involved in longevity pathways, or destroy harmful senescent cells that accumulate as we age and help to fuel disease. Sinclair and LaPlante claim that some of these drugs might already be here. The effects of the widely prescribed diabetes drug metformin and the immune modulator rapamycin, for instance, seem to mimic beneficial strategies — the equivalent of (respectively) exercising more and eating less, in pill form.

Defining ageing as a disease is central to their approach. If we treat age medically, as we do heart disease or cancer, they argue, innovative therapies will emerge more rapidly. That mirrors the increasingly popular 'geroscience hypothesis', which posits that therapies targeting the fundamental biology of ageing will help to slow or prevent chronic diseases that plague older people, such as type 2 diabetes and dementia. Sinclair's argument, based on decades in the lab, is that there is no immutable biological tenet that limits how long, or how well, we can live.

Sinclair and LaPlante examine the economics of extending lives on a crowded, resource-limited planet, and the ethics of tinkering with the supposed natural order. But they also speculate on some inadvertent, potentially positive effects. Knowing you were going to meet your great-great-grandchildren, for instance, might make you a more accountable steward of the present. If many generations lived and worked together, we might all become more empathetic — as Sinclair puts it, "more human". At a time of political, economic and environmental uncertainty, that could be ever more important.

If *Lifespan* is a lively sprint into the future of ageing, *Elderhood* is a contemplative walk in its here and now. Since the early 1990s, Aronson has worked as a geriatrician at the University of California, San Francisco. Her exquisitely written book mixes vignettes about her patients (remarkably, she still makes house calls) with lessons learnt from caring for her elderly parents and insights from her own experience of ageing.

**Lifespan: Why We Age — and Why We Don't Have To**
DAVID A. SINCLAIR AND MATTHEW D. LAPLANTE
*Atria (2019)*

**Elderhood: Redefining Ageing, Transforming Medicine, Reimagining Life**
LOUISE ARONSON
*Bloomsbury (2019)*

Many of her stories reveal cracks in the US health-care system. We learn, for instance, about Neeta, a frail patient with mild dementia who breaks her hip. After surgery, Neeta is transferred to a less-than-stellar care home where she becomes agitated, is sedated, develops bedsores and spirals into hospice care. We also learn of Aronson's personal frustrations. In one instance, when physicians in a busy accident and emergency department were too distracted, she had to perform a rectal examination on her own father to demonstrate that he was bleeding internally.

## ESSENTIAL STAGE

Meshed with these very human tales are a wealth of social, cultural and historical perspectives. At the start of the book, Aronson tells of an encounter with Guy Micco, a physician teaching at the University of California, Berkeley. Micco asked a class to write down associations with the word 'old': concepts such as weak and frail predominated. The word 'elder', by contrast, elicited terms including respect, experience and knowledge. To Aronson, part of the problem is that we adhere to a utilitarian, late-nineteenth-century concept of the body as a machine. Viewed through that industrial lens, being 'old' is no longer the apex of life experience. It is a loss of function and, by extension, of intrinsic worth.

Aronson sees life as a three-act drama: childhood, adulthood and elderhood, the latter subdivided into senior, old, elderly and aged. Each act builds on the one before, and is essential. Aronson notes that emphasizing only the vicissitudes of elderhood is like saying that youth is defined by acne. In fact, in old age we might know ourselves better than ever and obtain more overall life satisfaction. Aronson conceives of anti-ageing not as Sinclair and LaPlante see it — as a bid to medically 'cure' the condition — but as battling the many "discriminatory beliefs and policies" affecting the elderly. In her view, the very idea of 'curing' ageing is ageist; such a concept is not invoked for any other life stage.

Indeed, in Aronson's eyes, the worst offender might be the medical system itself. She sees it as failing both patient and physician. It lacks nuance on subtle but important differences in life phases, and focuses on "diseases and organs rather than people and lives". For instance, she notes that many over-the-counter medicines are not tested on older people, adding risk to prescribing them. She advocates a new paradigm: a re-balancing act in which technology has a role but the focus returns to care. Unlike the high-tech, algorithmic march of modern medicine, her idea of truly 'personalized medicine' incorporates the patient's past experiences and current expectations. This integrative, humanistic model of geriatrics is rare. One can only hope its practices are adopted swiftly.

What are we to conclude? Is ageing a disease that can be eradicated by science, or the natural third act of life, threatened by over-medicalization? Viewpoints will undoubtedly be as variable as experience and temperament. There might be some wisdom in simply following an adage attributed to seventeenth-century philosopher Francis Bacon: "old age is always 15 years older than I am". ■

**Toren Finkel** *holds the Beckwith Chair in Translational Medicine and is director of the Aging Institute at the University of Pittsburgh and the University of Pittsburgh Medical Center in Pennsylvania.*
*e-mail: finkelt@pitt.edu*

SPACE SCIENCE

# India on Mars: the film

**Subhra Priyadarshini** lauds a movie on the country's first interplanetary mission.

In 2013, India reached for Mars. Its first interplanetary mission, dubbed Mangalyaan (officially the Mars Orbiter Mission, or MOM), launched a probe carrying five instruments to study aspects of the red planet, from its mineral composition to potential signs of past life. Now, a fictional treatment on film by first-time director Jagan Shakti celebrates the scientists who got MOM off the ground.

