroscience Lab. She studies motivations that drive people toward or away from empathy, and develops empathy-building interventions.

JAMIL ZAKI is a professor of psychology at Stanford University and the director of the Stanford Social Neuroscience Lab. He has written about psychology and neuroscience for *The New York Times*, *The Atlantic*, *Nautilus*, *Scientific American*, and *Wired*, among others. He is currently at work on a book, *Choosing Empathy*, which focuses on building empathy under difficult circumstances.

REFERENCES

1. Epley, N., Caruso, E., & Bazerman, M.H. When perspective taking increases taking: reactive egoism in social interaction. *Journal of Personality and Social Psychology* **91**, 872–889 (2006).
2. Bruneau, E. G., Cikara, M., & Saxe, R. Parochial empathy predicts the reduced altruism and the endorsement of passive harm. *Social Psychological and Personality Science*. Retrieved from DOI: 10.1177/1948550617693064
3. Cohen, G. L. Party over policy: The dominating impact of group influence on political beliefs. *Journal of Personality and Social Psychology* **85**, 808–822 (2003).
4. Goldenberg, A., Saguy, T., & Halperin, E. How group-based emotions are shaped by collective emotions: Evidence for emotional burden and emotional transfer. *Journal of Personality and Social Psychology* **107**, 581–596 (2014).
5. Waytz, A., Dungan, J., & Young, L. The whistleblower's dilemma and the fairness-loyalty tradeoff. *Journal of Experimental Social Psychology* **49**, 1027–1033 (2013).
6. Asch, S.E. Studies of independence and conformity: A minority of one against a unanimous majority. *Psychological Monographs* **70**, 1–70 (1956).



The Inflated Debate Over Cosmic Inflation

Why the majority of physicists are on one side of a recent exchange of letters

BY AMANDA GEFTER



ON THE MORNING OF DEC. 7, 1979, a 32-year-old Alan Guth woke up with an idea. It had come into his head the previous night, but now, in the light of a California day, he could see the shape of the thing, and was itching to work through the math. He hopped on his bike and rode to his office at the Stanford Linear Accelerator Center. His excitement got him there in record time: 9 minutes, 32 seconds. At his desk, Guth neatly carried out the calculations in his notebook, forming the numbers and symbols in tight, careful lines. Then, at the top of a fresh page, he wrote in all caps: SPECTACULAR REALIZATION.

A year later and some 6,000 miles away, in Moscow, in the middle of the night, Andrei Linde, having read Guth's paper, had his own spectacular realization. He had been working on his own idea and now he saw how to bring it to life by fixing the difficulties that plagued Guth's theory. He woke his sleeping wife. "I think I know how the universe was created."

Guth and Linde had worked out the beginnings

of the theory of cosmic inflation. The theory would go through several incarnations over the next few decades, as kinks were worked out and details honed. But the core idea was spectacularly simple: In the earliest fraction of a second of time, a small patch of universe expanded faster than the speed of light, doubling its size again and again, growing a million trillion trillion times bigger in the blink of an eye. A little patch of world, about the size of a dime, grew into our entire observable universe.

What began as a radical notion has now become standard wisdom among physicists—except, notably, Paul Steinhardt, Anna Ijjas, and Avi Loeb. The three physicists recently wrote a scathing article in *Scientific American* arguing that it's time to abandon inflation and look for a competing idea. (What idea, you ask? Steinhardt, conveniently, has one that he's been pushing for decades.) Inflation is too unlikely to occur, too flexible to be confirmed or rejected experimentally, and too messy in its implications, the



THE OBJECTORS

From top to bottom: Anna Ijjas, the John A. Wheeler Postdoctoral Fellow at the Princeton Center for Theoretical Science; Paul Steinhardt, a professor of physics at Princeton University and director of the Princeton Center for Theoretical Science; and Avi Loeb, chair of the department of astronomy at Harvard University.

threesome argued. It “cannot be evaluated using the scientific method.”

It’s not surprising, then, that Guth and Linde—along with physicists David Kaiser and Yasunori Nomura—published a terse response in *Scientific American* earlier this month defending their theory. What is more surprising, perhaps, is that 29 more of the world’s leading physicists signed it—including four Nobel laureates and a Field’s medalist.

In the media flurry that followed, the disagreement between these groups of physicists was presented as a straight debate, of the kind that often occurs in science when there are multiple interpretations of data. But describing an equivalence between the opinions of Steinhardt, Ijjas, and Loeb on the one hand, and nearly the entirely cosmology community on the other, is a mistake.

The long list of signatories to the recent rebuttal letter in *Scientific American* puts the lie to the claim that the community is divided. When Ed Witten, Steven Weinberg, Leonard Susskind, Frank Wilczek, Juan Maldacena, Eva Silverstein, Sir Martin Rees, and Stephen Hawking (to name a few) write a letter saying you’ve gotten something wrong ... well it’s probably worth considering.

The rebuttal letter also challenges us to understand more clearly why so many scientists are passionate about inflation. What is it about this theory that has the greatest minds in the known universe leaping to its defense?

FROM ITS INCEPTION, INFLATION has offered a remarkable synthesis of seemingly unrelated aspects of physics. It draws on a concept from particle physics called scalar fields—fields that look the same no matter how you view them, but can contain energy or pressure. Their high level of symmetry suggests that one would be most likely to find them in the earliest moments of the universe’s history, which makes them relevant to cosmology. And scalar fields have the special property that they can have negative pressure—a curiosity that takes on deeper meaning in the context of general relativity, where pressure contributes to the curvature of spacetime. Normal pressure produces gravity. Negative pressure produces inflation.

Inflation shows us that we can take a scalar field from particle physics, apply Einstein’s theory of general relativity, sprinkle in some quantum fluctuations, and get the entire universe replete with all the features we observe when we look around us—features that otherwise would remain inexplicable—from the homogenous distribution of stars and galaxies in all directions and the large-scale geometry of spacetime to the precise bumps and wiggles in the remnant heat from the Big Bang to the very existence of matter itself. When the incredible burst of inflation begins, the uncertainty that rules nature’s tiniest scales is stretched to astronomical proportions, linking the quantum world with the cosmic. When it ends, the expansion energy is transformed into matter and radiation, which sinks into the ripples and divots of spacetime forged by those quantum

fluctuations, laying a blueprint for the formation of stars and galaxies.

As Kaiser, the letter's co-author and a physicist at the Massachusetts Institute of Technology, explains, "Inflation is a conservative, minimalist outcome of two of the most important conceptual principles in physics: the equivalence principle of general relativity and the uncertainty principle of quantum mechanics." If a theory's explanatory power, as co-author Nomura of the University of California, Berkeley says, lies in the ratio of the number of things it can explain to the number of assumptions it takes to explain them, inflation packs a serious punch.

To be fair, when Guth and Linde first put forth the idea, there were aspects that seemed a little, well, odd—as if inflation arose by exploiting loopholes in physics. Yes, it's true nothing can travel through space faster than light, but space itself can expand faster than light; no one had ever seen a scalar field, but physics didn't expressly forbid it; Einstein himself had conceived of an antigravitational force that would stretch space, but no one had ever observed the stuff. But in the decades since, all of those weird ingredients have shown up. In 1998, astrophysicists discovered an antigravitational force—"dark energy"—that's driving the accelerated expansion of space right now, with the galaxies farthest from us crossing out of our cosmic horizon faster than the speed of light. In 2012, physicists at the Large Hadron Collider in CERN found clear evidence of a scalar field—the Higgs field. As Murray Gell-Mann once quipped, in physics, "Everything not forbidden is compulsory." Including, it seems, the universe itself.

In its early days, too, testing inflation seemed nearly impossible. It predicted that the background heat from the early universe that pervades the sky today—stretched into microwave wavelengths now by 13 billion years of cosmic expansion—would be uniform in temperature to 1 part in 100,000, but beyond that, tiny temperature fluctuations would take on a specific statistical distribution across the sky. No one in 1980 could have imagined the minute level of detail with which spacecraft like NASA's WMAP, launched in 2001, and the ESA's Planck Satellite, launched in 2009, would map those tiny differences, bearing out the expectations of inflationary models.

You can create a universe from nothing—you can create infinite universes from nothing—as long as they all add up to nothing.

"The most astonishing thing for me is that it has proved so susceptible to experimental-observational confirmation," says Susskind, the Stanford physicist and founder of string theory who co-signed the letter. "The outlook for further confirmation is excellent and to say otherwise indicates a lack of appreciation for the accomplishments to date." Ongoing experiments—including telescopes that are now searching the skies for primordial gravitational waves—could further confirm the predictions of inflation.

(Susskind, incidentally, was one of the first people with whom Guth shared his spectacular realization on that fateful December day back in 1979. Susskind listened to his colleague's jubilant news, then said, "You know, the most amazing thing is that they pay us for this.")

One of inflation's early predictions seemed, at the time, flat out wrong. A universe that underwent inflation ought to appear extremely flat (its spacetime metric Euclidean to any measurable degree), because any curvature it had will have been stretched to such huge proportions that you'd never notice it—just like you don't notice the Earth's curvature when you're standing on a flat sidewalk. But the metric of spacetime, according to general relativity, is determined by how much stuff is in it, and a flat metric requires a critical amount of mass and energy. Adding up the weight of all the galaxies in the observable universe,

What is it about this theory that has the greatest minds in the known universe leaping to its defense?

physicists came up about 96 percent short.

That's not a little wrong—that's *absurdly* wrong. And yet, in the days since, astrophysicists have discovered that the universe is full of invisible dark matter, detectable by its gravitational effects, which brought the total up to 27 percent of the critical mass. Then came the discovery of dark energy, which could be weighed by its effect on the expansion of space, bringing the total to a perfect 100 percent—the critical number for a flat universe, far too conspiratorial to be a fluke.

GIVEN ALL OF INFLATION'S SUCCESSES, why are Steinhardt, Ijjas and Loeb claiming that it isn't science?

First, they argue that inflation is too unlikely to occur. The initial conditions required for that scalar field to start inflating, they say, requires an improbable amount of fine-tuning. Within the chaotic conditions at the beginning of time, they argue, you'd need a large, smooth, flat patch of spacetime within which inflation could occur. But large, smooth, flat patches of spacetime are hard to come by—in fact, they are the very features of our universe that inflation was invented to explain. Getting the right initial conditions to trigger inflation, then, would render inflation totally unnecessary.

That might have been true in the past, but it was never clear that it really mattered. If you start with chaos, there's bound to be a smooth patch in it somewhere, just randomly, and it doesn't matter how rare it is because once it inflates it grows so big it completely dominates the universe. That's the thing about cosmology—you don't have to show that the universe began easily or quickly. You just have to show that it could begin at all.

In any case, the story has since changed dramatically in the last few years. Major developments¹ in what's known as “full numerical general relativity”—powerful computer simulations of the actual dynamics of spacetime—have shown, surprisingly, that inflation can begin much more easily than anyone ever thought. In fact, you don't need a smooth, flat patch—even lumpy, messy regions will start inflating. “This has been one of the biggest leaps forward,” Kaiser says.

“The problem of the initial smooth patch has

disappeared, in our opinion,” says Leonardo Senatore, a Stanford physicist who worked on the simulations and signed the letter to *Scientific American*. According to the work, only very few barriers to inflation remain. This “reversed the problem of the probability to start inflation,” says Senatore. “Right now, it seems unlikely for it not to start.” “The problem of initial conditions was solved in 2015,” Linde agrees. “This criticism shows a total ignorance of what is going on.”

So what about the second criticism, that inflation is too flexible to be tested? It’s true that while the idea behind inflation is simple, its parameters can be tweaked in seemingly endless ways: You can change the energy scale at which inflation begins, the features of the scalar field that drives its expansion, or the number of times spacetime doubles in size before inflation rolls to an end. Turning the dial on any of those parameters leads to different patterns in the microwave background radiation, different arrangements of stars and galaxies and different amplitudes of gravitational waves. In other words, the critics say, go out and measure almost anything and someone will say, “hey, that’s evidence for inflation.” Theories that can predict anything predict nothing. Inflation, they say, isn’t science.

But supporters argue that this shows a fundamental misunderstanding of what inflation is. It’s not a single model, they insist—it’s a class of models, a sweeping principle, a paradigm from which individual models can be derived and then tested. The key is to figure out *which* model of inflation is right—if any—and not to prove or falsify all of them all in one fell swoop. “Each model makes specific predictions, and can be tested with precision by the traditional methods of empirical science,” says Guth, now at MIT. Darwin’s concept of evolution by natural selection does not predict exactly which species of animal you’ll see outside your window; Einstein’s concept that gravity is the curvature of spacetime does not predict the actual spacetime geometry of our universe; and inflation doesn’t predict every last bump and wiggle in the microwave background radiation.

It’s fashionable to refer to the philosopher Karl Popper’s falsification criterion as a kind of litmus test to determine what is and is not science—Susskind has called those who are quick to cry Popper

“the Popperazzi.” But in the case of inflation, invoking Popper doesn’t quite add up. “I don’t think that Popper, or any other responsible thinker, has ever advocated that to decide if a theory is scientific, one should ask what class of theories does that theory belong to, and then ask if there is an experimental finding that would rule out that entire class at once,” Guth says. “That would make no sense.”

Philosophers of science have long known that falsification is not as black and white as it sounds. For every theoretical prediction we put to the test, there are scores of auxiliary assumptions implicit in the entire experimental set-up—observations are “theory-laden,” as the philosophers say. If a prediction doesn’t pan out, is it the theory we’re testing that’s wrong, or one of the auxiliary assumptions? They’re impossible to disentangle. Historians of science, meanwhile, know that science has never proceeded by falsification anyway. If a theory has real explanatory power, scientists don’t abandon it just because it seems too flexible or even if it’s disproven by an anomalous observation. They abandon it if a better theory comes along.

Take Newtonian gravity. It was a remarkably elegant idea—connecting the motions of falling apples with the motions of orbiting planets—but it had its problems. One of them was that Mercury’s orbit did not conform to its equations. Mercury, by Popperazzi standards, had rendered Newtonian gravity falsified. Wash your hands of it, take it out with the trash falsified. But no one tossed the theory aside, nor should they have. It was only when general relativity came along—which could accurately predict Mercury’s orbit, yes, but also had more elegance, more explanatory power—that Newtonian gravity was declared wrong. “Wrong” is too strong a term, really—when velocities are small and gravity is weak, Einstein’s equations reduce to Newton’s. Newtonian gravity was right—it just wasn’t the whole picture.

