WILCZEK'S UNIVERSE

FRANK WILCZEK

Seeing Wonder Through the Eyes of Science

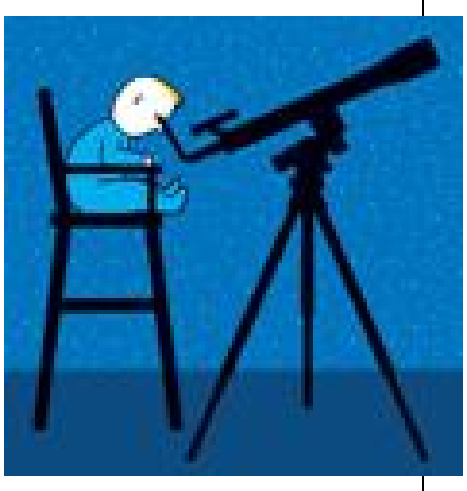
RECENTLY I'VE BEEN watching my grandson develop from a helpless infant into a functioning child. It's inspiring and deep to see Luke learn to make sense of the world. I watched him drop spoons from his high chair over and over again, each time checking that they'd relocated to the ground. Every parent (or grandparent) has seen such comical yet deeply serious "experiments."

Through these investigations, babies learn how to translate the jumble of photons that pass through our tiny pupils and impinge on our two-dimensional retinas into the three-dimensional world of objects that we navigate in everyday life. Other babyish meditations build up our concept of self and our explanatory models of other minds inside other bodies. These are great achievements. Researchers in artificial intelligence have struggled to replicate them, with limited success.

To understand reality, it's efficient and reasonable for children to take lessons from the way things behave in the everyday world. But our eyes can't perceive distant galaxies or the atoms and molecules that build up matter. The electromagnetic waves that power radios and microwave ovens pass unnoticed, as do the electric flows that power our muscles and encode our thoughts. We do not have the infrared vision of snakes, the ultraviolet vision of bees, or bats' ability to pick up ultrasound.

The physical world revealed by modern science is fundamentally different from the model we construct as babies. Scientific instruments let us perceive the world better than we can using only our bodies. We can use microscopes, telescopes, spectroscopes, magnetometers, particle accelerators, atomic clocks and other tools to explore the physical world's reality.

Even more crucially, we can use critical reasoning to bore down to fundamentals and imagination to build them back up again. The universe is vastly large and vastly old, on human time scales. But if the



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world is abundant, so are we. As Walt Whitman exulted, "I contain multitudes." Every human brain contains a galaxy's worth of complex neurons that fire billions of times within our lifetime, creating dynamic patterns of information and thought.

If you once again open yourself up to the world, curious and without preconceptions—if you allow yourself to be born again—you will find new keys that open hidden doors. This is, of course, quite different from being "born again" in the sense of evangelical revelation. Yet it beautifully fulfills Saint Paul's verse: "When I was a child, I spoke as a child, I understood as a child, I thought as a child; but when I became a man, I put away childish things."

Scientific understanding does not replace the modes of thought we use in everyday life, but it can supplement and enhance them. Rainbows are more beautiful, the starry night is more awesome, and other minds are more fascinating when you view them more fully, by the light of fundamental realities they reflect. You may come, in special moments, to live out William Blake's vision:

To see a World in a Grain of Sand
And a Heaven in a Wild Flower
Hold Infinity in the palm of your hand
And Eternity in an hour.

Prof. Wilczek received the Nobel Prize in Physics in 2004. This column is adapted from his new book "Fundamentals: Ten Keys to Reality," which will be published on Jan. 12 by Penguin Press.

FROM TOP: QILAI SHEN/BLOOMBERG NEWS; ALY SONG/REUTERS

A screen demonstrates facial-recognition technology at the World Artificial Intelligence Conference, Shanghai, China, Aug. 29, 2019.

The Danger of Exaggerating China's Technological Prowess

The conventional wisdom about Beijing's supposed advantages in AI and 5G shows how incomplete tech knowledge can lead to policy mistakes.

BY PETER COWHEY AND SUSAN SHIRK

The U.S.-China relationship will be the great geopolitical rivalry of the early 21st century, and every facet of the competition will involve the two big powers' capabilities in science and technology. Figures from across the political spectrum worry about a technology race with China, and many Americans fear that China has already surpassed us in such frontier technologies as artificial intelligence and 5G broadband communications. "China has stolen a march and is now leading in 5G," then-Attorney General William Barr declared in a recent keynote speech at a Justice Department conference on China. Graham Allison of Harvard University warns that China "is currently on a trajectory to overtake the United States in the decade ahead" in artificial intelligence.

The conventional wisdom about China's supposed advantages in AI and 5G shows how easy it is for incomplete understanding of technologies to lead to misjudgments and policy mistakes. Balancing economic and security considerations requires considerable knowledge of specific technologies—not just a current snapshot but also a sense of how the fundamentals will shape their evolution. We believe that the most effective U.S. policies will pair openness to China with scrupulous efforts to manage the risks posed by specific technologies.

