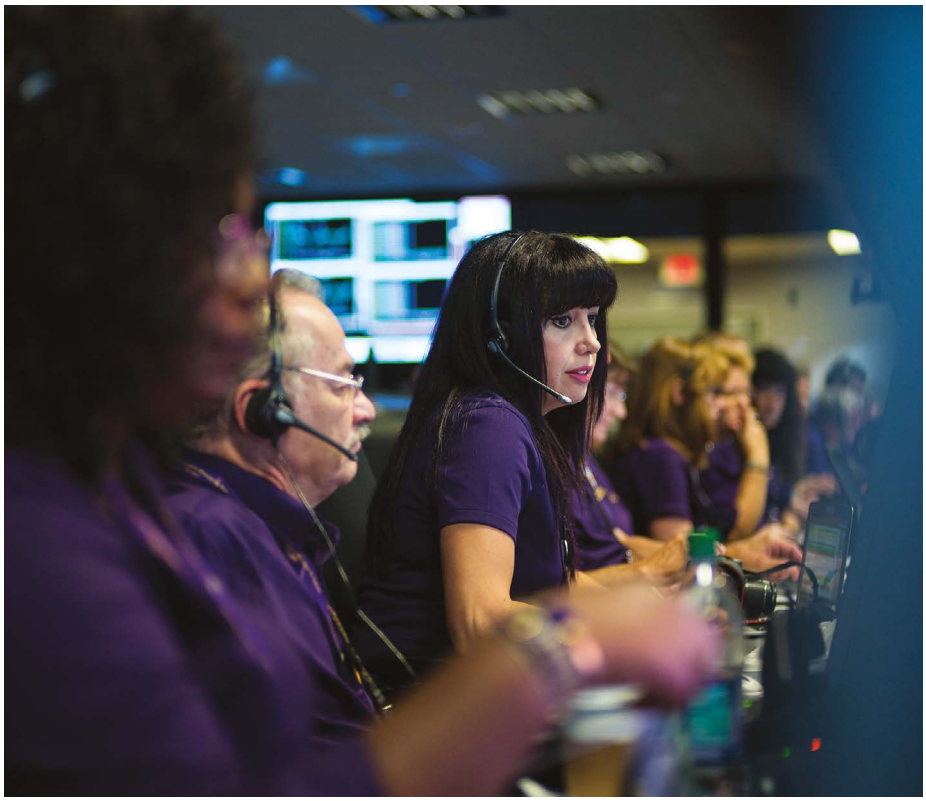
Books & arts



JOEL KOWSKY/NASA

Mission scientists monitor the spacecraft Cassini as it plunges into Saturn's atmosphere.

Lessons in teamwork from the heart of NASA

What gets discovered depends on how scientists collaborate, a sociologist shows. **By Alexandra Witze**

In 25 years of covering US planetary science, I've become used to seeing certain faces in press briefings, at conferences and on webcasts presenting discoveries from the NASA spacecraft exploring the Solar System. And I've enjoyed ferreting out the complex relationships between these researchers.

But I've never had a direct, sustained view of their interpersonal interactions. Now, sociologist Janet Vertesi has lifted the curtain for all to see. Embedded with various NASA projects for years, she takes readers into the heart of two of them — the Cassini mission to Saturn and the Mars Exploration Rovers.

What we see isn't always pretty. But it is useful. In *Shaping Science*, Vertesi does not simply describe the nuts and bolts of how these missions operate. Rather, she draws sweeping conclusions about the very nature of scientific discovery — what gets found — and how it depends on the ways in which scientists collaborate. That has implications for just about any group of researchers in any field.