Inflation produces a remarkably accurate account of the geometry of the observable universe and explains why distant patches of sky that would never otherwise have come into contact are in near perfect thermal equilibrium. Like Newtonian gravity, inflation isn’t the whole picture. It can’t be—because it isn’t formulated using quantum gravity, the complete “theory of everything” that will unify quantum



THE OBJECTION In an article published this January in *Scientific American*, Ijjas, Steinhardt, and Loeb laid out their arguments against the theory of cosmic inflation.

mechanics with general relativity. “In my opinion, the problems with inflation are probably going to be solved by a deeper theory of quantum gravity, or by some other process that occurred before slow roll (non-eternal) inflation started in our patch of the universe,” says co-signer Juan Maldacena of the Institute for Advanced Study. “The problems with the hot Big Bang theory were not removed by discarding the Big Bang theory. They were solved by another type of evolution prior to the big bang phase (namely, inflation). Similarly, I think that the problems with inflation will not be solved by ditching inflation but by some other theory of what happened before.”

And here’s the kicker: Inflationary cosmology itself provides the best hope we have for getting an empirical look at quantum gravity in action. After all, the whole point of inflation is that it takes the quantum-scale dynamics of spacetime itself and magnifies them to cosmic proportions. In doing so, it allows us to study physics at energies 10 billion times greater than the energy scales reached by the Large Hadron Collider at CERN. We will never find a better magnifying glass to peer at the most intricate details of reality. The horizon of a ginormous black hole would make a decent one, but it would still be nothing compared to

inflation. “This may be the closest we will ever get to seeing the combined effects of quantum mechanics and general relativity,” Susskind says. One can begin to understand, then, why physicists from fields ranging from the most concrete experimental astrophysics to the most abstract M-theory signed the letter supporting inflation.

Now for the third and final criticism leveraged by Steinhardt, Ijjas, and Loeb. Back in the early days of inflation, Linde realized that thanks to quantum uncertainty, inflation won’t stop at precisely the same time everywhere. So as our universe exits the inflationary phase and begins its ordinary subluminal expansion, a little patch of scalar field remains. That little patch inflates into a whole new universe, which in turn leaves behind yet another patch, creating yet another universe, ad infinitum. Each universe can contain different fields with different particles with different masses with different behavior. Linde called it the eternal self-reproducing universe. Today, physicists call it the multiverse.

The multiverse was yet another aspect of inflation that seemed kind of crazy at first, but then the rest of physics caught up. String theory, for instance, turned out to describe a near-infinite number of universes,

all of which cried out for a physical mechanism that might produce them. Meanwhile, observations like the value of dark energy were turning up that seemed improbably fine-tuned for the existence of biological life, crying out for an explanation. In each case, eternal inflation came to the rescue.

Still, not everyone likes the idea of a multiverse. Steinhardt, Ijjas, and Loeb refer to it as “the multimes.” They dislike the fact that various features of physics can differ from one universe to the next, because that reduces the features of our little universe to mere happenstance. “I believe it is a great advantage of the theory,” Linde says, “but they believe it’s a crime.” But not liking the implications of a theory doesn’t make it wrong. “It does seem to make some people uncomfortable—but the comfort zone is not necessarily where we want to be,” Susskind says.

It does seem like universes forever beyond our reach might also lie beyond the reach of experiment. But there’s an interesting way that eternal inflation can be put to the test. Energy is always conserved in physics—you can’t create more stuff than what you started with. And eternal inflation seems, on glance, to violate this with abandon. There’s another loophole, though: Gravity is a form of negative energy. As inflation creates more universes, it simultaneously creates more gravity, and the two work to perfectly cancel out. Energy—which adds up to zero—is conserved. What about other conservation laws? Angular momentum is conserved—but if you tally up the angular momentum of all the galaxies in the universe, it sums to zero. Electric charge is conserved, but the universe is electrically neutral; it adds up to zero, too. Eternal inflation can make universes like ours precisely because it doesn’t have to violate any conservation laws to do it. It’s making more and more of nothing.

Again, inflation has taken what seems like a loophole in physics and exposes it to be a profound glimpse into the nature of reality: You can create a universe from nothing—you can create infinite universes from nothing—as long as they all add up to nothing. Not only is that a deep insight, it also creates a testable prediction. “Eternal inflation certainly predicts that the average density of all conserved quantities should be zero,” Guth says. “So if we ever became convinced that the universe has a nonzero density of

Theories
that can
predict
anything
predict
nothing.



electric charge or angular momentum, eternal inflation would no longer be an option.”

Still, infinity makes Steinhardt, Ijjas, and Loeb uneasy because it makes it extremely difficult to define probabilities for the outcomes of measurements. In an infinite multiverse, anything that can happen will happen—an infinite number of times. Such a situation requires what’s called a probability measure to assign different likelihoods to different events, even when there are an infinite number of them. But different measures yield different probabilities, and it hasn’t been clear which measure is the right one. That leaves us in a situation where we can’t predict anything, the critics say.

That might be true—but all it means is that physicists have to figure out which measure to use, not that the multiverse is a free-for-all. “Even the rarest of events will occur an infinite number of times,” Guth explains. “But such events will remain extremely rare. The claim that no outcome will be preferred over any other has absolutely no basis in logic. Mathematicians have known for nearly a century that probabilities can be rigorously defined on infinite spaces, and it is certainly not the case that all events must be

equally likely. So, unfortunately, even if there is a multiverse, the chances of my winning the Massachusetts lottery tomorrow will remain incredibly small.”

“The problem of the measure is very complicated,” Linde says. “It’s very similar to what happened with the interpretation of quantum mechanics. Everyone knows that quantum mechanics works, but people have been debating its interpretation for 100 years. The multiverse is somewhat similar. It is a deep problem, putting a quantum mechanical description of gravity and cosmology all together.”

A deep problem, indeed—and far subtler than critics of the multiverse imply. (Steinhardt, Ijjas, and Loeb, it should be noted, are far from the only multiverse critics.) The infinite universes that comprise the multiverse are separated from one another by event horizons which, because they are described by both general relativity and quantum mechanics, are strange objects, and not always what they seem. In the last few decades, physicists have discovered that fundamental assumptions about the nature of reality come into question whenever an event horizon lurks. Thought experiments and paradoxes concerning the fate of information that falls behind the horizon of

a black hole led Susskind to introduce the notion of “horizon complementarity”: The two sides of a horizon should not be thought of as distinct regions of spacetime, but more like two different descriptions of the very same reality. If horizon complementarity holds in the multiverse, it’s possible that the multiverse is a kind of vast redundancy, and the fundamental theory of the universe may well be written in terms of a single observable universe, rendering the measure problem moot. All the metaphysical baggage of the multiverse, and the distaste some people have for it, might be nothing more than an artifact of all-too-classical thinking. “You have to interpret the multiverse carefully,” says Nomura. “Our world is quantum mechanical.”

Hawking—who signed the letter—has been working on a model he calls top-down cosmology. In his view, in light of quantum mechanics, it doesn’t make sense to talk about the origin and evolution of the universe as if it followed a single unique trajectory. Instead, he argues, we ought to use the universe as we observe it right now—coupled with the assumption that it arose from nothing—and take a quantum superposition of every possible history that could have led from nothing to now. It’s not that we don’t know which history really occurred—it’s that they all occurred. Rather than a multiverse with a single history, you have a single universe with multiple histories. When Hawking takes the sum of these histories to determine the most probable path, it is—voilà!—a history in which the early universe went through inflation. Inflation pops out on its own, from a theory that doesn’t involve a multiverse.

Many roads, it seems, lead back to inflation and inflation in turn leads to unexpected places. Steinhardt, Ijjas and Loeb are standing by their criticisms of the theory, and have made a website to reiterate them. But the 33 leading physicists who signed the letter—and countless others—are more confident in inflation than ever, exploring its strange territory, optimistic that it will eventually lead them to its own replacement: a more complete theory of the universe’s origin. That, certainly, is science. And it is pretty spectacular. ☺

AMANDA GEFTER is a physics writer and author of *Trespassing on Einstein’s Lawn: A father, a daughter, the meaning of nothing and the beginning of everything*. She lives in Cambridge, Massachusetts.

REFERENCES

East, W.E., Kleban, W., Linde, A., & Senatore, L. Beginning inflation in an inhomogenous universe. *Journal of Cosmology and Astroparticle Physics* (2016).

The Hidden Sexism of How We Think About Risk

If men take more risks than women, it's not because of biology

BY CORDELIA FINE

MY ELDEST SON has long been irresistibly drawn to danger. At 6 months old he rolled across the entire expanse of the living room in order to more closely inspect the drill that his father—forgivably assuming that five yards was a safe distance to place a power tool from a baby who couldn't yet crawl—had put on the floor. On one memorable toddler playdate, within five minutes he had located the drawer of sharp kitchen knives that his little host Harry had failed to discover in his two years of life, and began juggling with its contents. At the age of 10, I left him happily engaged in the normally hazardless activity of assembling a cake batter, only to return five minutes later to discover him about to plunge a roaring hairdryer into the mixture. As he calmly explained, he had forgotten to melt the butter before adding it to the bowl, and was therefore trying to do so retroactively.

I admit that at times like these I have occasionally wondered why it was my lot in life to have a child

so blasé about risk, and whether ultimately this will prove to be a blessing or a curse. On optimistic days I imagine him reaping enormous benefits: the invention of a time machine, say, after decades of dangerous experimentation. But in darker moments, I foresee much bleaker fates featuring mortuary lockers. While proponents of what I call Testosterone Rex—the idea that women are driven by biology and evolution to be cautious, and men to be daring—obviously don't share this fascination with my firstborn and his future, they do have a strong interest in the idea of risk taking as an inherently male trait. They would regard each of my son's perilous follies as successful manifestations of evolutionary pressures: a pitiful consolation, I can assure you, when you are trimming singed hair from your child's bangs and hoping the other guests at the barbecue won't ask too many questions. Economists Moshe Hoffman and Erez Yoeli recently spooled out the familiar chain of assumptions in the *Rady Business Journal*:

ILLUSTRATION BY YIRAN GUO



When males take on extra risk in foraging for food, ousting rivals, and fighting over territory, they are rewarded with dozens, even hundreds of mates, and many, many babies. A worthwhile gamble! Not so for the females.

Dozens? Hundreds? Sure—if you’re a red deer, or the leader of an ancient Mongol empire. While Hoffman and Yoeli’s arguments mostly refer to the “fighting” part of Darwin’s sexual selection theory (intra-sexual selection), other researchers suggest that risk taking also adds to men’s appeal as a mate; the “charming” part of Darwin’s subtheory (or intersexual selection). As psychologists Michael Baker Jr. and Jon Maner explain:

Among men, risky behaviors have potential for displaying to potential mates characteristics such as social dominance, confidence, ambition, skill, and mental acuity, all of which are highly desired by women seeking a romantic partner.

But for women, there are no such benefits to be gained from taking risks. This is because—the authors seem to try to put it as tactfully as they can—“men tend to desire women with characteristics that signal high reproductive capacity (e.g., youth) rather than characteristics that might be signaled by risk-taking.” In other words, so long as the hair is glossy, the skin smooth, and the hip-to-waist ratio pleasing, then a cringingly low sense of self-worth, apathy, incompetence, and stupidity are relative trifles, more easily overlooked from the male perspective.

Having drawn on a vintage version of sexual selection to claim an evolutionary imperative for male risk taking, the next obvious step is to argue that this is a major contributor to persistent sex inequalities, helping to explain why fame, fortune, and corner offices are disproportionately acquired by men. Hoffman and Yoeli, for instance, argue that:

SPECIFIC RISKS Research has shown that people likely to take one sort of risk, like betting on a horse race, aren’t necessarily more likely to take another sort of risk, like skydiving or playing the stock market.



Stocks have higher average returns than bonds, and competitive jobs can be quite lucrative. These rewards make gender differences in risk preferences one of the pre-eminent causes of gender difference in the labor market.

The reference to competitive jobs points to a related explanation for occupational inequalities also much in vogue within the economics community: competition. Competition also involves risk taking since outcomes are uncertain, and the possible gains have to be weighed against the costs of taking part and defeat. Thus:

Over the past decade, economists have become increasingly interested in investigating whether gender differences in competitiveness may help explain why labor market differences persist. If women are more reluctant to compete, then they may be less likely to seek promotions or to enter male-dominated and competitive fields.

ALTHOUGH THE INSIGHT WILL probably fail to bring excitement to your next trip to the supermarket, there is an element of uncertainty to everything we do. Risk taking, in everyday understanding, is an action that potentially enables us to achieve a desired goal or benefit, but that also brings the possibility that we will fail, or something will go wrong. As a consequence, we may lose out on something we had, or could have had for sure (the kids' college fund, an unblemished reputation, the steady income from a government bond, a left arm) or, despite costly efforts, fail to gain something we hoped for (a date, a bulging pension fund, a prestigious promotion). It's long been assumed that the propensity for risk taking is a stable personality trait—that is, a particular individual will consistently tend to seek, or avoid, risks in every realm of life. Indeed, for many years psychologists used measures of risk taking that added up a person's willingness to take risks in several different domains (like health, investments, and career) to yield a single risk-taking score. Many economists, meanwhile, study risk taking by presenting participants with series of carefully designed lottery tasks, in which people choose between, say, \$5 for sure or an 80 percent chance of \$10. The assumption is that economists can apparently infer “the” risk-taking profile of a person from his or her selections.

The more positively we feel about something, the more we minimize the risks.

The long-held belief that everyone can be neatly located at a point on a single continuum between “risk taker” and “risk avoider” fits nicely with the expectation for “a taste for competitive risk taking to be an evolved aspect of masculine psychology as a result of sexual selection.” Males, according to this view, are clustered mostly over on the risk-taking side, women on the careful end.

However, for decades there have been indications that risk taking isn't a one-dimensional personality trait: Instead, there are “insurance-buying gamblers” and “skydiving wallflowers,” as one group of researchers put it. An early study of more than 500 business executives, for example, looked at their preferences across a variety of risky choices, like business and personal investments, complex financial choice dilemmas, the amount of their own wealth held in risky assets, as well as non-financial risks. Clearly, if risk taking were a stable personality trait, then someone who tended to take risks in one area of decision making would also tend to report being a risk taker in the other domains. Yet this simply wasn't so. Knowing the riskiness of an executive's personal wealth strategy, for instance, told you nothing about how he'd behave in a business investment context.

To investigate this surprising pattern more closely, Columbia University's Elke Weber and colleagues asked several hundred undergraduates in the United States how likely they would be to take risks in five different domains: financial, health, recreational, social, and ethical decisions. Again, a person's risk-taking propensity didn't follow any kind of consistent pattern across the different domains—that is, the person who would happily blow a week's wages at the races was no more likely to leap from a bridge attached to a rubber cord, invest

in speculative stock, ask their boss for a raise, have unprotected sex, or steal an additional TV cable connection, than was someone who'd as soon flush dollar bills down the toilet as put them on a horse. Researchers drew the same conclusion a few years later in a study that deliberately recruited people on the basis of their affinity to a particular kind of risk: like skydivers, smokers, casino gamblers, and members of stock-trading clubs. Once again, risk taking in one domain didn't extend to others. So gamblers, say, unsurprisingly stood out as the most risk taking when it came to questions about betting. But they were no more risk taking than the other groups, including even a group of health-risk-averse gym members, when it came to questions about recreational or investment risks.

