helped to speed up the process. Today, more than 5800 exoplanets have been confirmed, and about half of these were discovered by the *Kepler* team. Jason Steffen, recruited to the *Kepler* science team before it was launched in 2009, gives a compelling account of this groundbreaking mission, including how the mission was conceived, the success of the primary mission that was cut short after four years by a hardware malfunction, and the redesign of the mission (dubbed K2) so that it was able to continue until 2018. He also describes the remarkable variety of worlds that *Kepler* brought to light, including the first super-Earths and sub-Neptunes, the first Earth-sized planets in the habitable zones of their stars, the first planets orbiting in a binary system, systems with seven and eight planets, and astrometric observations that enabled unprecedented photometric studies of numerous stars. The remarkable conclusions are that there are more planets than stars in the Milky Way galaxy, and that many of these worlds are comparable in size to our Earth. Perhaps we are not alone after all! — Peter Bond.

Starbound, by Ed Regis (Cambridge University Press), 2025. Pp. 240, 22·5 × 14·5 cm. Price £25/$29·95 (hardbound; ISBN 978 1 009 45759 0).

There are several versions of a painting under various titles commonly known as *The Fall of Icarus*. The painting, possibly by the Flemish painter Pieter Bruegel (the elder) from perhaps around 1558, shows a coastal landscape in which a horse-drawn plough is guided by a farmer across a field. In the middle distance, in the sea beyond the farm, Icarus, his wings having disintegrated, plunges to his death. Only his flailing legs are visible in the large splash. The farmer doesn't notice. The painting is said to be an allegory about both the dangers of excess ambition and the security to be had from humble toil. The story of Icarus and his father Daedalus, the maker of the wings, is said to originate with the Roman poet Ovid — the dream to fly is very old, and to fly to the stars is a desire possibly as old as humanity itself. In other versions of the Icarus painting the fate of Daedalus is also depicted; he is seen to have continued his flight to land safely on the shore.

Ed Regis is a thoughtful and amusing commentator but his exasperation with wilder extrapolations from reality seems to increase through the 12 chapters of this book, and by the last he has had enough and reveals his inner dream-shattering grouch. But it is in one of the early chapters about three 'Icons of Star Travel' that he lays out his stall. Describing the Bernal sphere, the Bussard Interstellar Ramjet, and Project Daedalus thus: "... each concept was a blend of unrealistic assumptions about what was possible or practical in an indefinite future", which he believes reflects the view that since an object had a name it also has an existence, even though "none of the designs obeyed general principles of standard engineering practice".

We need not trouble ourselves with the details of those projects to see clearly what Regis thinks is important about most of the schemes and plans to deliver humanity to the stars. He would like to see some standard engineering practice, and indeed some real existing physical objects. In 12 chapters he carefully unpicks and assesses the stories and the technology of proposed interstellar travel. He begins by leading us through the origins of the dream — and to be clear the dream is for the transport of humans to a suitable Earth-like planet in orbit around a star other than the Sun. He is not discussing manned excursions to Solar System locations: Mars, Europa, or wherever. The subject of discussion

in this book is interstellar starships. Regis takes in turn each of the proposed engineering and social topics involved in the project and applies a healthy dose of reality. For example, simply pointing out that the stars are actually very far away and that human lifespans are comparatively short, makes the proposed task very difficult. To reach the nearest stars at 4·5 light-years distant using something like current propulsion technology would require thousands of years. Enhancing the technology by some means to approach around a tenth of the speed of light, using chemical energy sources, would require more chemical energy than is available on the entire Earth.

With such plain-speaking factual information, garnered from numerous sources, Regis addresses propulsion systems from the almost near-future fusion reactors to drives powered by multiple nuclear explosions, to Earth-based lasers pushing distant space sails, to far-future ideas of space warping and antimatter drives. All fail either to deliver the necessary drive or require the development of solar-system-scale fabrication capabilities. At the end of each topic chapter Regis tries to be positive and says something along the lines of "let's assume that in the future such a system becomes possible" what then? Because individual human life is short he examines the potential for gigantic interstellar spacecraft containing perhaps thousands of travellers on multigenerational voyages. He discusses the morality of such a trip where only the first generation are volunteers. Are the crew on such a ship, particularly second-generation crew, in any worse situation than the current population of the Earth by being on board a sphere enclosed in a life-support system travelling through space with no possibility of escape?