Let's start with AI, where outdated analogies have led to wrongheaded policies. Prof. Allison has dubbed China "the Saudi Arabia of the twenty-first century's most valuable commodity": data. But this fashionable metaphor implies that China's larger supply of data—garnered from its more than one billion people, with very limited privacy protection—gives it a big advantage. Chinese machine-learning algorithms can be trained on far larger data sets, this line of thinking contends, and can thus advance more quickly and powerfully than their American counterparts.

This assessment makes two fundamental errors. For one, data aren't interchangeable. Machine learning depends on specialized data sets, not mountains of undifferentiated data points. For another, this argument ignores the law of diminishing returns. Infinitely larger supplies of an input like data don't produce infinitely better results; indeed, they may actually reduce performance. For many AI tasks, machine simulations are more productive than mountains of data.

When people think of AI functions that must be sequestered from China, they are often thinking of AI as a specific device or program, like HAL, the omniscient computer in the movie "2001: A Space Odyssey." But AI is actually a variety of procedures applied to different tasks. Almost all AI research is public and conducted by a global community of researchers. Only a very few applications for specialized security tasks need to be classified and subject to export controls.

Besides computing power, the biggest driver of AI is human talent. The U.S. leads the world in AI because it attracts the best researchers in the world. If the U.S. slows down those talented scientists by locking up their work as national-security secrets or restricting them from taking on Chinese students, they will simply take their skills elsewhere. Canada is just a short plane ride away. Overclassifying research to preserve scientific primacy is a quick road to decline.

The American debate about 5G mobile broadband also illustrates the dangers of failing to understand long-term technology development. In recent years, Washington has obsessed about the potential for espionage and sabotage thought to be inherent in the use of equipment from Huawei, the Chinese company with the world's largest share of 5G radio access network equipment, or RAN. Some have concluded that the U.S. should cripple Huawei to restore U.S. dominance.

The Trump administration's campaign against Huawei persuaded only a few close U.S. allies to ban the firm's inexpensive and well-engineered offerings. Debates still rage over whether much stricter security measures short of a ban could make Huawei-related risks manageable, but current U.S. policy fundamentally misunderstands the factors determining 5G competitiveness and security.

Huawei's first generation of 5G RAN base stations is a modified version of the older 4G infrastructure that yields faster speeds. The ultimate promise of 5G is an ubiquitous network customized to user needs. Trillions of devices and applications—known as the Internet of Things—using 5G technology will offer new solutions for everything from autonomous vehicles to industrial production management to remote surgery. But the drivers of 5G's evolution will be semiconductors, software systems and cloud computing—areas in which the U.S., not Huawei or any other Chinese company, is the world leader.

U.S. foreign policy makers shouldn't be intimidated by Huawei.

A Huawei company logo at Shenzhen International Airport, China, July 22, 2019.

Instead of being intimidated by Huawei, U.S. foreign policy makers should recognize the Chinese company's situation, which is akin to the dominance that IBM enjoyed during the age of mainframe computing. IBM's massive scale and proprietary standards and software made it hard for competitors to match its offerings. Only in the 1970s and '80s, when Japan massively subsidized new competitors like NEC, did IBM falter. But the true decline of IBM and its Japanese competitors came with the rise of the internet. The web's transparent standards enabled many new firms to "plug and play." Semiconductors, software and desktop computing eventually led to the apps on your smartphone at a fraction of the cost of such functions 30 years ago.

Today, 5G is at a similar moment. A new generation of technological standards for 5G would allow specialist suppliers—like the Microsofts and Intels of the internet era—to compete against Huawei, Ericsson, Nokia and Samsung. Control via the old RAN infrastructure will be diminished by control via cloud computing and software, which plays to a key U.S. strength. Introducing these standards will take concerted action from U.S. firms, along with targeted U.S. government support, such as the adoption of procurement requirements to embody these new rules.

The 5G Internet of Things will connect tens of thousands of suppliers of devices and pieces of software with massive rivers of data flowing across national borders. China will be a major security problem, but only one of many. Think of the challenge posed by the 5G Internet of Things as a massively scaled-up version of the cybersecurity threats that pervade networked computing today. As such, 5G security will need to follow today's cybersecurity template of carefully designed risk management.

Weighing such trade-offs is a job for politicians and diplomats with a sophisticated grasp of the underlying technology. A security strategy aimed at eliminating all risks from technological engagement with China would fail, and as we have seen, even many U.S. allies won't join us in breaking such ties. Tech-savvy policy leaders must find more productive ways of managing the risks of engagement with China while boosting America's innovation ecosystem and competitiveness.

Prof. Shirk is chair of the 21st-Century China Center at the University of California, San Diego, where Prof. Cowhey is dean of the School of Global Policy and Strategy. Both are members of the Working Group on Science and Technology in U.S.-China Relations, which recently released a report entitled "Meeting the China Challenge: A New American Strategy for Technology Competition."