To see the problem this creates for the idea of risk taking as an essential masculine trait, ask yourself which group are the "real" men, or show a properly evolved masculine psychology: the skydivers, or the traders? That we expect Testosterone Rex to create an all-around risk taker is implicit in Hoffman and Yoeli's remark that men are "more likely [than women] to die in a car accident while speeding in the Ferrari they bought with their stock-market earnings." But as we've just seen, the reckless Ferrari driver might well prefer bonds to stocks. (That hypothetical ass probably inherited his wealth.) The pure, unadulterated daredevil no doubt exists, but such individuals are statistical exceptions to the general rule that people are fascinatingly idiosyncratic and multifaceted when it comes to risk.

So what makes someone eager to take risks in one domain, but reluctant in another? It turns out to be risk takers' less negative perception of the risks and more positive perception of the benefits, Weber and colleagues found. The study of the skydivers, gamblers, smokers, and stock traders came to a similar conclusion. The risk takers in this study didn't like risk *per se* any more than did the risk-averse gym members. Rather, they perceived greater benefits in their particular pocket of risk taking, and this explained why they took risks that others avoided, and took one kind of risk rather than another. Similarly, contra common lore, entrepreneurs don't have a more indulgent, risk-loving attitude than do others toward the possibility of losing large sums of money; rather, they have greater confidence that everything will work out just fine.



A THIN LINE Philippe Petit, who walked a wire strung a quarter of a mile high between the Twin Towers, described himself as "absolutely the contrary of a daredevil."

In fact, people are generally mildly risk-averse. This may at first seem to defy belief. However, *Chancing It* author Ralph Keyes drew exactly the same conclusion, based on extensive interviews about risk with people from many walks of life. One of his interviewees was the wire-walker Philippe Petit, famous for the remarkable feat of walking a wire strung a quarter of a mile high between the Twin Towers. However, Petit emphatically described himself to Keyes as "absolutely the contrary of a daredevil," adamantly declaring that "in no way, shape or form did he consider himself to be a taker of risks." I was reminded of this remark at an

What on first inspection seemed like a sex difference was actually a difference between white males and everyone else.

extravagant magic show I saw recently with my children. In the melodramatic final act, an escape artist was handcuffed, then lowered upside down and padlocked into a snugly fitting glass tank of cold water, armed with only a single bobby pin with which to effect his escape. As we complacently watched the proceedings from the comfort of our seats, the master of ceremonies emphasized the extreme danger of the situation. Yet clearly, the theater would have been heaving with the rush of parents clamping hands over children's eyes if there had been even a modest possibility that an afternoon's treat at the theater would include witnessing a man drown on stage.

The critical point here is that "the risk in a given situation is inherently subjective, varying from one individual to the next." It's simply not possible to assess the "objective" characteristics of a risky situation, then infer a person's appetite for risk from the decision she or he makes. The importance of subjectivity in the perception of risks and benefits for humanity's colorful diversity of risk taking turns out to be equally crucial for understanding sex differences. Contrary to what many might assume, women and men have similar risk attitudes, Weber and colleagues found. For the same subjectively perceived risk and benefit, they are equally likely to tempt fate. When men and women do diverge in risk-taking propensity, it is because they perceive the risks and benefits differently. So are men inherently constituted to perceive risks more positively, making

them more inclined to take them? A closer look at the actual pattern of sex differences in risk taking reveals important nuances that make this unworkable as an explanation.

A good starting point is a large meta-analysis that collated studies of female/male differences in risk taking across a variety of domains (like hypothetical choices, drinking, drugs, sexual activity, and driving), and across five different age groups from middle childhood to adulthood. This analysis did indeed lead to the conclusion that males are more risk taking than females, on average. But about half of the differences were very modest, and in 20 percent of cases they were even in the "wrong" direction (that is, there was greater female risk taking). The meta-analysis also revealed changeable patterns of difference depending on the age group and the kind of risk. For example, studies of 18- to 21-year-olds found that males were a little more likely, on average, to report drinking and drug taking, and risky sexual activities. But for older adults, this sex difference was almost exactly reversed. Nor was there any obvious pattern in the effect of age on sex differences. This is surprising: If risk taking evolved to increase reproductive success, you'd presumably expect an especially clear divergence of the sexes following pubescence. The traditional view of risk taking as a masculine trait therefore requires revision, the researchers concluded, in the face of evidence that "risk taking ... does not seem to manifest itself in a simple or constant way across ages or contexts."

Indeed, there are already documented exceptions to the notion of risk taking as a masculine trait. A number of studies have found that women are at least as willing as men to take social risks (like admitting that their tastes are different from those of their friends, or disagreeing with their father on a major issue). Women were also found to be more likely than men to report that they would take risks in situations in which there was a small chance of benefit for a small fixed cost (such as trying to sell an already-written screenplay to a Hollywood studio, or calling a radio station running a promotion in which the 12th caller receives money). So why do perceptions of risks and benefits apparently differ between the sexes in some realms but not others? One obvious answer is that some activities—like unprotected sex or excessive drinking—may actually

be objectively more risky for females. Risk researchers have also found that both knowledge and familiarity in a particular domain reduces perceptions of risk. Plausibly, men may tend to be relatively more knowledgeable or familiar with some of the risky activities that tend to feature in surveys (like sports betting, financial investments, and motorcycle riding).

The point is that an “unruly amalgam of things” underlies choices, as Harvard University legal scholar Cass Sunstein puts it: “aspirations, tastes, physical states, responses to existing roles and norms, values, judgments, emotions, drives, beliefs, whims.” And so, we’re not only sensitive to the material benefits and costs when we make choices, Sunstein argues, but

Perhaps white males see less risk in the world because they create, manage, control, and benefit from so much of it.

also to the less tangible effects a particular choice could have on self-concept and reputation. In a gendered world, these impacts are inevitably different for females and males. (One obvious example of risk imbalance involves an infamous experiment in which male and female college students were asked by a complete stranger of the opposite sex, “Would you go to bed with me tonight?” Unsurprisingly, more men agreed.)

Another striking demonstration comes from research investigating the risks people perceive from technological, lifestyle, and environmental hazards (like nuclear power, smoking, and ozone depletion).

These studies routinely find that women perceive higher risks to themselves, family, and society from such hazards. For instance, James Flynn and colleagues surveyed more than 1,500 U.S. households and found that women on average perceived higher risks across

the board. The Testosterone Rex explanation of this would be that women, as the nurturers of precious offspring, have evolved to be more cautious about threats to physical health. However, Flynn and colleagues then subdivided the sample by ethnicity as well as sex, and discovered that one subgroup stood out from all the rest. Society seemed a significantly safer place to white males than it did to all other groups, including non-white men. What on first inspection seemed like a sex difference was actually a difference between white males and everyone else.

Flynn and colleagues then established that it was a particular subset of white males who were particularly cavalier about risks: those who, in response to the social justice movement’s currently fashionable suggestion to “check your privilege,” would take significantly longer than others to complete the task. These men were well educated, rich, and politically conservative, as well as more trusting of institutions and authorities, and opposed to a “power to the people” view of the world. A number of studies have now replicated this so-called “white male effect” with other large U.S. samples, and the research points to it being “not so much a ‘white male effect’ as a ‘white hierarchical and individualistic male effect.’”

Interestingly, a recent study conducted in the more socially egalitarian and gender-equal Sweden failed to find the “white male effect.” This national survey of nearly 1,500 households found that, all else being equal—and in stark contrast with the U.S. data—Swedish men and women had very similar perceptions of lifestyle, environmental, technological, health, and social risks. The survey found instead just a “white effect,” with people from foreign backgrounds, who are subject to social disenfranchisement and discrimination, perceiving risks as higher than did native Swedes.

In trying to understand how social place and identity can affect risk perception in such a marked way, it’s helpful to know that people often use their feelings as a guide to the risk-benefit trade-off. The more positively we feel about something—whether it’s unpasteurized French cheese, vaccinations, or abortion—the more we tend to minimize the risks and play up the benefits. Conversely, if we feel antipathy toward an activity or hazard, we “tend to judge the opposite—high risk and low benefit.” Political worldview is a potent



RISKY LESSONS Gender norms affecting our understanding of risk are taught early in life.

source of strong emotions about risky hazards, and it may be that people perceive risk in ways that protect their social identities, roles, and status: “Perhaps white males see less risk in the world because they create, manage, control, and benefit from so much of it. Perhaps women and non-white men see the world as more dangerous because in many ways they are more vulnerable, because they benefit less from many of its technologies and institutions, and because they have less power and control,” suggests Flynn.

This point was neatly demonstrated by some statistical fun, inspired by Nelson’s insight that we tend to *think risk, think male*. Yale Law School academic Dan Kahan showed that, when asked about the risks to human health, safety, or prosperity arising from high tax rates for business, now it was the women’s and minority men’s turn to be sanguine. This, he notes, beautifully illustrates Nelson’s point:

It confirms that men are more risk tolerant than women only if some unexamined premise about what counts as a “risk” excludes from assessment the sorts of things that scare the pants off of white men (or at least hierarchical, individualistic ones).

The white male effect in the U.S., viewed alongside the similar risk perceptions of native Swedish men and women, suggests that it can at least sometimes be the different social place, identities, and experiences of men and women in the world, rather than some enduring dissimilarity of biology, that underlie sex differences in risk perception. This is a vital point since, as we’ve seen, it is these subjective perceptions that underlie sex differences in risk taking. The idea that women have evolved to be biologically predisposed to perceive greater risks to health is intuitively plausible, but appears to be simply wrong. As the researchers who first identified the white male effect point out: “Biological factors should apply to non-white men and

women as well as to white people.”

No less importantly, social identities come in a package that includes social norms. These norms, as Sunstein has emphasized, play a crucial role in our decision making. Gender, of course, is a rich source of norms that apply differently to males and females, with some behaviors more strongly expected of one sex, and others more strongly censured. For example, there is a stronger expectation of women to “be nice” than there is of men. When women violate this norm in a workplace setting (by behaving in domineering ways or negotiating for better remuneration and conditions, for instance) they encounter backlash from others, who become less willing to work with them, and like them less. This means that statements that men “are more likely to bargain aggressively for their starting salaries” need some unpacking. If so, is it really because women are intrinsically risk averse, or care less about money? Or is it because there is a violation of feminine norms involved in bargaining aggressively in one’s own self-interest, and so women quite accurately intuit a less favorable balance of benefits and risks from doing so?

On the first point, research has found that a sex difference in negotiating for bigger pay (in a lab task) can be eliminated simply by framing exactly the same behavior in a way that’s more in keeping with feminine norms of politeness: “asking,” rather than negotiating. As the authors point out, “the term negotiation is not gender-neutral.” And regarding the second point, does violating those norms yield the same benefits? One study found that although top-flight female MBA students were just as likely as their male counterparts to negotiate their initial post-course salary, the financial payoff for them was less. It’s not hard to imagine those women being less likely to negotiate in the future, but because of the anticipation of less reward rather than an evolved disinclination to take risks.

In many domains, gender norms tend to favor *male* risk taking, which is a norm of masculinity and seen as a more important trait for men than for women. This means that, in addition to material gains, taking risks may often bring greater reputational benefits or smaller costs: Women in counterstereotypical leadership roles are judged more harshly than men when risky decisions don’t work out. Underscoring the

importance of Sunstein’s unruly amalgam, both men and women seem to be responsive to cultural information about how their risk-taking behavior will be perceived by others.

In one study, for instance, single men presented with a newspaper article claiming that women found risk taking unattractive in partners subsequently made less risky choices in a lab task administered by a female experimenter (compared with men who’d read a stereotype-consistent article). Or consider a recent study of young Chinese women and men, who played a risk-taking game either privately or while being observed by an attractive person of the other sex. In China, the authors argue, the ideal of womanhood strongly precludes risk taking, valuing instead those who are “timid, reserved, shy, obedient, unassertive, humble, attentive, respectful, and, above all, chaste.” In contrast with this feminine ideal, Chinese women were every bit as risk taking as the men when unobserved. But in line with gender norms, men increased their risk taking when supposedly observed by an attractive other-sex observer, while women decreased it. Some research teams have acknowledged this minor devastation of a pet hypothesis with good grace, accepting that the proposal that men have evolved to display risky behavior in order to attract females “does not account for the observed similarities between men and women” and “offers little explanation ... for men’s preference for risk-takers.” Summarizing this “picture of overall similarity between the sexes,” while at the Max Planck Institute for Human Development, Andreas Wilke and colleagues suggested instead

that men and women learn to value the same traits for non-adaptive reasons (e.g., a cultural norm) or that the same sort of risk taking might (at least in societies with male investment comparable to female levels) be a reliable cue to quality for both sexes.

In other words, maybe there isn’t anything so special about male risk taking, after all.

WRITING IN THE FINANCIAL TIMES about our supposedly admiring attitudes toward those who take big financial risks, columnist John Kay draws direct links to our Stone Age past, contrasting “prudent hunters” who peered about anxiously for dangerous animals

and “stayed at home when it was too dangerous,” with more courageous hunters who “chose not to buy or exercise these options” and therefore “took more risks and caught more prey.” Lest there be any doubt in readers’ minds as to which sex it was that won admiration for their daring, Kay then rhetorically asks, “Were the young women of the tribe more impressed when the cautious described their uneventful days, or when the bold recalled their heroic escape from danger?” For some reason, Kay omits asking readers to consider how the women would have appreciated the conversation of hunters whose throats had been ripped out by wild animals.

We are now a long way from the bundle of assumptions packed into this familiar vignette. Risk taking is not a stable personality trait, allowing us to assume that the person who would willingly take the physical risks of hunting (or white-water rafting or skydiving) would be a fearless CEO or trader. Nor is risk taking something that only men do, or that only women are drawn to in a potential partner. Meanwhile, the growing evidence that females do compete at equal rates to men when the nature of the task seems to authorize it, and that girls and women from populations further afield than the typical Western samples are no less eager than males to compete, undermines assumptions that this is an “essential” sex difference.

What does this mean for assumptions of “testosterone-fueled” male risk taking? From the old understanding of risk taking as a masculine trait, sex differences in testosterone is an intuitive, obvious, and common explanation. But the shape and pattern of sex differences defies explanations in terms of a single, powerful cause that splits the sexes.

