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HOLLYWOOD'S MELODRAMATIC reworking of a 1963 Czech B movie envisions the universe's end.

A brief history of the future

The End of Everything (Astrophysically Speaking), by Katie Mack, is a lively antidote to our otherwise cheerful times. Instead of agonizing over a pandemic, political polarization, and economic upheaval, why not fret over the end of the entire universe?! All jokes aside, why bother studying our universe's demise? Well, as Mack says, contemplating our end helps us "understand the fundamental nature of reality itself."

Known as AstroKatie to her legions of followers on Twitter, Mack is a theoretical astrophysicist and an assistant professor of physics at North Carolina State University. She contemplates such cosmological catastrophes as the Big Rip, the heat death of the universe, and, most terrifyingly, vacuum decay—the possible transition from the false "metastable" vacuum state we may currently be enjoying into its true minimum, or ground state, which would cause the instantaneous disintegration of baryonic matter, among other day-ruining effects. In her skillful hands, we learn that although our cosmic comeuppance won't be pretty, we at least have billions of years before it will occur. That is, unless vacuum decay—discussed with the perfect blend of academic rigor and poetic license—is the ultimate culprit of our doom, in which case cosmic catastrophe may occur as you read this sentence.

Following Yogi Berra's dictum that "it's tough to make predictions, especially about the future," Mack warns us that how the universe will end is much less certain than how it began. Although she largely eschews the typical approach of recapitulating cosmology's vast history, she does note that our knowledge of the origin of the universe also was once more nebulous. Well into the 20th century, there were many rival cosmogonies, including the cosmic egg, Lemaître's primeval atoms, and even the biblical book of Genesis. Nevertheless, cosmic eschatology has gotten short shrift.

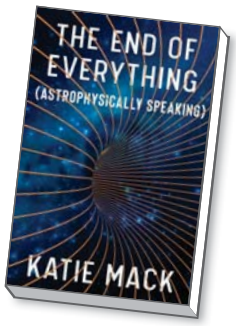
The End of Everything was published exactly 100 years after the famous debate between astronomers Harlow Shapley and Heber Curtis over whether the Milky Way galaxy was the entire universe or other galaxies were in the cosmos. The so-called Great Debate was resolved three years later when Edwin Hubble demonstrated that the object then known as the "great spiral nebula" in Andromeda was not a nebula at all but an entirely separate galaxy. Further observations by Hubble proved that the universe was expanding, which prompted speculation about what happened when its expansion began. Scientists eventually settled on the Big Bang theory accepted today. All the while, attention to the opposite end of the timeline—if there is one—has been sparse, and speculation reigns.

Mack's surprisingly lively account of the Big Bang's end-of-time counterpart is uplifting, with a wry wit permeating its 240 pages. It is meticulously researched, nicely illustrated, and copiously footnoted. Although footnotes are usually the bane of the reading experience, that is not so with Mack's: Her joke-per-footnote ratio is near unity.

Comparable books aimed at a popular science audience are Stephen Hawking's epochal *A Brief History of Time: From the Big Bang to Black Holes* (1988) and Sabine Hossenfelder's *Lost in Math: How Beauty Leads Physics Astray* (2018). The latter similarly blends first-person expert perspective, wit, and interviews with other experts, including some of the same

The End of Everything (Astrophysically Speaking)

Katie Mack
Scribner/Simon & Schuster, 2020.
$26.00



scientists Mack conversed with. Unlike Hossenfelder, though, Mack is more optimistic about possibilities for scientific progress in realms of astroparticle physics that are currently untestable, such as multiverse theories, vacuum decay, and the large-extra-dimensions model.

My only (minor) qualm with this otherwise masterful work is that it lacks the vantage point of an experimental astrophysicist. Had Mack surveyed a few of us alongside the many theorists and high-energy experimentalists she interviewed, it would have added another dimension to her book: Instrument builders can and should act as assayers of the theories they test.

Amidst Mack's humor is beautiful prose. Contemplating future end-times research, she writes, "Someday, deep in the unknown wilderness of the distant future, the Sun will expand, the Earth will die, and the cosmos itself will come to an end. In the meantime, we have the entire universe to explore, pushing our creativity to its limits to find new ways of knowing our cosmic home. We can learn and create extraordinary things, and we can share them with each other. And as long as we are thinking creatures, we will never stop asking: 'What comes next?'"

In *The End of Everything*, eschatology meets cosmology, evoking in this reader an aphorism from Ecclesiastes: "Better is the end of a thing than its beginning." Mack's brief history of the future is bound to inspire minds young and old not to deny the eventual death of the universe but rather to embrace it while there's still time.

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POSTERS FOR ACTIVITIES and student groups at MIT, March 2020.

A landmark study reconsidered

Students, especially women and minorities, continue to leave science, technology, engineering, and mathematics, or STEM, disciplines in large numbers. Who are those students, and why do they leave? That is the topic of a new volume edited by Elaine Seymour and Anne-Barrie Hunter titled *Talking About Leaving Revisited: Persistence, Relocation, and Loss in Undergraduate STEM Education*. (Full disclosure: I am a part-time research associate at the University of Colorado Boulder's Center for STEM Learning; both Seymour and Hunter are also affiliated with the university.) The extensive study discussed therein reevaluates the findings of a landmark 1997 study that Seymour wrote with Nancy Hewitt called *Talking About Leaving: Why Undergraduates Leave the Sciences*, which prompted a reform movement when it revealed that poor teaching and negative classroom cultures were pushing students out of STEM disciplines.

Talking About Leaving Revisited
Persistence, Relocation, and Loss in Undergraduate STEM Education
Elaine Seymour and Anne-Barrie Hunter, eds.
Springer, 2019. $149.99

How has the situation changed after 20 years? Spoiler alert: Many of the same problems remain. The findings will be of interest to advisers, those teaching introductory courses, department chairs, and education researchers in general.

Authored by a strong team of qualitative and quantitative researchers, the book is a compendium of detailed research reports about the current comprehensive study, which had two major components. First, the researchers surveyed 7800 STEM students across the US to gain quantitative insight into broad patterns of switching and persistence. Second, to explore the qualitative factors driving those trends, the team revisited six of the seven institutions that participated in the 1997 study and conducted 346 interviews of STEM switchers and persisters.

Talking About Leaving Revisited begins with a review of the prior investigation and then moves to a discussion of the first portion of the current study—namely, the quantitative national survey of switching and persistence. That chapter should be required reading for all institutional research personnel, as it is a blueprint for conducting similar analyses. The authors found that the rate of switching has reduced over the past 20 years: Of students who begin college as STEM majors, 28% switch to a non-STEM major today compared with 47% in the 1997 study. However, they also found that 20% of STEM majors leave college altogether—meaning that only 52% of students who begin college in a STEM major complete a STEM degree. Early retention efforts appear to