Crew psychology is tricky and has been examined, with far fewer numbers than proposed for a starship, in the self-sustaining, enclosed experimental conditions of *Biosphere 2.0* in Arizona in the 1990s. Over the two years of the project, factions quickly emerged among the eight participants — exacerbated by lack of food and low oxygen levels, both clothes and tempers became frayed. All such crew problems could in principle be neatly circumvented if the crew were asleep, placed into hibernation or suspended animation during the voyage. Long-duration hibernation has not been experimentally verified and problems abound — not least the continued growth of hair and fingernails during sleep.

As well as the host of technical problem associated with interstellar star ships there remains the overriding question — "Why Go?". Regis addresses this in his usual direct manner. He requires logical, rational answers to this challenge, which, even if the voyage is planned to take place a couple of thousand years or so in the future, would still require an unbelievably vast expenditure of resources. What benefit would it be to mankind to go wandering among the stars? Well, the obvious answer is that at some time in the future the Sun will expand and die and in the process incinerate all the planets at least as far out as Mars. Earth and humanity will be no more. But this is billions of years in the future and not one species of Earth-based complex life has lasted more than a small fraction of that time, a few hundred-million years at most. Humans with their uniquely susceptible, almost uniformly identical, DNA are more likely than most to face earlier rather than later extinction. Many commentators think it unlikely that we will last the next 1000 years. The usual answers that are given to the 'why go' question involve poetic feelings of the sort 'our future lies in the stars' or 'exploring is human nature, it is in our DNA'. Regis quite reasonably points out that the vast majority of people do not go exploring but quite contentedly sit on the sofa drinking beer and eating crisps — so it is clearly not a universal

component of our DNA. The technocrats answer that a far-reaching technical endeavour such as a multigenerational starship will provide focus to such lives — a focus for human ambition. Well maybe, but again Regis notes that there are equally ambitious projects like universal health care, clean water, or contented fruitful lives for most of the Earth's human population which are also capable of providing focus and with a much more likely chance of success.

The British journalist and political commentator Marina Hyde describes a rhetorical technique used to oppose any piece of proposed government legislation or planning — a technique she calls "Whataboutery". Whataboutery describes an argument which highlights, and places penny-pinching obstacles, real or imagined, in the path that may inhibit the smooth acceptance of the proposal. "What about the financial markets?", "What about the housing stock?", "What about the farmers?". Whataboutery is particularly effective against the more ambitious proposals — what about the parking, for example, when discussing the development of a major power station. Whataboutery appears wise and thoughtful without the effort of having to argue an alternative approach, merely to point out potential difficulties. But Regis is not indulging in Whataboutery, or necessarily criticising ambition, but simply pointing out some hard facts. His discussion is not in the minutiae of small details but addresses the overwhelmingly vast lack of potentially capable technology.

The science-fiction writer Kurt Vonnegut says of *The Star Spangled Banner* that in a Universe of a gazillion civilisations no other has chosen an anthem of "gibberish sprinkled with question marks". Gibberish or not, to loyal patriots the song is inspiring and deeply meaningful. Poetry and dreams matter. As Ed Regis points out in the preface to this book, dreams have been responsible for scientific breakthroughs — he quotes the example of Kekulé and the structure of the benzene ring. There is a Flemish proverb, perhaps in relation to Bruegel's painting "and still the farmer ploughs" — perhaps we could add to that "and while he ploughs he dreams".

Perhaps the choice isn't necessarily between the hubris of ambition or the humility of the *status quo*, there is a middle way, as Daedalus discovered, to use tried-and-tested and carefully calibrated technology within the bounds of its capabilities. This excellent and thoroughly readable book guides our thinking and starship imaginings to follow Regis's ideal of not letting our dreams outrun what is possible and as he says, and delivers, in the final chapter: "What is needed is a severe and sober calculation of the odds". — Barry Kent.

Target Earth, by Govert Schilling (translated by Marilyn Hedges) (MIT Press), 2025. Pp. 120, 21 × 14 cm. Price $21·95 (about £17) (hardbound; ISBN 978 0 262 55134 2).

There is a story that Eric Clapton was given his first guitar, a metal-strung acoustic, at a very early age — perhaps five or seven years old. It had a particularly high action and the metal strings hurt his young fingers so he found it difficult to play and he gave up. Later and a bit older he tried again with a different guitar and the rest is musical legend. Many people have also given up playing music when their first instrument has been difficult and perhaps badly made. In spite of the lyrics by one-time Bristol-based singer Fred 'Leadbelly' Wedlock who claimed to have made his name singing "the folk tradition" — "With a yard of Spanish plywood and a capo" — a poor introductory instrument can be off-putting. I imagine there are generations of budding astronomers who have also been dissuaded by poor-quality beginner telescopes. Beginners' instruments