As I was editing this piece, a survey of more than 3,500 Australian surgeons revealed a culture rife with bullying, discrimination, and sexual harassment, against women especially (although men weren’t untouched either). To give you a flavor of professional life as a woman in this field, female trainees and junior surgeons “reported feeling obliged to give their supervisors sexual favours to keep their jobs”; endured flagrantly illegal hostility toward the notion of combining career with motherhood; contended with “boys’ clubs”; and experienced entrenched sexism at all levels and “a culture of fear and reprisal, with known bullies

in senior positions seen as untouchable.” I came back to this chapter on the very day that news broke in the state of Victoria, Australia, where I live, of a Victorian Equal Opportunity and Human Rights Commission report revealing that sexual discrimination and harassment is also shockingly prevalent in the Victorian Police, which unlawfully failed to provide an equal and safe working environment.

I understand that attempts to identify the psychological factors that underlie sex inequalities in the workplace are well-meaning. And, of course, we shouldn’t shy away from naming (supposedly) politically unpalatable causes of those inequalities. But when you consider the women who enter and persist in highly competitive and risky occupations like surgery and policing—despite the odds stacked against them by largely unfettered sex discrimination and harassment—casual scholarly suggestions that women are relatively few in number, particularly in the higher echelons, because they’re less geared to compete in the workplace, start to seem almost offensive.

Testosterone Rex implicitly blames women for their lower salary and status, distracting attention away from the “unruly amalgam” of gendered influences—the norms, beliefs, rewards, inequalities, experiences, and, let’s not forget, punishment by those who seek to protect their turf from lower-status outsiders—that unevenly tip the cost-benefit scales. ☹

CORDELIA FINE is an associate professor of the history and philosophy of science at the University of Melbourne, and the author of *Delusions of Gender* and *A Mind of Its Own*.

Reprinted from *Testosterone Rex* by Cordelia Fine. Copyright © 2017 by Cordelia Fine. With permission of the publisher, W.W. Norton & Company, Inc. All rights reserved.

49

THERE'S A FAMOUS PARADOX according to which Achilles will always lose a race against a tortoise, if the tortoise has a head start. For Achilles to win, the reasoning goes, he'd first need to catch up to where the tortoise had been. But by then, the tortoise would have moved on.

It took about a century to find the flaw in the argument, conceived of by Zeno of Elea. The paradox was also one of the first examples of proof by contradiction, which today is at the core of mathematics. And, together with Zeno's other paradoxes, it helped shape the Socratic method and Western education more broadly.

Not bad for a discussion of the absurd. But maybe not so unusual.

The absurd has a way of crystallizing our thinking. Satire spurs social change. Studies have shown reading Kafka boosts pattern recognition ability. Extreme coincidences in the fundamental constants of physics challenge us to reconsider our metaphysics.

We got where we are with the help of the absurd. Without it, life would be strange indeed.

Welcome to "The Absurd."

—MS

"One can enjoy the pursuit without believing in or expecting answers."

ROBERT A. BURTON

"When Neurology Becomes Theology" p.88

The Absurd

BEYOND REASON

The Impossible Mathematics of the Real World

Near-miss math provides exact representations of almost-right answers

BY EVELYN LAMB

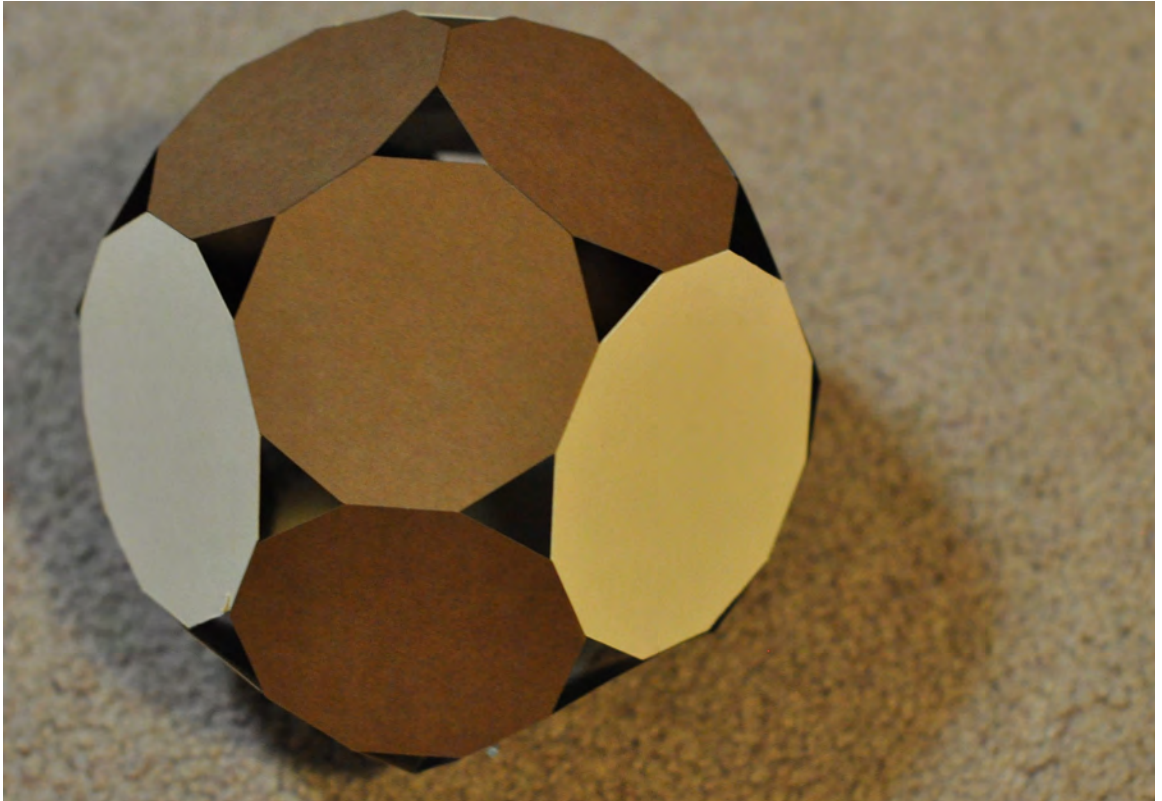


U **SING STIFF PAPER** and transparent tape, Craig Kaplan assembles a beautiful roundish shape that looks like a Buckminster Fuller creation or a fancy new kind of soccer ball. It consists of four regular dodecagons (12-sided polygons with all angles and sides the same) and 12 decagons (10-sided), with 28 little gaps in the shape of equilateral triangles. There's just one problem. This figure should be impossible. That set of polygons won't meet at the vertices. The shape can't close up.

Kaplan's model works only because of the wiggle room you get when you assemble it with paper. The sides can warp a little bit, almost imperceptibly. "The fudge factor that arises just from working in the real world with paper means that things that ought to be impossible actually aren't," says Kaplan, a computer scientist at the University of Waterloo in Canada.

It is a new example of an unexpected class of mathematical objects that the American mathematician Norman Johnson stumbled upon in the 1960s. Johnson was working to complete a project started over 2,000 years earlier by Plato: to catalog geometric perfection. Among the infinite variety of three-dimensional shapes, just five can be constructed out of identical regular polygons: the tetrahedron, cube, octahedron, dodecahedron, and icosahedron. If you mix and match polygons, you can form another 13 shapes from regular

They look tantalizingly
open to solution,
but ultimately prove
impossible.



IMPOSSIBLY REAL This shape, which mathematician Craig Kaplan built using paper polygons, is only able to close because of subtle warping of the paper.

polygons that meet the same way at every vertex—the Archimedean solids—as well as prisms (two identical polygons connected by squares) and “anti-prisms” (two identical polygons connected by equilateral triangles).

In 1966 Johnson, then at Michigan State University, found another 92 solids composed only of regular polygons, now called the Johnson solids. And with that, he exhausted all the possibilities, as the Russian mathematician Viktor Zalgaller, then at Leningrad State University, proved a few years later. It is impossible to form any other closed shapes out of regular polygons.

Yet in completing the inventory of polyhedra, Johnson noticed something odd. He discovered his shapes by building models from cardboard and rubber bands.

Because there are relatively few possible polyhedra, he expected that any new ones would quickly reveal themselves. Once he started to put the sides into place, the shape should click together as a matter of necessity. But that didn’t happen. “It wasn’t always obvious, when you assembled a bunch of polygons, that what was assembled was a legitimate figure,” Johnson recalls.

A model could appear to fit together, but “if you did some calculations, you could see that it didn’t quite stand up,” he says. On closer inspection, what had seemed like a square wasn’t quite a square, or one of the faces didn’t quite lie flat. If you trimmed the faces, they would fit together exactly, but then they’d no longer be exactly regular.

Intent on enumerating the perfect solids, Johnson

didn't give these near misses much attention. "I sort of set them aside and concentrated on the ones that were valid," he says. But not only does this niggling near-perfection draw the interest of Kaplan and other math enthusiasts today, it is part of a large class of near-miss mathematics.

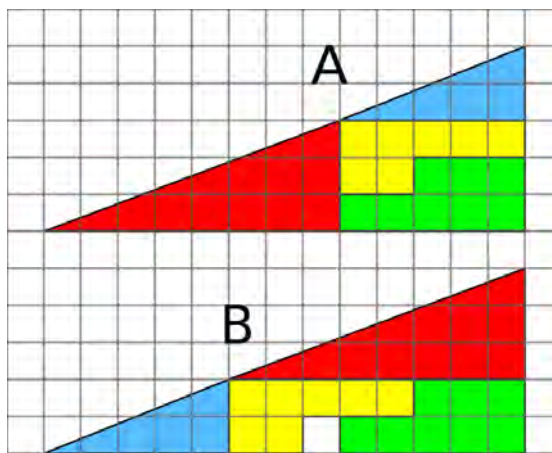
There's no precise definition of a near miss. There can't be. A hard-and-fast rule doesn't make sense in the wobbly real world. For now, Kaplan relies on a rule of thumb when looking for new near-miss Johnson solids: "the *real, mathematical error* inherent in the solid is comparable to the practical error that comes from working with real-world materials and your imperfect hands." In other words, if you succeed in building an impossible polyhedron—if it's so close to being possible that you can fudge it—then that polyhedron is a near miss. In other parts of mathematics, a near miss is something that is close enough to surprise or fool you, a mathematical joke or prank.

Some mathematical near misses are, like near-miss Johnson solids, little more than curiosities, while others have deeper significance for mathematics and physics.

THE ANCIENT PROBLEMS of squaring the circle and doubling the cube both fall under the umbrella of near misses. They look tantalizingly open to solution, but ultimately prove impossible, like a geometric figure that seems as though it must close, but can't. Some of the compass-and-straight-edge constructions by Leonardo da Vinci and Albrecht Dürer fudged the angles, producing nearly regular pentagons rather than the real thing.

Then there's the missing-square puzzle. In this one (see Shell Game), a right triangle is cut up into four pieces. When the pieces are rearranged, a gap appears. Where'd it come from? It's a near miss. Neither "triangle" is really a triangle. The hypotenuse is not a straight line, but has a little bend where the slope changes from 0.4 in the blue triangle to 0.375 in the red triangle. The defect is almost imperceptible, which is why the illusion is so striking.

A numerical coincidence is perhaps the most useful near miss in daily life: $2^{7/12}$ is almost equal to $3/2$. This near miss is the reason pianos have 12 keys in an octave and the basis for the equal-temperament system in Western music. It strikes a compromise between the



SHELL GAME When the top shape is cut up into four pieces and rearranged, a gap appears. This is the result of an imperceptible distortion in the two triangles.

A hard-and-fast rule doesn't make sense in the wobbly real world.

two most important musical intervals: an octave (a frequency ratio of 2:1) and a fifth (a ratio of 3:2). It is numerically impossible to subdivide an octave in a way that ensures all the fifths will be perfect. But you can get very close by dividing the octave into 12 equal half-steps, seven of which give you a frequency ratio of 1.498. That's good enough for most people.

Sometimes near misses arise within the realm of mathematics, almost as if mathematics is playing a trick on itself. In the episode "Treehouse of Horror VI" of *The Simpsons*, mathematically inclined viewers may have noticed something surprising: the equation $1782^{12} + 1841^{12} = 1922^{12}$. It seemed for a moment that the screenwriters had disproved Fermat's Last Theorem, which states that an equation of the form $x^n + y^n = z^n$ has no integer solution when n is larger than 2. If you punch those numbers into a pocket calculator, the equation seems valid. But if you do the calculation with more precision than most hand calculators can manage, you will find that the twelfth root of the left side of the equation is 1921.99999995867 ..., not 1922, and Fermat can rest in peace. It is a striking near miss—off by less than a 10-millionth.

But near misses are more than just jokes. "The ones that are the most compelling to me are the ones where they're potentially a clue that there's a big story," says University of California-Riverside mathematician John Baez. That's the case for a number sometimes called the Ramanujan constant. This number is $e^{\pi \sqrt{163}}$, which

equals approximately 262,537,412,640,768,743.999999999999925—amazingly close to a whole number. *A priori*, there's no reason we should expect that these three irrational numbers— e , π , and $\sqrt{163}$ —should somehow combine to form a rational number, let alone a perfect integer. There's a reason they get so close. "It's not some coincidence we have no understanding of," says Baez. "It's a clue to a deep piece of mathematics." The precise explanation is complicated, but hinges on the fact that 163 is what is called a Heegner number. Exponentials related to these numbers are nearly integers.

Or take the mathematical relationship fancifully known as "Monstrous Moonshine." The story goes that in 1978 mathematician John McKay made an observation both completely trivial and oddly specific: $196,884 = 196,883 + 1$. The first number, 196,884, had come up as a coefficient in an important polynomial called the j -invariant, and 196,883 came up in relation to an enormous mathematical object called the Monster group. Many people probably would have shrugged and moved along, but the observations intrigued some mathematicians, who decided to take a closer look. They uncovered connections between two seemingly unrelated subjects: number theory and the symmetries of the Monster group. These linkages may even have broader, as yet ungrasped, significance for other subjects. The physicist Edward Witten has argued that the Monster group may be related to quantum gravity and the deep structure of spacetime.

MATHEMATICAL NEAR MISSES SHOW the power and playfulness of the human touch in mathematics. Johnson, Kaplan, and others made their discoveries by trial and error—by exploring, like biologists trudging through the rainforest to look for new species. But with mathematics it can be easier to search systematically. For instance, Jim McNeill, a mathematical hobbyist who collects near misses on his website, and Robert Webb, a computer programmer, have developed software for creating and studying polyhedra.

