

will not be able to say: “no one warned us; no one reminded us of what history shows could so easily go wrong when it is considerations of money and power that alone drive events”.

The next generation

It is precisely to enable such wider debate that I focus so much of my effort and outreach on building the capabilities of African youth in the domain of space governance. According to the World Economic Forum, more than 40% of the global youth population will be African by the end of this decade. They are an important stakeholder, and they are the custodians of our collective space future.

When I was a trainee lawyer working for the Nigerian space agency nearly 17 years ago, my area of specialization was the application of international environmental law to space debris. Today, space junk is a global and increasingly mainstream concern. This is why genuine international cooperation is essential. The best ideas can come from anywhere. Diversity should build trust.

Looking ahead, if I can indulge in some crystal-ball gazing, it seems likely that institutional and state governance mechanisms for managing the Moon – and outer space – will become a priority area in the coming years. Usually, such international arrangements tend to arise when there is a real risk of conflict. Despite the prevailing narrative about a second space race, there is currently little appetite for international dialogue on space-related matters that limits the freedom of the dominant actors. But this could change. What happens when the middle powers rise?

International space law is unique because the state is directly responsible and liable for all activities undertaken by its citizens, including those in the private sector. Given that some private space firms have more wealth and power than do many space-venturing nations, the scrutiny on these non-state actors will only increase.

Any future dispute-resolution mechanisms must balance inclusivity and justice, and acknowledge that space commercialization is a deep national security concern for many states. What happens in outer space should inextricably be linked to developmental debates on Earth. Otherwise, although space might nominally be for the ‘benefit of all’ – as per the Outer Space Treaty – a select few nations or companies could indulge in rapacious over-exploitation. So, we need to seriously ponder who will benefit and what will comprise the common interest.

Although Grayling does not address all these concerns in depth, *Who Owns the Moon?* is still an important introductory text on the issues and challenges that humanity will have to confront as it ventures to the Moon and beyond.

Timiebi Aganaba is the founder of the Space Governance Lab at Arizona State University in Tempe.



In 2010, astronaut Cady Coleman left her husband and young son to go into space.

How loneliness haunts astronauts

The mental strain of space travel might be as hard as the physical feat, a film reveals. **By Alexandra Witze**

Neither NASA nor the Chinese space agency are probably consulting screenwriters as they develop their plans to send humans to the Moon and Mars. But they need to take the problem of astronaut isolation seriously, as director Ido Mizrahy sets out in his heartfelt documentary *Space: The Longest Goodbye*. Released in cinemas and online last week, this thoughtful film shares first-hand accounts of how leaving family behind can wreak havoc on an astronaut’s well-being.

Any crewed trip to Mars, for example, will involve up to three years of spaceflight – a sea change in what humans have experienced so far. Russian cosmonaut Valery Polyakov holds the record for the longest-duration spaceflight: 437 consecutive days aboard the Mir space station from January 1994 to March 1995. He and other cosmonauts pioneered the study of how the human body responds to microgravity over time, from bone deterioration to muscle loss and vision changes.

Yet the psychological impacts of spaceflight are equally important, argues Al Holland, an operational psychologist at the NASA Johnson Space Center in Houston, Texas, who drives much of the narrative for *The Longest Goodbye*. He and his colleagues studied NASA astronauts who flew on Mir, and used the lessons to try to improve astronauts’ mental health and well-being on board the International Space

Space: The Longest Goodbye

Greenwich Entertainment

Directed by Ido Mizrahy

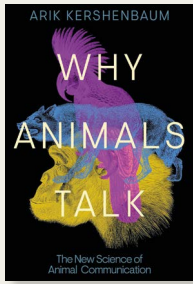
In theatres & digital release 8 March 2024

Station (ISS) during the 1990s. For example, carrying mechanical spare parts on board, which weren’t always stowed on Mir, reduced stress levels because astronauts knew that they had backups in case of an emergency.

Holland’s team developed ways to lessen the psychological strain of separation, such as by providing twice-weekly audio- or video-conferences between astronauts aboard the ISS and their families, and phone calls home whenever needed. *The Longest Goodbye* explores these long-distance conversations poignantly, through video recordings shared by Cady Coleman, a NASA astronaut who spent 159 days aboard the ISS in 2010–11.

As Coleman speaks with her husband and ten-year-old son from orbit, they mimic her, drifting across the screen as they pretend to float in microgravity. In another call, Coleman and her son play a flute duet. But after being separated from his mum for so long, he begins to act up. As she reads a story to him, he gets off the couch and makes faces at the camera. He is often like this just before joining calls with Coleman, her husband tells her. From her screen, Coleman can’t do much more than raise her eyebrows sternly.

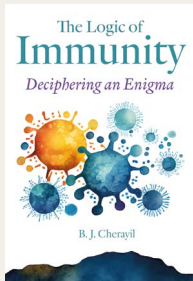
Books in brief



Why Animals Talk

Arik Kershenbaum *Viking* (2024)

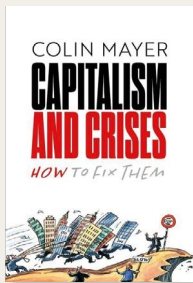
Are humans the only animals with a language? asks zoologist Arik Kershenbaum. Laboratory studies of animals suggest we are. But analyses of animals in the wild produce a more complex answer, Kershenbaum argues in this highly readable book, based on field investigations globally. Its seven chapters consider communication in wolves, dolphins, parrots, hyraxes, gibbons, chimpanzees and humans. Maybe the difference between human communication and that of other animals is one of degree, rather than kind, he proposes.



