

As Cowles argues on page 185, studies of animal intelligence in comparative psychology “expanded outward to new minds and turned inward in new ways simultaneously, seeking the source of their scientific thinking in observable animal behaviors.” Psychologists began to study children in the hope that they would reveal the developmental roots of human reasoning. After discussing John Dewey’s

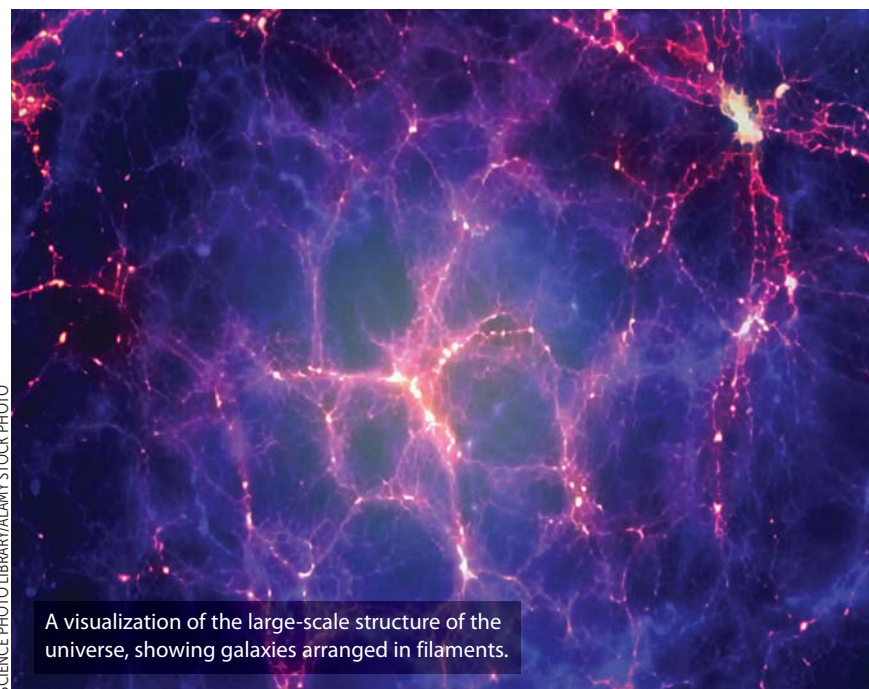
interest in experimentalism, Cowles concludes by outlining how the school of psychology Dewey founded, functionalism, became the dominant line of thought in the US by the end of the 19th century.

The Scientific Method is an absorbing read that illuminates the history of the natural and social sciences in Britain and the US. It features nuanced readings of important scientific figures from a new

perspective. Well-argued, accessible, and based on extensive research, Cowles’s hypothesis about the transformation of the scientific method by evolutionary theory should win the struggle for existence in Darwin’s “tangled bank” of scholarship on 19th-century science.

Bernard Lightman

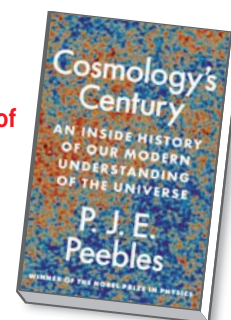
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A visualization of the large-scale structure of the universe, showing galaxies arranged in filaments.

Cosmology's Century An Inside History of Our Modern Understanding of the Universe

P. J. E. Peebles
Princeton U. Press,
2020. \$35.00



discovery of the expansion of the universe, evidenced by the redshift of distant galaxies, and the establishment of Big Bang cosmology. Throughout the book, Peebles carefully highlights alternative research directions that appeared promising at first but eventually fell out of favor due to their conflicts with observations. He emphasizes the historical importance of those false starts, such as the once-popular steady-state cosmology, and argues that they were catalysts for the development of innovative ideas that tested what eventually became the dominant paradigm.

Peebles then outlines how the abundance of light elements and, most importantly, the discovery of the cosmic microwave background (CMB) tilted the balance in favor of the hot Big Bang model. It is fascinating to see how George Gamow had the amazing intuition to establish that picture decades before it came into focus observationally. A description of early ideas about the formation of structure and galaxies in our universe follows. The author’s depiction of early hypotheses about the formation of galaxies is somewhat reassuring: It shows that scientists first tried the most intuitive approach—which failed—and only arrived at today’s more complex models after decades of refinement.

Cosmology’s Century contains an illuminating and riveting discussion of the growing evidence for subluminal matter

Looking back on a modern scientific revolution

The 20th century saw a revolution in our observational and theoretical understanding of the universe. P. J. E. Peebles’s latest book, *Cosmology’s Century: An Inside History of Our Modern Understanding of the Universe*, offers an inside look at how the pillars of modern cosmology were built. Using detailed historical research, quotes from key scientists, and his own recollection, the author presents an engaging story of the twists and turns taken on the long road toward our modern understanding of cosmology.

Peebles is uniquely positioned to recount that tale, as he is the key player in the story’s genesis. After making monu-

mental contributions to essentially every aspect of our current cosmological model, he received the 2019 Nobel Prize in Physics. As both a fan of history and a practicing cosmologist, I found his book to be a captivating read that immediately put my understanding of the universe into a new historical perspective. It should be a mandatory read for cosmology graduate students and seasoned cosmologists alike.