Near misses live in the murky boundary between idealistic, unyielding mathematics and our indulgent, practical senses. They invert the logic of approximation. Normally the real world is an imperfect shadow of the Platonic realm. The perfection of the underlying mathematics is lost under realizable conditions. But

with near misses, the real world is the perfect shadow of an imperfect realm. An approximation is "a not-right estimate of a right answer," Kaplan says, whereas "a near miss is an exact representation of an almost-right answer."

In this way, near misses transform the mathematician's and mathematical physicist's relationship with the natural world. "I am grateful for the imperfections of the real world because it allows me to achieve a kind of quasi-perfection with objects that I know are intrinsically not perfect," Kaplan says. "It allows me to overcome the limitations of mathematics because of the beautiful brokenness of reality." ☺

EVELYN LAMB is a mathematician who specializes in complex analysis. She writes extensively on math and science. She blogs for the American Mathematical Society and for her own blog, "Roots of Unity." @evelynjlamb



ILLUSTRATION BY **JOHN HENDRIX**

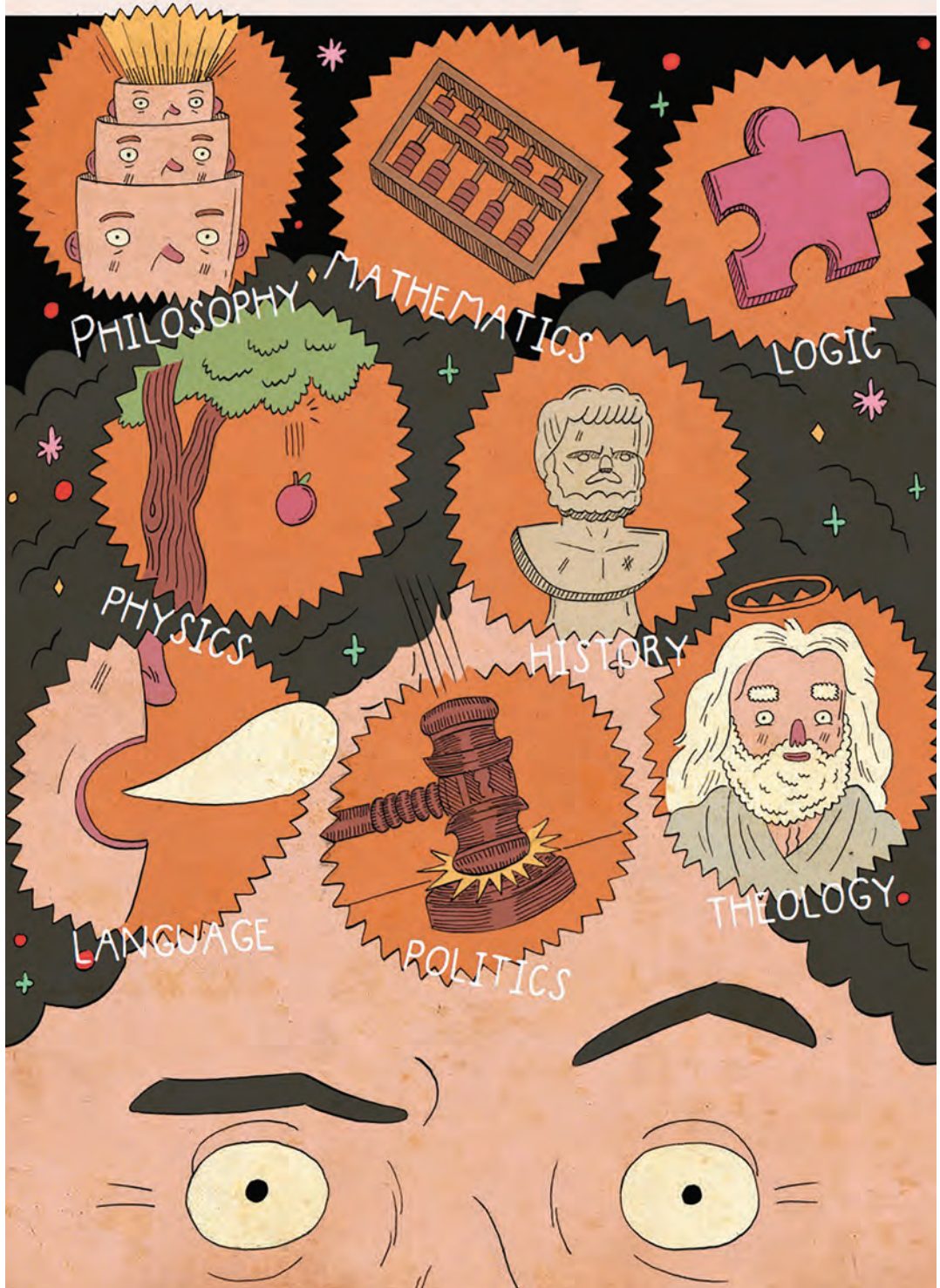
The Multiverse of 1686

Speculation on multiple universes goes back farther than you might think

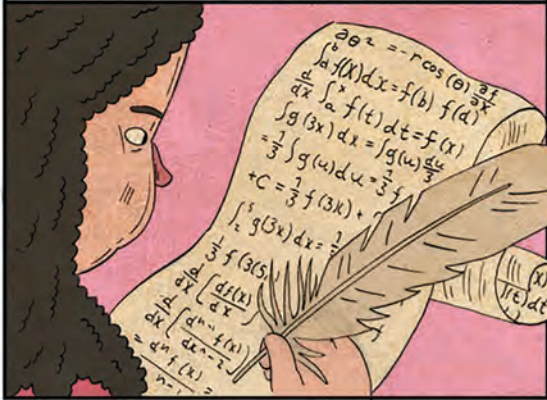
BY STEVEN NADLER & BEN NADLER



HIS EXPERTISE EXTENDED TO

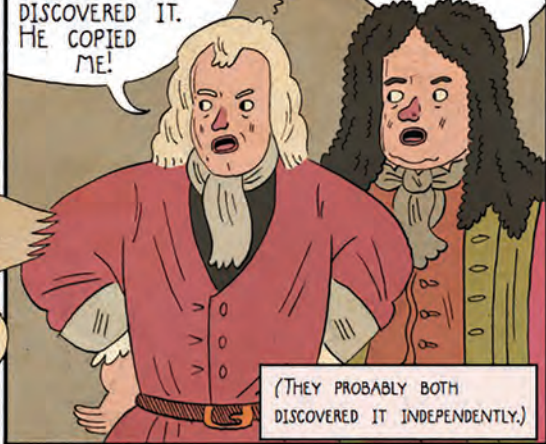


HE DEVELOPED CALCULUS, THE MATHEMATICAL STUDY OF CHANGE AND INFINITESIMALS.



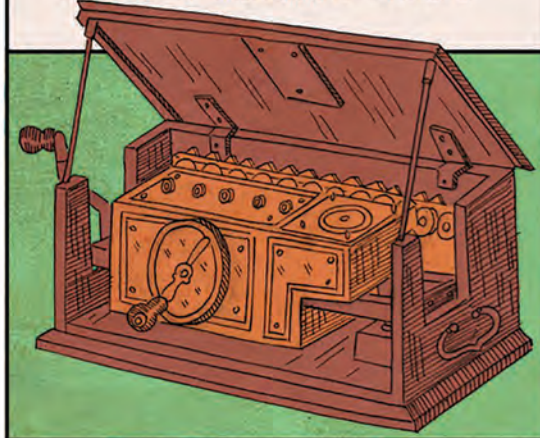
NOW WAIT A SECOND! - IT WAS I WHO DISCOVERED IT. HE COPIED ME!

SO YOU SAY, NEWTON!



(THEY PROBABLY BOTH DISCOVERED IT INDEPENDENTLY.)

HE WAS ALSO AN INVENTOR, AND DESIGNED A CALCULATING MACHINE.



IN THE FALL OF 1676, LEIBNIZ WAS ON HIS WAY HOME AFTER FOUR YEARS IN PARIS, WHERE HE HAD BEEN SENT ON A DIPLOMATIC MISSION BY THE ELECTOR OF MAINZ.



HE TOOK ADVANTAGE OF THE RETURN JOURNEY TO MAKE A DETOUR TO HOLLAND AND MEET THE INFAMOUS SPINOZA.



LEIBNIZ, A LUTHERAN, AND SPINOZA, AN EXCOMMUNICATED JEW, MUST HAVE HAD QUITE A CONVERSATION.



LEIBNIZ KNEW SPINOZA'S VIEWS ON RELIGION, THE BIBLE, AND MIRACLES FROM THE *THEOLOGICAL-POLITICAL TREATISE*.



BUT WHAT LEIBNIZ REALLY WANTED TO KNOW MORE ABOUT WAS SPINOZA'S METAPHYSICS.



LEIBNIZ WAS TROUBLED BY SPINOZA'S ACCOUNT OF THE NECESSITY OF THE WORLD AND EVERYTHING IN IT.



PROBABLY BECAUSE HIS OWN PHILOSOPHY SEEMED TO COME DANGEROUSLY CLOSE TO SUCH A CONCLUSION.



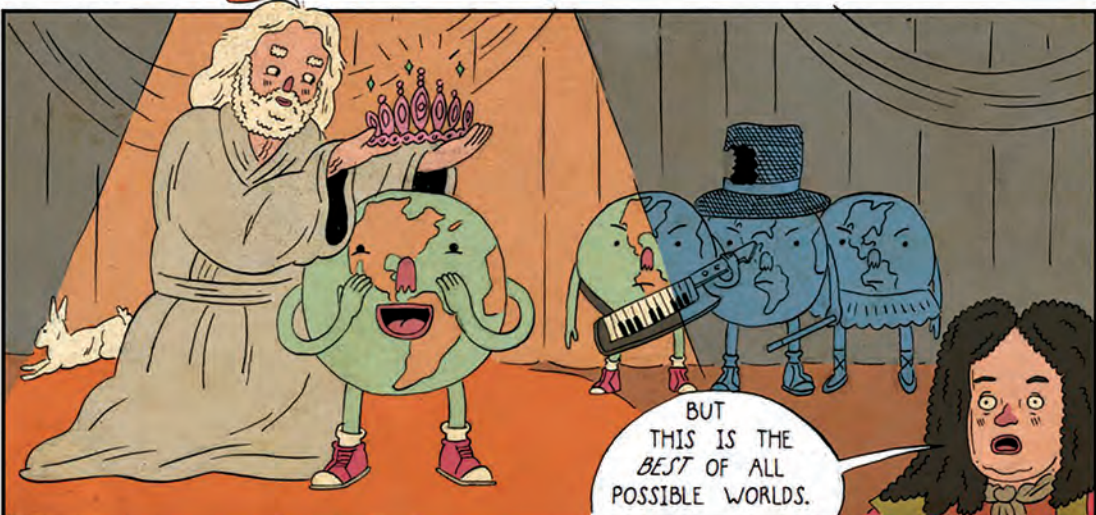
BY 1686, LEIBNIZ, NOW WORKING FOR THE DUKE OF HANOVER, HAD FIGURED OUT SOME METAPHYSICAL THINGS OF HIS OWN.

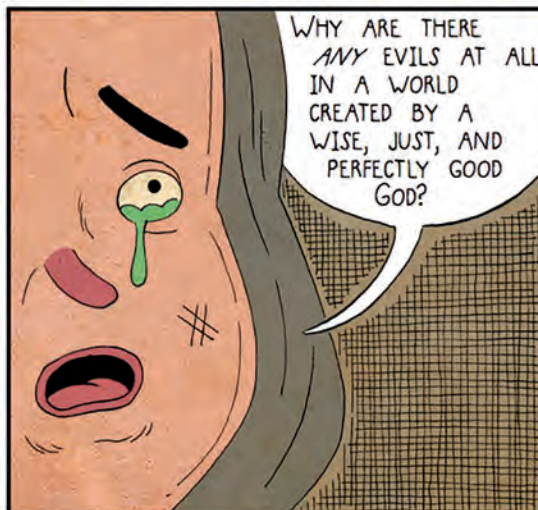


IN HIS *DISCOURSE ON METAPHYSICS*, HE INSISTS THAT THIS IS NOT THE ONLY POSSIBLE WORLD.



THERE ARE INFINITELY MANY POSSIBLE WORLDS THAT GOD COULD HAVE CREATED.





LEIBNIZ COINED THE TERM "THEODICY" FOR A SOLUTION TO THIS PHILOSOPHICAL CONUNDRUM.



BEING THE BEST WORLD OVERALL DOES NOT MEAN THAT IT WILL BE BEST FOR EVERY INDIVIDUAL IN IT.



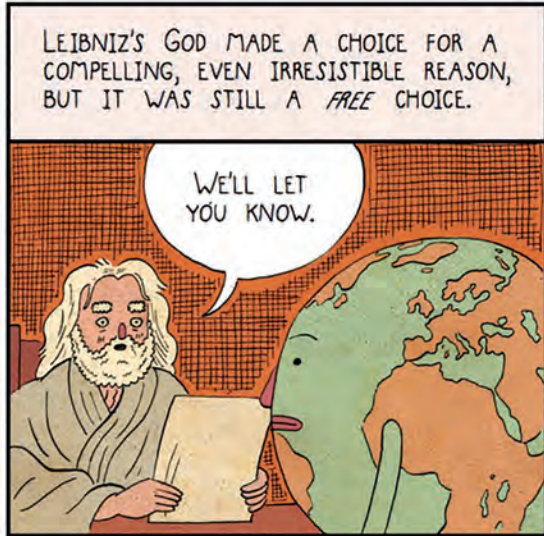
AND IN PAINTING, WHERE SHADOWS ALLOW THE ILLUMINATED PARTS TO EMERGE...

AS IN MUSIC, WHERE DISSONANCE IS NECESSARY TO HIGHLIGHT THE HARMONY...



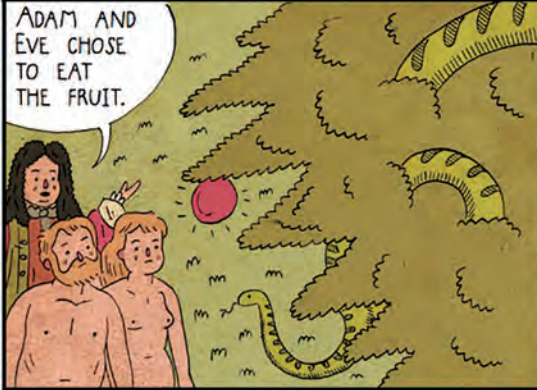
SO IN THE BEST WORLD THERE WILL BE DEFECTS THAT MAKE THE PERFECTIONS STAND OUT EVEN MORE CLEARLY.