The Logic of Immunity

B. J. Cherayil *John Hopkins Univ. Press* (2024)

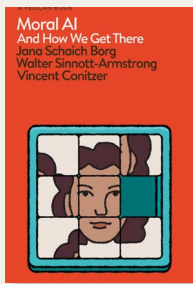
Vaccines against diseases such as smallpox are perhaps some of medicine's greatest triumphs. But, writes physician-scientist B. J. Cherayil, the immunology underlying vaccination still puzzles both specialists and the public because of its unpredictability. In his book, motivated by COVID-19, he describes the human immune system with elegant clarity and explains the "exponential" advances in understanding brought about over his decades of research, but admits that we still don't know why immunity protects only some people.



Capitalism and Crises

Colin Mayer *Oxford Univ. Press* (2024)

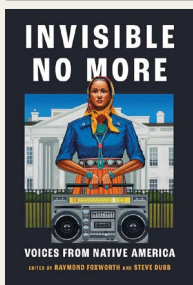
As a professor of management studies, Colin Mayer has long explored capitalism's effect on business, government and society. Despite recognizing its benefits, he suggests that capitalism causes "terrible suffering, disasters, inequality, environmental degradation, and social exclusion", because profits come from "causing as well as solving problems". His hard-hitting analysis argues that, although capitalists embrace Adam Smith's *The Wealth of Nations* (1776), they have unwisely disregarded his 1759 book *The Theory of Moral Sentiments*.



Moral AI

Jana Schach Borg et al. *Pelican* (2024)

The industrialization of machines in the nineteenth century and of chemicals in the twentieth century led to both gains and disasters. Artificial intelligence (AI) will produce even more complex effects, argue three interdisciplinary researchers. Indeed, they introduce their book's stimulating analysis of moral dilemmas in AI with snippets of both good and bad AI-related news — from the worlds of art, environment, investment, law, media, medicine, the military, politics and more. AI "deserves both pessimism and optimism", they note.



Invisible No More

Eds Raymond Foxworth & Steve Dubb *Island* (2023)

In the film *Oppenheimer*, J. Robert Oppenheimer proposes in late 1945 that Los Alamos be returned "to the Indians" — and then-US president Harry Truman laughs. "Often, Native Americans have been treated as vestiges of the past, not living people," notes Steve Dubb, who edited this collection with Raymond Foxworth, a citizen of the Navajo Nation. Native American leaders write about philanthropy, climate justice and economics, including how Yosemite National Park's Native residents were expelled "in the name of conservation". **Andrew Robinson**

The video connection breaks up repeatedly. Coleman cries on camera — a lot. In recent interviews for the film, her son talks about how he didn't understand why she had to be gone for so long. It is a heartbreaking glimpse into the personal challenges of one of NASA's most accomplished astronauts, and a warning for anyone thinking about taking a three-year trip to Mars. Being separated from your family for a long journey on Earth is challenging enough; being apart while enduring the unique stresses and dangers of spaceflight is much harder.

The film illuminates this while following the story of Kayla Barron, a NASA astronaut who flew aboard the ISS from November 2021 to May 2022. Barron is a former submariner who has experienced stressful military deployments, but says that going to space is very different. Just getting to orbit in the first place involves putting yourself atop a flaming rocket, she notes. "It's the most dangerous thing you've ever done, and then you invite all of your family and friends to come watch it." "My spouse is on top of this ball of fire," her husband thinks.

The couple confronts the existential question of whether, if she dies, she is doing what she wanted to be doing. In one scene, she rushes to shelter in a protected part of the ISS as an errant piece of space debris threatens to hit the station. Her husband sits helplessly at home, frantically trying to get updates.

Might spacefarers find other ways to recreate human bonds? European Space Agency astronaut Matthias Maurer, who was on the ISS at the same time as Barron, is shown interacting with an artificial-intelligence assistant. It looks like a floating football and has a screen with a creepily simplified human face. Viewers are likely to be relieved when Maurer packs it away in its storage case.

The film also recaps the rescue of 33 Chilean miners in 2010, who had been trapped during a mine collapse and spent 69 days underground. Holland and other NASA employees advised the Chilean government on how to sustain the miners' physical and psychological well-being during their extended isolation. They were told to eat and sleep on a strict schedule, and set up an illuminated area so they could transition between 'day' and 'night' while they awaited rescue. Lessons from space thus helped the miners to survive underground.

The Longest Goodbye doesn't describe what might work best for astronauts on their way to Mars. But it does offer a poignant look at the isolation and loss of connection that so many astronauts feel in space, and that many of the rest of us might recognize a little from our own experiences during the COVID-19 pandemic.

Alexandra Witze writes for *Nature* from Boulder, Colorado.