Peebles begins his book by discussing Albert Einstein’s key ideas: that a philosophically sensible universe was homogeneous and isotropic, and that in general relativity such a universe must expand or contract. He then reviews the

in astronomy during the 20th century. It gradually became apparent that the mysterious subluminal matter was identical to the nonbaryonic dark matter proposed by particle physicists. The text also tracks the numerous theoretical and experimental dead ends that eventually led to the community's acceptance of the cold dark matter (CDM) paradigm. Peebles himself was instrumental in that process: In 1982 he wrote a paper showing that CDM provides a simple explanation for both the highly inhomogeneous state of the local universe and the smoothness of the CMB. Showing characteristic humility, he recounts his surprise at how quickly the model became a convincing picture of the early universe. Yet again, Peebles's insightful speculation led the community toward a fuller cosmological picture.

The book ends with an account of the

cosmological "revolution" of 1998–2003, which firmly established the validity of the Lambda–Cold Dark Matter (Λ CDM) cosmological model. That such a simple model can explain both the initial seconds after the Big Bang and the distribution of galaxies today is a testament to a century of cosmology. Those of us who entered the field after that revolutionary era can find it easy to take our current cosmological paradigm for granted and forget that it took decades to get there.

Cosmology's Century serves as a reminder that we stand on the shoulders of giants. It also holds many lessons for today's researchers. At one point, Peebles emphasizes the importance of speculation to scientific progress, humorously saying that "one of the arts of science is to probe the boundaries between empty and productive speculation." He also draws a historical parallel to Lord

Kelvin's turn-of-the-century pronouncement that "clouds" were hanging over physics. Those "clouds" led to the discovery of special relativity and quantum mechanics. Peebles similarly sees two "clouds" hanging over the Λ CDM model of the universe: the unknown physics of the very early universe and the enigmatic simplicity of dark energy and dark matter. Will those "clouds" lead to genuinely new ideas in physics?

Peebles accurately points out that large failures akin to the breakdown of classical physics on the atomic scale have yet to occur in cosmology. He hopes that such failures will lead to a much deeper understanding of our universe. Will the next century teach us as much about cosmology as the last?

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NEW BOOKS & MEDIA

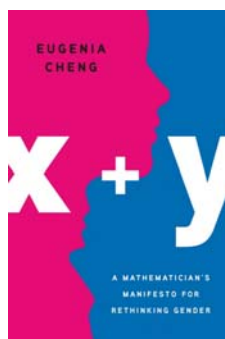
$x + y$

A Mathematician's Manifesto for Rethinking Gender

Eugenia Cheng

Basic Books, 2020. \$28.00

Women face more barriers in science, technology, engineering, and mathematics than men. To get at the root of the problem, Eugenia Cheng explores personal characteristics in her new book, $x + y$. She argues that society values ingressive behaviors, such as being competitive and independent, more than congressive ones, such as being collaborative and caring toward others. But if we focus less on whether those characteristics have masculine and feminine connotations and instead redefine successful people to include those with predominantly congressive behaviors, the representation of women and other underrepresented groups in science may improve. —AL



Anti-vaxxers

How to Challenge a Misinformed Movement

Jonathan M.

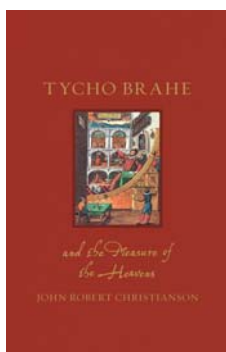
Berman

MIT Press, 2020.

\$19.95 (paper)

Written by renal physiologist and science educator Jonathan Berman, *Anti-vaxxers* is a how-to guide for those looking to counter rising anti-vaccine sentiment across the globe.

Nevertheless, much of the book describes the intertwined history of vaccinations and anti-vaccine movements; surprisingly, Berman shows that anti-vaccine sentiment has existed since the first vaccine was developed in the 19th century. Today the movement is fueled by social media, "fake news," and other disinformation. Berman argues that "community-based" strategies that consider the identity and values of parents and groups targeted by anti-vaxxers are the most likely to succeed in convincing them of vaccine safety. The book will be of interest to science-minded parents and policymakers alike.



Tycho Brahe and the Measure of the Heavens

John Robert Christianson

Reaktion Books, 2020. \$22.50

A new biography aims to restore early modern Danish astronomer Tycho Brahe to what the author, historian John Robert Christianson, asserts is his rightful place as a "world-class figure of the late Renaissance." Richly illustrated and based on a detailed analysis of Tycho's surviving texts, *Tycho Brahe and the Measure of the Heavens* also draws on significant new scholarship written in the Nordic languages. Christianson

deftly depicts Tycho's tumultuous relationship with his one-time assistant Johannes Kepler, while paying careful attention to the context of Tycho's position in the Danish and Bohemian courts and the sociopolitical ramifications of the Reformation. Ultimately, Christianson argues that Tycho's empirical methods had a "profound and enduring" effect on the history of science. The book is required reading for scholars of early modern astronomy.

—RD

—RD **IT**