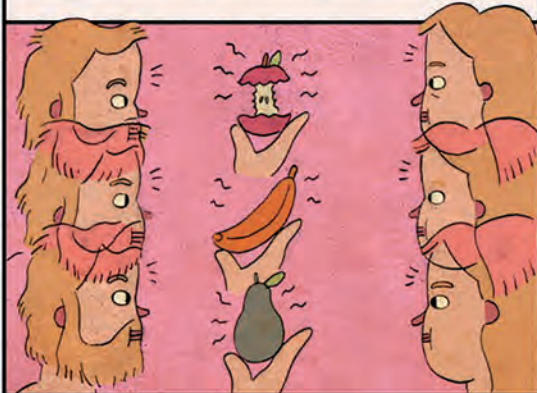


BUT BECAUSE ALTERNATIVE POSSIBILITIES ARE STILL *CONCEIVABLE*, THE NECESSITY OF THINGS IS NOT A LOGICAL OR ABSOLUTE NECESSITY.

ADAM AND EVE CHOSE TO EAT THE FRUIT.



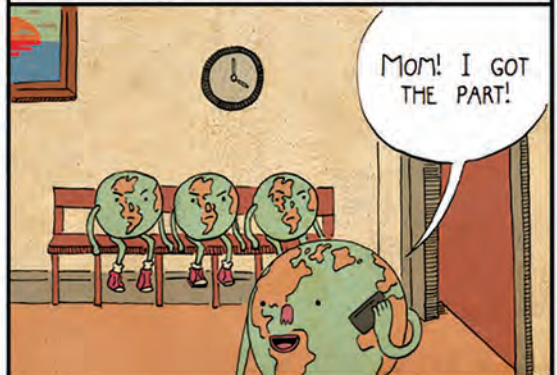
THIS WORLD WITH THIS ADAM AND EVE EATING THIS FRUIT IS NOT THE ONLY LOGICALLY POSSIBLE WORLD.



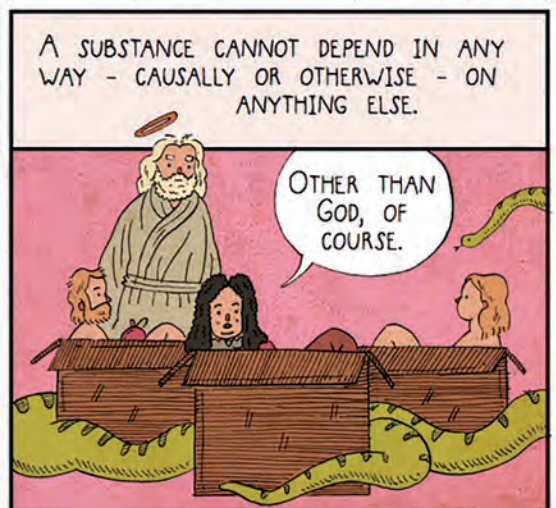
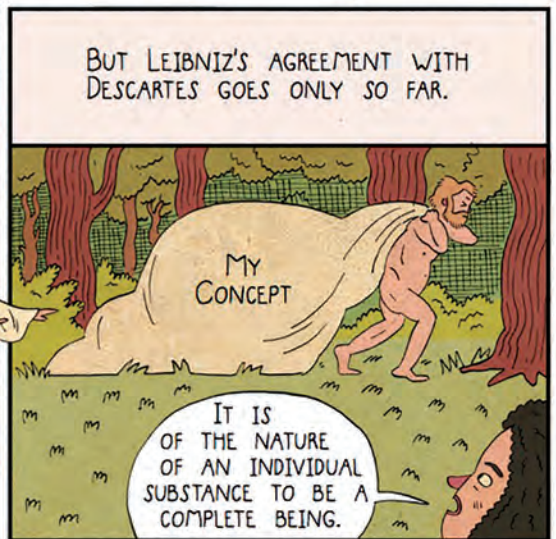
AND GIVEN GOD'S CHOICE OF THIS WORLD WITH THIS ADAM AND THIS EVE,

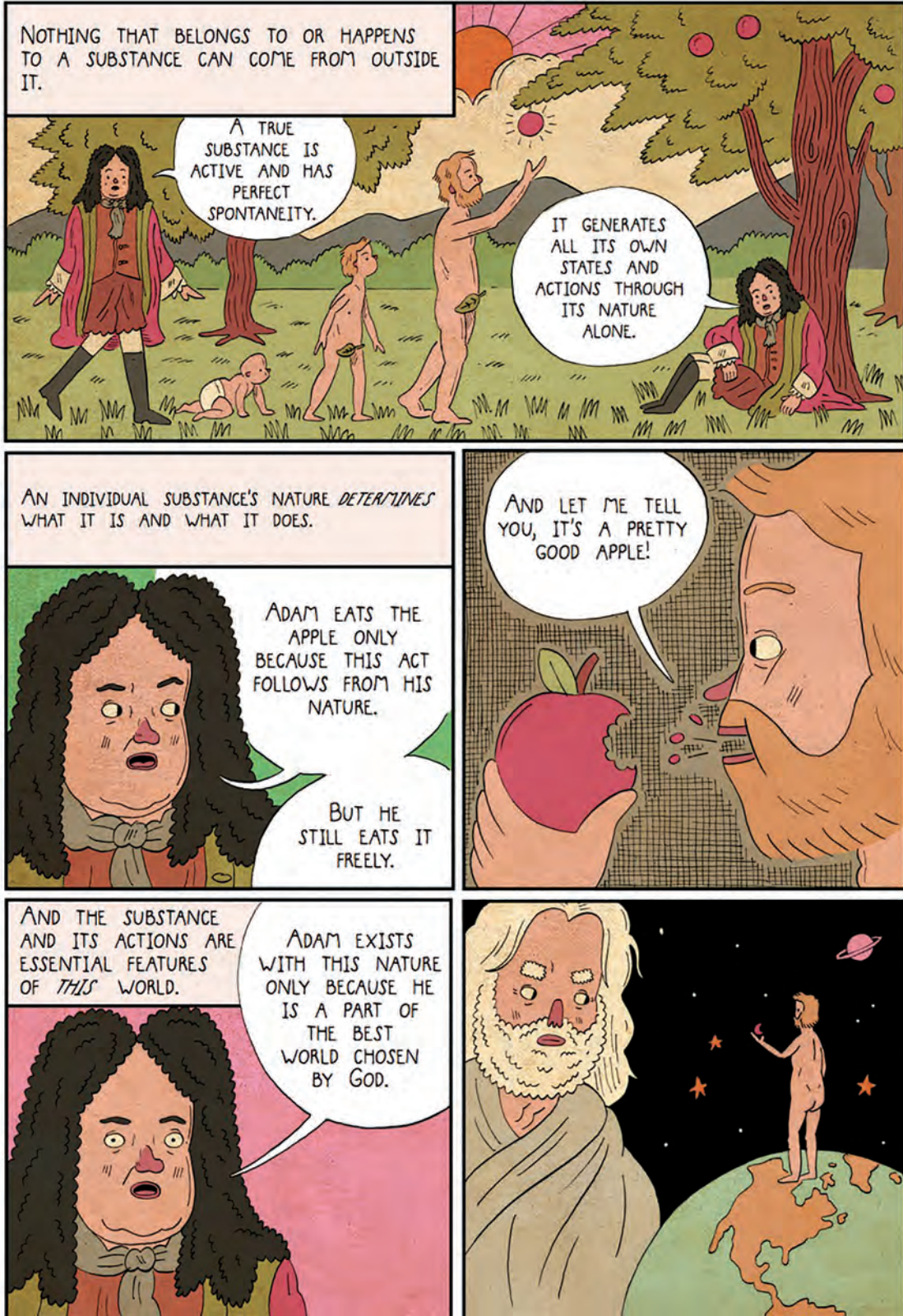


OTHER WORLDS WITH OTHER ADAMS AND OTHER EVES ARE STILL POSSIBLE "IN THEMSELVES," ALTHOUGH GOD WOULD CERTAINLY *NOT* HAVE CHOSEN ANY OF THOSE WORLDS, SINCE THEY ARE NOT COMPATIBLE WITH DIVINE WISDOM.





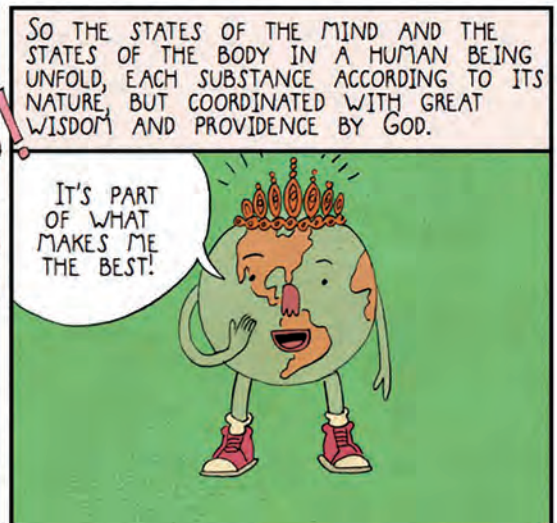
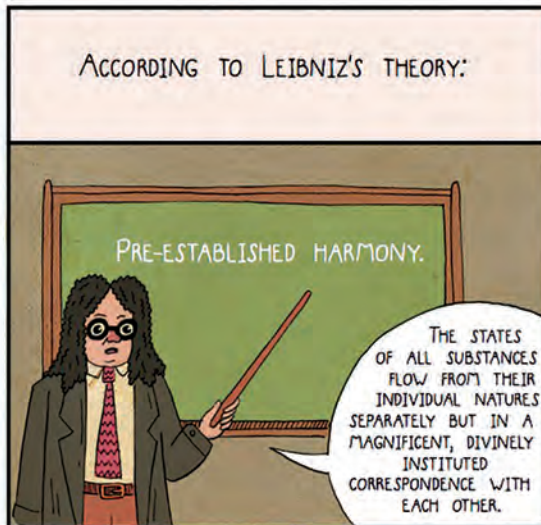




LEIBNIZ CONCLUDES THAT IF ANY SUBSTANCE MUST BE THE ACTIVE SOURCE OF ITS OWN STATES, THERE CAN BE NO CAUSAL *INTERACTION* BETWEEN SUBSTANCES.









When Neurology Becomes Theology

A neurologist's perspective on research into consciousness

BY ROBERT A. BURTON

EARLY IN MY NEUROLOGY RESIDENCY, a 50-year-old woman insisted on being hospitalized for protection from the FBI spying on her via the TV set in her bedroom. The woman's physical examination, lab tests, EEGs, scans, and formal neuropsychological testing revealed nothing unusual. Other than being visibly terrified of the TV monitor in the ward solarium, she had no other psychiatric symptoms or past psychiatric history. Neither did anyone else in her family, though she had no recollection of her mother, who had died when the patient was only 2.

The psychiatry consultant favored the early childhood loss of her mother as a potential cause of a mid-life major depressive reaction. The attending neurologist was suspicious of an as yet undetectable degenerative brain disease, though he couldn't be more specific. We residents were equally divided between the two possibilities.

Fortunately an intern, a super-sleuth more interested in data than speculation, was able to locate her parents' death certificates. The patient's mother had died in a state hospital of Huntington's disease—a genetic degenerative brain disease. (At that time such illnesses were often kept secret from the rest of the family.) Case solved. The patient was a textbook example of psychotic behavior preceding the cognitive decline and movement disorders characteristic of Huntington's disease.

As a fledgling neurologist, I'd already seen a wide variety of strange mental states arising out of physical diseases. But on this particular day, I couldn't wrap my mind around a gene mutation generating an isolated feeling of being spied on by the FBI. How could a localized excess of amino acids in a segment of DNA be transformed into paranoia?

Though I didn't know it at the time, I had run headlong into the "hard problem of consciousness," the enigma of how physical brain mechanisms create purely subjective mental states. In the subsequent 50 years, what was once fodder for neurologists' late night speculations has mushroomed into the pre-eminent

question in the philosophy of mind. As an intellectual challenge, there is no equal to wondering how subatomic particles, mindless cells, synapses, and neurotransmitters create the experience of red, the beauty of a sunset, the euphoria of lust, the transcendence of music, or in this case, intractable paranoia.

Neuroscientists have long known which general areas of the brain and their connections are necessary for the state of consciousness. By observing both the effects of localized and generalized brain insults such as anoxia and anesthesia, none of us seriously doubt that consciousness arises from discrete brain mechanisms. Because these mechanisms are consistent with general biological principles, it's likely that, with further technical advances, we will uncover how the brain generates consciousness.

However, such knowledge doesn't translate into an explanation for the *what* of consciousness—that state of awareness of one's surroundings and self, the experience of one's feelings and thoughts. Imagine a hypothetical where you could mix nine parts oxytocin, 17 parts serotonin, and 11 parts dopamine into a solution that would make 100 percent of people feel a sense of infatuation 100 percent of the time. Knowing the precise chemical trigger for the sensation of infatuation (the *how*) tells you little about the nature of the resulting feeling (the *what*).

Over my career, I've gathered a neurologist's working knowledge of the physiology of sensations. I realize neuroscientists have identified neural correlates for emotional responses. Yet I remain ignorant of what sensations and responses are at the level of experience. I know the brain creates a sense of self, but that tells me little about the nature of the sensation of "I-ness." If the self is a brain-generated construct, I'm still left wondering who or what is experiencing the illusion of being me. Similarly, if the feeling of agency is an illusion, as some philosophers of mind insist, that doesn't help me understand the essence of my experience of willfully typing this sentence.