Shaping Science: Organizations, Decisions, and Culture on NASA's Teams
Janet Vertesi
Univ. Chicago Press (2020)

Vertesi builds on classic work on the emergence of knowledge, such as that of sociologists Harry Collins, who spent years embedded among gravitational-wave hunters, and Diane Vaughan, who explored the culture of space-shuttle managers to understand how they came to normalize risk. For Vertesi, planetary science is fertile ground for studying the organization of complex teams. For both Cassini and the Mars mission, large groups of scientists, engineers and managers designed, built and operated robots to serve as our emissaries to planets beyond Earth — but they did so in fundamentally different ways. (Distractingly, Vertesi pseudonymizes the missions as "Helen" and "Paris" and gives their players fake names, perhaps to preserve their privacy; cognoscenti will merely play 'guess who').

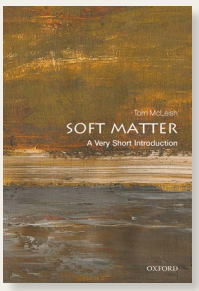
Cassini, which launched in 1997 and ended with a plunge into Saturn's atmosphere in 2017, was a high-stakes mission from the start. It was one of NASA's flagship planetary missions — costing billions of dollars, freighted with huge expectations, and partnered with the European Space Agency. As a result, it tried to mesh many competing interests into one functioning whole. A complex matrix approach linked groups focused around the specific aspect of the Saturnian system they wanted to study (rings, atmosphere, moons and so on). Mission leaders worked to integrate these aims. This often resulted in different working groups essentially bartering to achieve their science goals: 'You can photograph the rings at this particular time if I get to switch my plasma instrument on at another time.'

By contrast, the Mars rovers Spirit and Opportunity, which launched in 2003 and ended in 2010 and 2018, respectively, had one principal investigator (Steven Squyres, at Cornell University in Ithaca, New York, although Vertesi spares his blushes by calling him Jeremy). He led the team, with all members providing input to make decisions collectively. Researchers worked together to identify and settle on courses of action, such as what rock to investigate next or which direction to drive the rovers in.

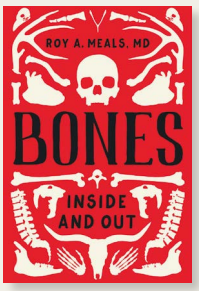
Both Cassini and the Mars mission were wildly successful. They made discoveries fundamental to planetary science. But Vertesi argues that the nature of those discoveries was shaped by how their human operators asked questions.

Cassini revealed deep insights about the moons, rings and other parts of Saturn from the perspective of individual instruments — such as radar studies of how the lakes on Titan, Saturn's largest moon, changed over time.

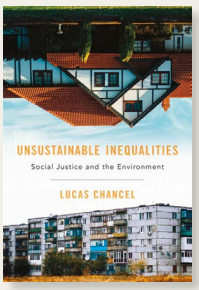
Books in brief



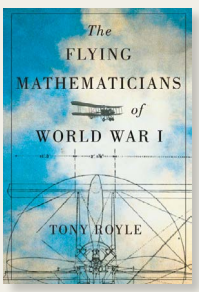
Soft Matter
Tom McLeish *Oxford Univ. Press* (2020)
Freeze a rose in liquid nitrogen then tap it with a hammer, and the petals shatter. "Its softness is a function of its temperature, not just its molecular constituents and structure," observes theoretical physicist Tom McLeish, one of the researchers who founded 'soft-matter physics' in the 1990s. The field covers milkiness, sliminess and pearliness in colloids, polymers, liquid crystals, membranes, foams, granular materials, glasses and gels, and draws on chemistry and biology. This short introduction is fascinating, if unusually challenging.



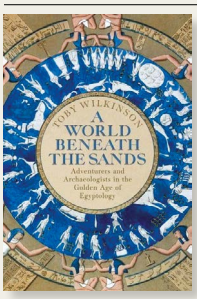
Bones
Roy A. Meals *W. W. Norton* (2020)
Bone is a marvel: light-weight, durable, responsive to changing conditions and self-repairing. But "hardly anybody has ever seen or wants to see living bone, especially their own", writes orthopaedic surgeon Roy Meals in his revealing, sometimes riveting and finely illustrated investigation, ranging from the dinosaurs to today. Hence, perhaps, the confusion over how many bones humans have: although 206 is the widely accepted figure, it actually varies from person to person. Even the number of ribs can differ, from 24 to 26.