**Mission Mangal**
DIRECTOR: JAGAN SHAKTI
*Cape of Good Films/Hope/Fox Star Studios (2019)*

Released on 15 August — India's independence day — *Mission Mangal* fictionalizes the tense months from approval to launch, a race to lift off when Mars would be closest to Earth. It is very much a homage to the Indian Space Research Organisation (ISRO) and the country's technological prowess, and as such stirs up national pride. But the film is also successful scientific storytelling, performed by a glittering cast.

Science communication can be notoriously tricky, treading a line between oversimplification of concepts and overuse of jargon. *Mission Mangal* avoids the latter,

**Vidya Balan plays Tara Shinde, project director for India's Mars Orbiter Mission, in *Mission Mangal*.**

STERLING MEDIA

but some sections have been accused of dumbing down highly technical ideas. One scene drew widespread criticism at the trailer's launch in July. MOM project director Tara Shinde (played by the supremely talented Vidya Balan) is shown making puris, deep-fried rounds of Indian bread. After she turns the stove off to save gas, the oil remains on the boil for some time. She then realizes that a similar technique would allow 'smart' space vehicles to stay in orbit: the fuel could be switched off to make use of Earth's gravitational pull. As I watched this supposedly divisive scene, a woman sitting beside me nodded approvingly. The principle of economy in space had hit home.

It's a key point: judicious use of resources is an ISRO speciality. The organization boasts the world's cheapest solutions for space missions. They range from the compact Small Satellite Launch Vehicle to space-saving satellites such as the Microsat, which weighs about 100 kilograms and can latch on to any space mission as a co-payload. *Mission Mangal* emphasizes how stripped-back ISRO labs and tight budgets encourage innovation.

## FRUGAL EFFICIENCY

After MOM launched, Prime Minister Narendra Modi commented that at just 4.5 billion rupees (US$74 million), it cost less than Alfonso Cuarón's 2013 film *Gravity*. In fact, starting with physicist Vikram Sarabhai and aerospace engineer Satish Dhawan in the 1960s and 1970s, Indian scientists paving the way to a national space programme have practised 'frugal efficiency'.

*Mission Mangal* is framed by an apparent setback. This is the moment in 2010 when a test of ISRO's Geosynchronous Satellite Launch Vehicle was aborted just over a minute after lift-off, after scientists detected snapped communication connectors. The film recounts how lead scientists Shinde and Rakesh Dhawan (Akshay Kumar) plan a relaunch, but are politely shunted to ISRO's unglamorous, underfunded Mars section.

*"The coming decade is set to see some of India's major space ambitions take wing."*

Here, they begin to work their magic as they pull together and train their team. NASA, inevitably, is a recurrent theme. The Indian-born, NASA-trained scientist Rupert Desai (Dalip Tahil) helms ISRO's prestigious Moon mission, Chandrayaan. The young Eka Gandhi (Sonakshi Sinha) wants to use ISRO as a stepping stone to the US space agency. There are glimpses, too, of the personal lives of scientists beyond lab and launch site, breaking down tedious stereotypes in the process. One scene shows the mission's female scientists dressed in bright saris — just as they were in a memorable 2014 photo showcasing ISRO's womanpower.

The technological jockeying for position common among space-faring nations is also captured. *Mission Mangal* alludes to a cartoon published in *The New York Times* in 2014, of a turbaned man leading a cow knocking at the door of a building marked 'Elite Space Club'. It was widely criticized as racist, and the paper apologized. Three years later, after India launched a record 104 satellites on one craft, *The Times of India* published a cartoon showing India inside the club as other countries seek entry.

The coming decade is set to see some of India's major space ambitions take wing. The Department of Space got an 11% budget hike for 2019–20, and ISRO is set to launch its first crewed mission, Gaganyaan, before the 75th anniversary of India's independence, in 2022. And, in a fitting 50th-anniversary tribute to Apollo 11, India's second mission to the Moon, Chandrayaan-2, set a course for the uncharted lunar south pole in July. As *Nature* went to press, the Vikram lander was due to touch down on 7 September.

Amid vast global challenges and the emergence of space-flight entrepreneurs, India's space innovation continues apace. *Mission Mangal*'s focus on the dedicated, visionary researchers behind ISRO's Mars mission reminds us how doing science that is of use to society demands an inner fire. ■

**Subhra Priyadarshini** *is chief editor of* Nature India.