Slowly, and with much resistance, it's dawned on me that the pursuit of the nature of consciousness, no

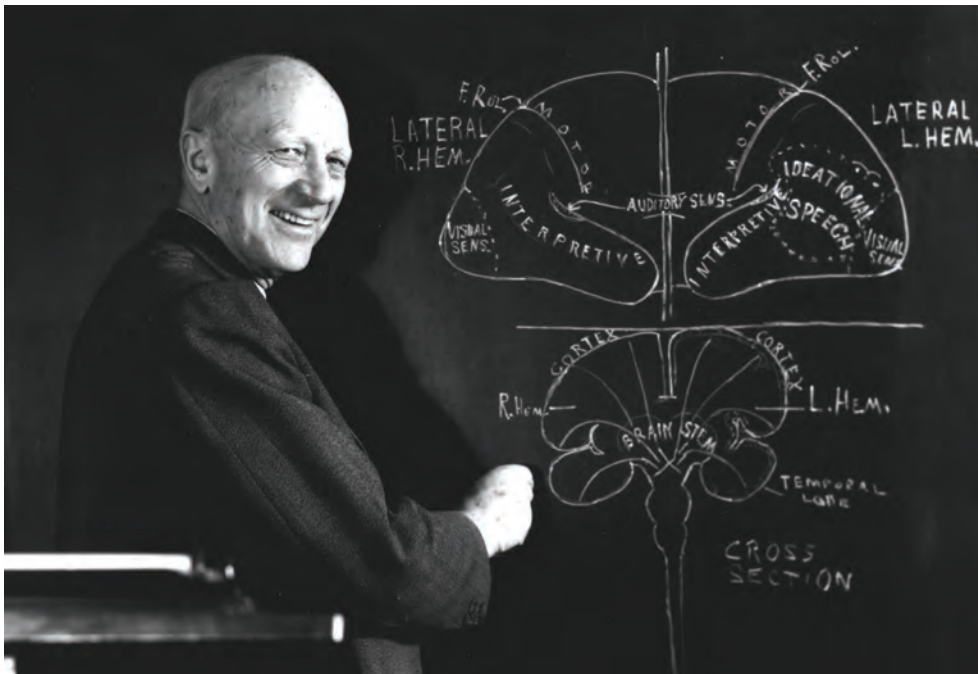
matter how cleverly couched in scientific language, is more like metaphysics and theology. It is driven by the same urges that made us dream up gods and demons, souls and afterlife. The human urge to understand ourselves is eternal, and how we frame our musings always depends upon prevailing cultural mythology. In a scientific era, we should expect philosophical and theological ruminations to be couched in the language of physical processes. We argue by inference and analogy, dragging explanations from other areas of science such as quantum physics, complexity, information theory, and math into a subjective domain. Theories of consciousness are how we wish to see ourselves in the world, and how we wish the world might be.

MY FIRST HINT OF THE INTERACTION between religious feelings and theories of consciousness came from Montreal Neurological Institute neurosurgeon

Wilder Penfield's 1975 book, *Mystery of the Mind: A Critical Study of Consciousness and the Human Brain*. One of the great men of modern neuroscience, Penfield spent several decades stimulating the brains of conscious, non-anesthetized patients and noting their descriptions of the resulting mental states, including long-lost bits of memory, dreamy states, *deja vu*, feelings of strangeness, and otherworldliness. What was most startling about Penfield's work was his demonstration that sensations that normally qualify how we feel about our thoughts can occur in the absence of any conscious thought. For example, he could elicit feelings of familiarity and strangeness without the patient thinking of anything to which the feeling might apply. His ability to spontaneously evoke pure mental states was proof positive that these states arise from basic brain mechanisms.

And yet, here's Penfield's conclusion to his

TO BE OR NOT TO BE Wilder Penfield spent decades studying how brains produce the experience of consciousness, but concluded "There is no good evidence, in spite of new methods, that the brain alone can carry out the work that the mind does."



I couldn't wrap my mind around a gene mutation generating an isolated feeling of being spied on by the FBI.

end-of-career magnum opus on the nature of the mind: "There is no good evidence, in spite of new methods, that the brain alone can carry out the work that the mind does." How is this possible? How could a man who had single-handedly elicited so much of the fabric of subjective states of mind decide that there was something to the mind beyond what the brain did?

In the last paragraph of his book, Penfield explains, "In ordinary conversation, the 'mind' and 'the spirit of man' are taken to be the same. I was brought up in a Christian family and I have always believed, since I first considered the matter ... that there is a grand design in which all conscious individuals play a role ... Since a final conclusion ... is not likely to come before the youngest reader of this book dies, it behooves each one of us to adopt for himself a personal assumption (belief, religion), and a way of life without waiting for a final word from science on the nature of man's mind."

Front and center is Penfield's observation that, in ordinary conversation, the mind is synonymous with the spirit of man. Further, he admits that, in the absence of scientific evidence, all opinions about the mind are in the realm of belief and religion. If Penfield

I'm still left wondering who or what is experiencing the illusion of being me.

is even partially correct, we shouldn't be surprised that any theory of the "what" of consciousness would be either intentionally or subliminally infused with one's metaphysics and religious beliefs.

To see how this might work, take a page from Penfield's brain stimulation studies where he demonstrates that the mental sensations of consciousness can occur independently from any thought that they seem to qualify. For instance, conceptualize thought as a mental calculation and a visceral sense of the calculation. If you add $3 + 3$, you compute 6, and simultaneously have the feeling that 6 is the correct answer. Thoughts feel right, wrong, strange, beautiful, wondrous, reasonable, far-fetched, brilliant, or stupid. Collectively these widely disparate mental sensations constitute much of the contents of consciousness. But we have no control over the mental sensations that color our thoughts. No one can will a sense of understanding or the joy of an a-ha! moment. We don't tell ourselves to make an idea feel appealing; it just is. Yet these sensations determine the direction of our thoughts. If a thought feels irrelevant, we ignore it. If it feels promising, we pursue it. Our lines of reasoning are predicated upon how thoughts feel.

Shortly after reading Penfield's book, I had the good fortune to spend a weekend with theoretical physicist David Bohm. Bohm took a great deal of time arguing

for a deeper and interconnected hidden reality (his theory of implicate order). Though I had difficulty following his quantum theory-based explanations, I vividly remember him advising me that the present-day scientific approach of studying parts rather than the whole could never lead to any final answers about the nature of consciousness. According to him, all is inseparable and no part can be examined in isolation.

In an interview in which he was asked to justify his unorthodox view of scientific method, Bohm responded, “My own interest in science is not entirely separate from what is behind an interest in religion or in philosophy—that is to understand the whole of the universe, the whole of matter, and how we originate.” If we were reading Bohm’s argument as a literary text, we would factor in his Jewish upbringing, his tragic mistreatment during the McCarthy era, the lack of general acceptance of his idiosyncratic take on quantum physics, his bouts of depression, and the close relationship between his scientific and religious interests.

MANY OF TODAY’S MYRIAD EXPLANATIONS for how consciousness arises are compelling. But once we enter the arena of the nature of consciousness, there are no outright winners.

Christof Koch, the chief scientific officer of the Allen Institute for Brain Science in Seattle, explains that a “system is conscious if there’s a certain type of complexity. And we live in a universe where certain systems have consciousness. It’s inherent in the design of the universe.”

According to Daniel Dennett, professor of philosophy at Tufts University and author of *Consciousness Explained* and many other books on science and philosophy, consciousness is nothing more than a “user-illusion” arising out of underlying brain mechanisms. He argues that believing consciousness plays a major role in our thoughts and actions is the biological equivalent of being duped into believing that the icons of a smartphone app are doing the work of the underlying computer programs represented by the icons. He feels no need to postulate any additional physical component to explain the intrinsic qualities of our subjective experience.

Meanwhile, Max Tegmark, a theoretical physicist at the Massachusetts Institute of Technology, tells

us consciousness “is how information feels when it is being processed in certain very complex ways.” He writes that “external reality is completely described by mathematics. If everything is mathematical, then, in principle, everything is understandable.” Rudolph E. Tanzi, a professor of neurology at Harvard University, admits, “To me the primal basis of existence is awareness and everything including ourselves and our brains are products of awareness.” He adds, “As a responsible scientist, one hypothesis which should be tested is that memory is stored outside the brain in a sea of consciousness.”

Each argument, taken in isolation, seems logical, internally consistent, yet is at odds with the others. For me, the thread that connects these disparate viewpoints isn’t logic and evidence, but their overall intent. Belief without evidence is Richard Dawkins’ idea of faith. “Faith is belief in spite of, even perhaps because of, the lack of evidence.” These arguments are best read as differing expressions of personal faith.

For his part, Dennett is an outspoken atheist and fervent critic of the excesses of religion. “I have absolutely no doubt that secular and scientific vision is right and deserves to be endorsed by everybody, and as we have seen over the last few thousand years, superstitious and religious doctrines will just have to give way.” As the basic premise of atheism is to deny that for which there is no objective evidence, he is forced to avoid directly considering the nature of purely subjective phenomena. Instead he settles on describing the contents of consciousness as illusions, resulting in the circularity of using the definition of mental states (illusions) to describe the general nature of these states.

The problem compounds itself. Dennett is fond of pointing out (correctly) that there is no physical manifestation of “I,” no ghost in the machine or little homunculus that witnesses and experiences the goings on in the brain. If so, we’re still faced with asking what/who, if anything, is experiencing consciousness? All roads lead back to the hard problem of consciousness.

Though tacitly agreeing with those who contend that we don’t yet understand the nature of consciousness, Dennett argues that we are making progress. “We haven’t yet succeeded in fully conceiving how meaning could exist in a material world ... or how consciousness works, but we’ve made progress: The

questions we're posing and addressing now are better than the questions of yesteryear. We're hot on the trail of the answers."

By contrast, Koch is upfront in correlating his religious upbringing with his life-long pursuit of the nature of consciousness. Raised as a Catholic, he describes being torn between two contradictory views of the world—the Sunday view reflected by his family and church, and the weekday view as reflected in his work as a scientist (the sacred and the profane).

In an interview with *Nautilus*, Koch said, "For reasons I don't understand and don't comprehend, I find myself in a universe that had to become conscious, reflecting upon itself." He added, "The God I now believe in is closer to the God of Spinoza than it is to Michelangelo's paintings or the God of the Old Testament, a god that resides in this mystical notion of all-nothingness." Koch admitted, "I'm not a mystic. I'm a scientist, but this is a feeling I have." In short, Koch exemplifies a truth seldom admitted—that mental states such as a mystical feeling shape how one thinks about and goes about studying the universe, including mental states such as consciousness.

Both Dennett and Koch have spent a lifetime considering the problem of consciousness; though contradictory, each point of view has a separate appeal. And I appreciate much of Dennett and Koch's explorations in the same way that I can mull over Aquinas and Spinoza without necessarily agreeing with them. One can enjoy the pursuit without believing in or expecting answers. After all these years without any personal progress, I remain moved by the essential nature of the quest, even if it translates into Sisyphus endlessly pushing his rock up the hill.

The spectacular advances of modern science have generated a mindset that makes potential limits to scientific inquiry intuitively difficult to grasp. Again and again we are given examples of seemingly insurmountable problems that yield to previously unimaginable answers. Just as some physicists believe we will one day have a Theory of Everything, many cognitive scientists believe that consciousness, like any physical property, can be unraveled. Overlooked in this optimism is the ultimate barrier: The nature of consciousness is in the mind of the beholder, not in the eye of the observer.

It is likely that science will tell us how consciousness

occurs. But that's it. Although the what of consciousness is beyond direct inquiry, the urge to explain will persist. It is who we are and what we do. ☺

ROBERT A. BURTON, a former chief of neurology at the University of California, San Francisco, Medical Center at Mount Zion, is the author of *On Being Certain: Believing You Are Right Even When You're Not*, and *A Skeptic's Guide to the Mind: What Neuroscience Can and Cannot Tell Us About Ourselves*.

The Death of Curiosity

by Howard Altmann

Then came the death of curiosity.
It was sudden and it was quick.
Many did not see it coming.
It woke up one morning and couldn't move its face away
from itself.
Narcissus would have gilded its frame.
An actor would have leaned in for a lesson.
A mime would have surrendered.
Painters and sculptors would have gathered their
instruments.
Children would have tried to make it laugh.
But curiosity was alone in its death as no one knew that
it had died.
Politicians graced it in speeches.
Scientists alluded to it in private conversations.
Neighbors greeted it on Sundays.
Crowds assumed it was in their laps.
All the while curiosity was at capacity.
It had what it had.
And it would have no more.

Then came the death of the country.
It was not sudden and it was not quick.
Few did not see it coming.
It woke up one morning and unhinged itself.
It did not leave a piece of land or a body of water.
It did not leave a flag.
It left no memory of soaring spacecraft or landing men.
There were no museums to document its descent.
There were no old maps to study.
Even the wars that never really died had no more blood
to go around.
Human and beast alike hovered in the air.
Yet there was nothing bird-like about them.
They were not leaves ushered by the wind into the great

hallways of time.
They were still human and they were still beast.
That simply had no ground to stand on.
The feet of trees wiggled their ankles in the air.
Buildings that stood up to the sky sat unmoored from
their foundations.

Then came the death of surrealism.
It was slow and it was painful.
And no one saw it coming.
If it woke up one morning not a soul could say.
Its oxygen was reality and its history of ailments.
The supply of raw materials to manipulate had exhausted
itself.
The shape of things had simply depleted the inventory of
possible contortions.
Imagined forms were confined to the unconscious
universe.
Floating in the horizon with animals and plants
Painters and sculptors lost all perspective.
No politician could claim chaos as a constituent.
No chemist could conduct an experiment.
The ink of philosophers had no medium to wander.
The dissolution of gestures gave actors nothing to mime.
Narcissus could not reflect upon her reflections.
Children could not fix their laughter.
The world could not place its fears.

HOWARD ALTMANN is the author of two collections of poetry,
Who Collects the Days and *In This House*.

This poem first appeared in *In This House*, published by Turtle Point
Press in 2010.

CARNEGIE LECTURES ON DEMAND

Exceptional science streams here

Travel to the stars. Splice genes.
Share the "aha" moment.
Watch videos of exceptional
science anytime, anyplace.
For free.