Unsustainable Inequalities
Lucas Chancel (transl. Malcolm DeBevoise) *Harvard Univ. Press* (2020)
When the United States announced its withdrawal from the 2015 Paris climate agreement, its president claimed to be protecting US miners' jobs. How, asks Paris-based economist Lucas Chancel, can the environment be protected while fighting poverty and inequality? His brief and moderately hopeful global analysis mentions Sweden, where poor households get assistance to replace obsolete heating equipment, and Indonesia, which swapped large fossil-fuel subsidies for "a vast program of social protection aimed at reducing inequalities".



The Flying Mathematicians of World War I
Tony Royle *McGill-Queen's Univ. Press* (2020)
The First World War was crucial to the development of UK aeronautics. Who better to tell the story than an ex-Royal Air Force pilot who is a trained mathematician, a dedicated historian and a lively writer: Tony Royle. His compelling book is inspired by academics who became pilots, such as physicist Frederick Lindemann — later scientific adviser to Winston Churchill — who experimented with putting an aircraft into a deliberate spin, calculating the effects and then stabilizing it. Lindemann's courage launched a standard spin-recovery procedure.



A World Beneath the Sands
Toby Wilkinson *Picador* (2020)
Two anniversaries approach: of the deciphering of Egyptian hieroglyphs in 1822 and the discovery of Tutankhamun's tomb in 1922. Egyptologist Toby Wilkinson's book addresses the intervening century, when Western archaeologists and imperialists scrambled to excavate ancient Egypt's civilization and procure treasures for collections abroad. He tells the story well, with attention to both scholarship and scandal. After 1922, he says, "in embracing scientific rigour, Egyptology would lose its panache". **Andrew Robinson**

Spirit and Opportunity resulted in discoveries about specific rocks, dunes or other Martian landforms as seen by many instruments. The first approach yields encyclopedic knowledge in chunks; the second produces more of a synthesis of understanding about a particular landscape.

Seen through this lens, these missions offer lessons for teams more generally. Consider data sharing. Vertesi argues that the Mars mission embraced the concept of open data not just because it was a taxpayer-funded mission — the usual explanation — but because its flat, collectivist organization required it. Meanwhile, on Cassini, the leader of the camera team ended up in a cycle of distrust with other scientists when she attempted to maintain control over images from her group.

Unsurprisingly, Vertesi notes that institutional sexism probably had a role in the camera leader's difficulties (one project scientist said he would make her "mud-wrestle" a male researcher to resolve an issue). Other women did rise to positions of power in the Cassini mission, but mainly towards the end of the spacecraft's life. It was acceptable for women to run an existing mission, not a new one. Happily, this is changing: planetary scientist Elizabeth Turtle is leading NASA's upcoming Dragonfly mission to Titan.

Other lessons involve the challenge of managing people who don't all work in the same place — particularly acute in the age of COVID-19 and videoconferencing. Although mission control provides an organizational hub, many team scientists work remotely from their home institutions. They jostle for position from a distance — something all too familiar now. The Cassini team overcame the challenges of working across borders and time zones by nurturing a virtual sense of community, with photographs of teleconference participants on the wall (shades of endless Zoom calls to come). This gave overseas scientists access to a groundbreaking mission, and gave NASA researchers access to top talent worldwide.

Such take-home messages might be useful for collaborations getting off the ground. Vertesi notes that tech start-ups tend to favour the Mars-like flattened hierarchy around one charismatic leader. Bigger institutions, such as universities juggling the interests of departments and disciplines, often use a Cassini-like matrix.

In the end, science from both missions flowed directly from the people involved. No matter how the lakes on Titan shimmer, or what the mineralogy of a particular Martian rock turns out to be, it was the people behind the spacecraft, keyboards and endless teleconferences that drove what these interplanetary robots discovered. I'm glad to have come to know them even better through this book.

Alexandra Witze is a correspondent for *Nature* based in Boulder, Colorado.