Visit our growing video library.
carnegiescience.edu/CSEvideos

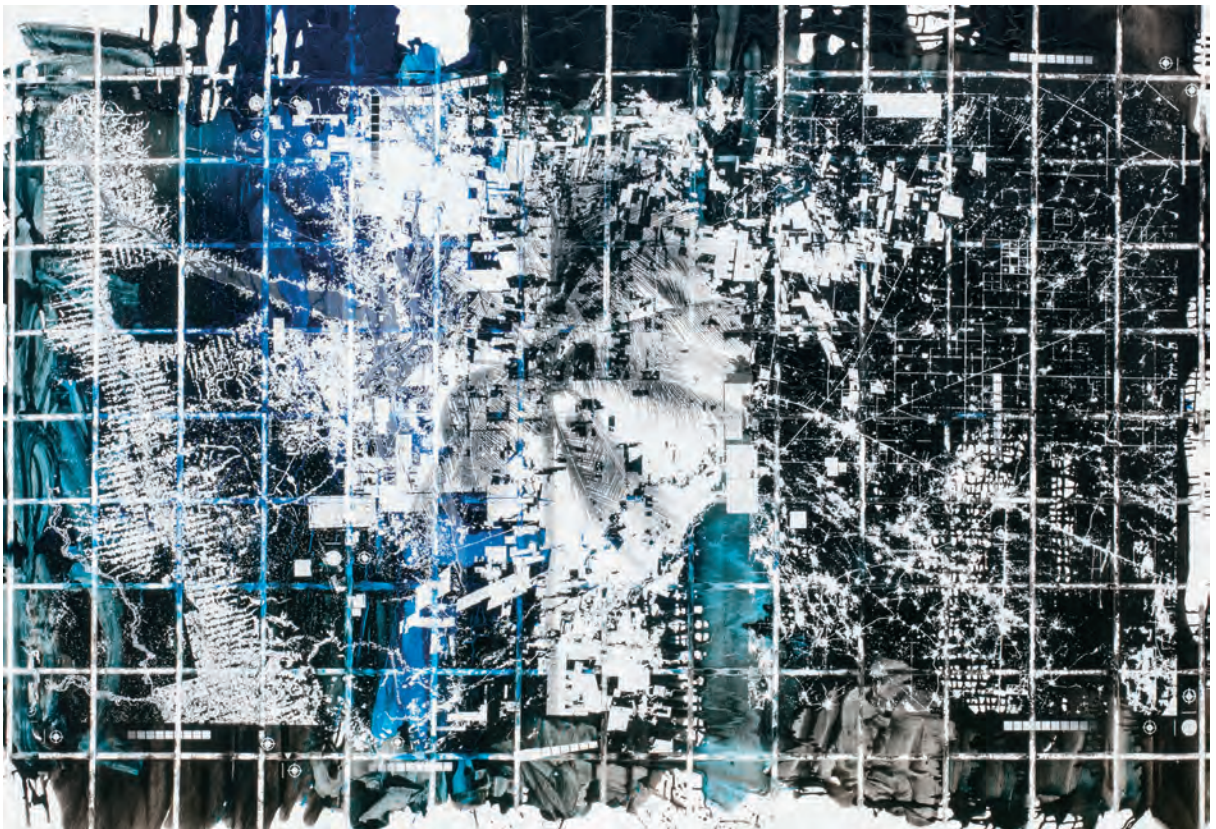


COSMOLOGY • ASTRONOMY • PLANETARY EVOLUTION
HIGH-PRESSURE PHYSICS • MATERIALS SCIENCE • GEOPHYSICS
GEOCHEMISTRY • MOLECULAR BIOLOGY • DEVELOPMENTAL BIOLOGY
PLANT SCIENCE • EVOLUTION • GENETICS • ECOLOGY

[@carnegiescience](https://twitter.com/carnegiescience)
facebook.com/carnegiescience

These videos are made possible by the generous support of Margaret & Will Hearst.

CULTURAL PROGRAMS OF THE NATIONAL ACADEMY OF SCIENCES



August 1, 2017 – January 31, 2018
2101 Constitution Ave., N.W., Washington, D.C.
Open weekdays 9-5. Free.
Photo ID required.

STEVE MILLER
HEALTH OF THE PLANET

FOR MORE INFORMATION, VISIT WWW.CPNAS.ORG.

   @CPNAS



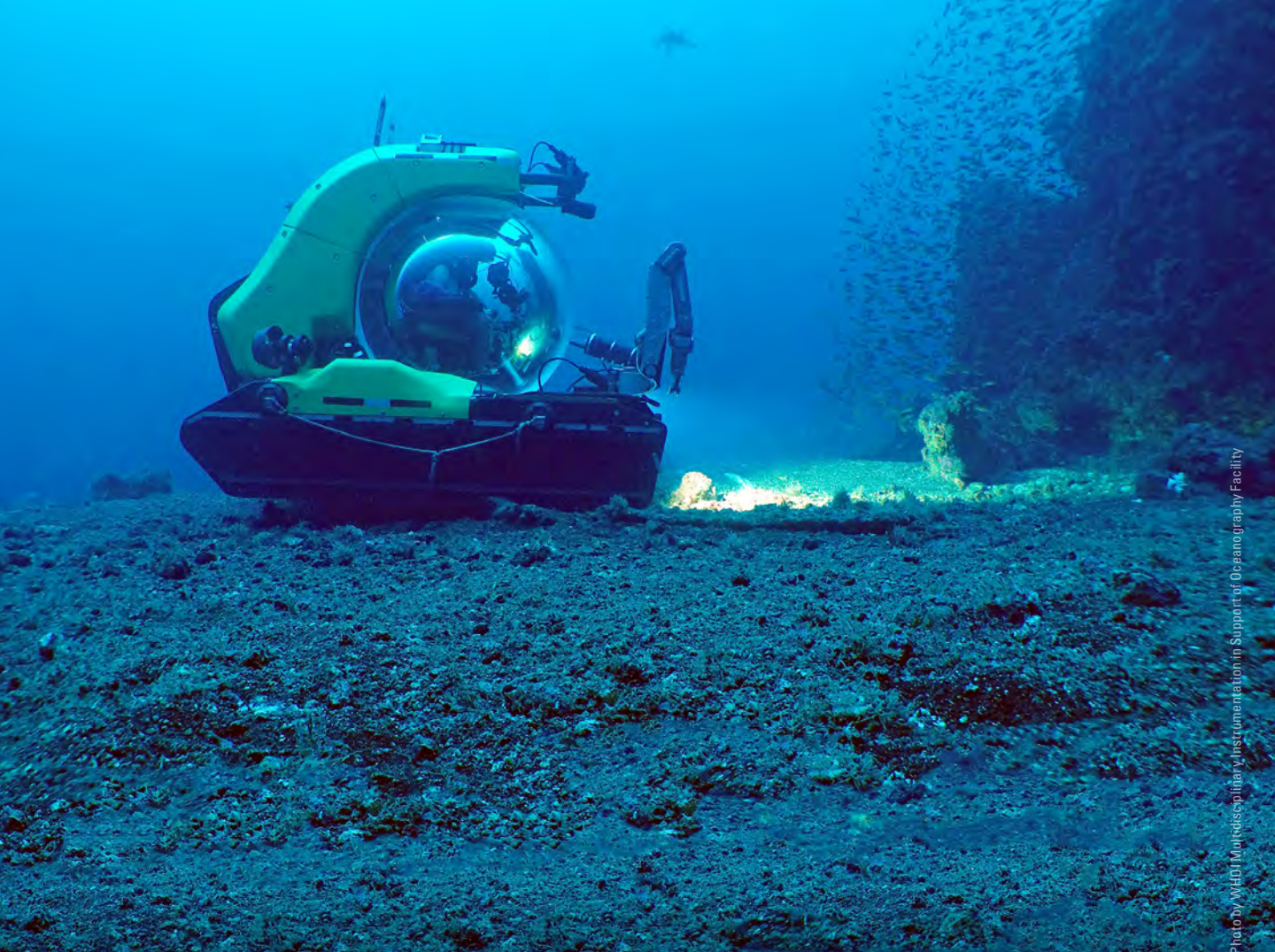


Photo by WHOI Multidisciplinary Instrumentation in Support of Oceanography Facility

DISCOVERING NEW WORLDS RIGHT HERE ON EARTH

Scientists in *Deep Rover 2* explore an oasis of deep-sea life near the Galápagos Islands.

Woods Hole
Oceanographic
INSTITUTION

A global leader in the study and exploration of the ocean

www.whoi.edu



“Smart, eager and with wonderful ‘can do’ attitudes, Kelly and Michael were prepared to make an immediate difference”

R. Douglas Kahn, Chairman & CEO
TetraGenetics, Inc.



Against company practice of hiring only graduate students, TetraGenetics Chairman and CEO Doug Kahn took a risk to hire two undergraduate interns – Kelly Brennan and Michael Sheets – from Olin College. The Ph.D. scientists in the lab were blown away by how quickly they became contributors. [Learn more about how Olin College educates innovative problem solvers with the skills and mindset to contribute from day one at Olin.edu.](#)



MP Neuro

BRAIN DISORDERS AND INJURY

COGNITION

DEVELOPMENT

INTEGRATIVE PHYSIOLOGY AND BEHAVIOR

MOTIVATION AND EMOTION

MOTOR SYSTEMS

NEURAL EXCITABILITY, SYNAPSES, AND GLIA

SENSORY SYSTEMS

TECHNIQUES



The Max Planck Society brings together hundreds of neuroscience researchers, equipping them with the best tools and resources to explore some of the most complex issues facing all facets of brain science.

This collective knowledge and expertise promotes creative, interdisciplinary approaches, allowing Max Planck scientists to make significant advances in the field and develop innovative technologies and techniques to advance neuroscience research across the globe.

Come see and share the future of neuroscience at

[MaxPlanckNeuroscience.org](https://www.MaxPlanckNeuroscience.org)



**Our vision is a world
where people think for
themselves and can
confidently ask questions,
question answers, and
understand the world
around them.**



Pier 15, San Francisco
exploratorium.edu

aging

is the climate change of human biology

GLENN FOUNDATION
FOR MEDICAL RESEARCH





Why Basic Science?



SCIENCE

PHILANTHROPY ALLIANCE

Advancing basic science—The foundation of our future

www.sciphil.org

Just Think.

We promote science, education, and the literary arts to expand public understanding of fundamental questions of scientific inquiry and their connection to culture. Through the creation of print, electronic, and visual media of the highest quality and depth, NautilusThink seeks to connect science to our everyday lives and explore the frontiers of scientific, mathematical, and philosophical inquiry and the human spirit.

Learn more at nautilusthink.org.



NAUTILUS *think*





Issue Index

Visit subscribe.nautilus.us for single issues, subscriptions, and more.

Science Connected.



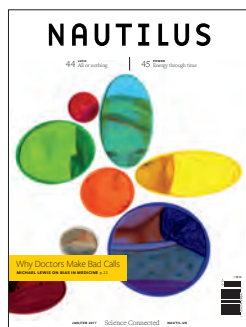
MAY/JUNE 2017 | 20

48 CHAOS
49 THE ABSURD



MAR/APR 2017 | 19

46 BALANCE
47 CONSCIOUSNESS



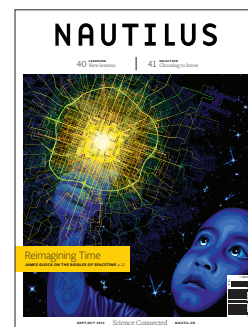
JAN/FEB 2017 | 18

44 LUCK
45 POWER



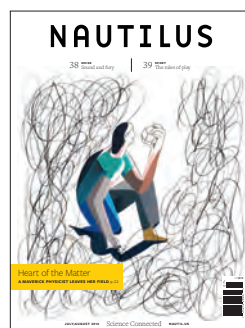
NOV/DEC 2016 | 17

42 FAKES
43 HEROES



SEP/OCT 2016 | 16

40 LEARNING
41 SELECTION



JULY/AUG 2016 | 15

38 NOISE
39 SPORT



MAY/JUNE 2016 | 14

36 AGING
37 CURRENTS



MAR/APR 2016 | 13

34 ADAPTATION
35 BOUNDARIES



JAN/FEB 2016 | 12

32 SPACE
33 ATTRACTION



NOV/DEC 2015 | 11

30 IDENTITY
31 STRESS



SEP/OCT 2015 | 10

28 2050
29 SCALING



JULY/AUG 2015 | 09

25 WATER
26 COLOR
27 DARK MATTER



MAY/JUNE 2015 | 08

22 SLOW
23 DOMINOES
24 ERROR



MAR/APR 2015 | 07

19 ILLUSIONS
20 CREATIVITY
21 INFORMATION



WINTER 2015 | 06

16 NOTHINGNESS
17 BIG BANGS
18 GENIUS



FALL 2014 | 05

13 SYMMETRY
14 MUTATION
15 TURBULENCE



SUMMER 2014 | 04

10 MERGERS & ACQUISITIONS
11 LIGHT
12 FEEDBACK



SPRING 2014 | 03

07 WASTE
08 HOME
09 TIME



WINTER 2014 | 02

04 THE UNLIKELY
05 FAME
06 SECRET CODES



FALL 2013 | 01

01 HUMAN UNIQUENESS
02 UNCERTAINTY
03 IN TRANSIT

SUBSCRIPTIONS

Nautilus (ISSN 2372-1758) is published bimonthly: Jan/Feb, March/April, May/June, July/Aug, Sept/Oct, Nov/Dec. Subscription and address changes should be addressed to *Nautilus* 25 Broadway, 9th Floor New York, NY 10004; phone: 212-221-3870; email: cs@store.nautil.us

Visit subscribe.nautil.us for more information.

POSTMASTER

Send address changes to: *Nautilus* 25 Broadway, 9th Floor New York, NY 10004

© 2017 NautilusThink, Inc. All rights reserved

Sarah Bakewell

The author of At the Existentialist Café reflects on the themes in Nautilus

THE ABSURD Much as they liked Albert Camus personally, neither Jean-Paul Sartre nor Simone de Beauvoir accepted his vision of absurdity. For them, life is not absurd, even when viewed on a cosmic scale, and nothing can be gained by saying it is. Life for them is full of real meaning, although that meaning emerges differently for each of us. Sartre wrote in his review of *The Stranger* that Camus is “claiming to render raw experience and yet he slyly filtering out all the meaningful connections which are also part of the experience.” Camus, he said, was too influenced by David Hume, who “announced that all he could find in experience was isolated impressions.” Sartre thinks life only looks like that when something has gone awry.

For Sartre, the awakened individual is neither Roquentin, fixated on objects in cafes and parks, nor Sisyphus, rolling a stone up the mountainside with the bogus cheerfulness of Tom Sawyer whitewashing a fence. It is a person who is engaged in doing something purposeful, in the full confidence that it means something. It is the person who is truly free.



CHAOS Science books and magazines bombard us with the news that we are out of control: that we amount to a mass of irrational but statistically unpredictable responses, veiled by the mere illusion of a conscious, governing mind. They tell us that, when we decide to sit down, to reach for a glass of water, to vote, or to choose whom we would save in the “trolley problem,” we are not really choosing at all but responding to tendencies and associations that are beyond the reach of both reason and will.

One gets the impression we take pleasure in this idea of ourselves as out-of-control mechanical dupes of our own biology and environment. We claim to find it disturbing, but we might be deriving a kind of reassurance from it—for such ideas let us off the hook. They save us from the existential anxiety that comes with considering ourselves free agents who are responsible for what we do. Sartre would call that bad faith. Recent research suggests those who have been encouraged to think they are unfree are inclined to behave less ethically, again suggesting we treat it as an alibi.

So, do we really want to understand our lives and manage our futures as if we had neither real freedom nor a truly human foundation for our existence? Perhaps we need the existentialists more than we thought. ☯

"The greatest thing to happen to science journalism in many years."

— David Gross, Nobel-Prize-winning physicist

Quanta magazine

**Reintroducing QuantaMagazine.org.
Because you want to know more.**

"My favorite science magazine...
a unique resource that everybody
who loves science should have at
the top of their reading list."

— Sean Carroll, CalTech physicist and
author of "The Big Picture: On the Origins
of Life, Meaning, and the Universe Itself."

An editorially independent publication of the
SIMONS FOUNDATION

@QuantaMagazine 

@QuantaMag 

QuantaNews 



Science Uncorked

VISIT SUBSCRIBE.NAUTIL.US