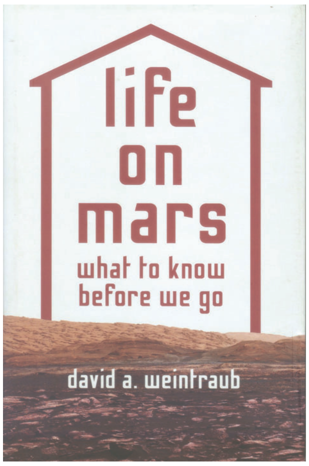


Life on Mars: What to Know Before We Go. David A. Weintraub. Princeton University Press, 41 William Street, Princeton, New Jersey 08540, USA. 2018. x + 302 pages. Price: US$ 29.95.

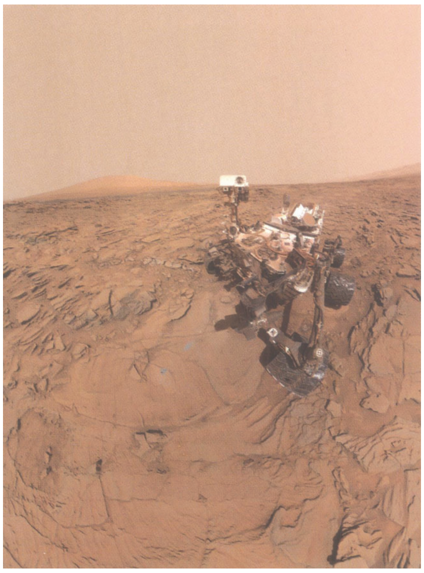
On 14 September 2020, a press release by scientists from Europe reported the first finding of phosphine (PH_3) on planet Venus. The discovery indicated that Venus is probably biologically active. However, this is now under debate among the peers. In the modern astronomical era, the debate about life beyond Earth, be it on Venus or Mars, has gained importance and has implications for understanding the origin of life on Earth and elsewhere. In this context, this book provides a good account of how our thinking about life on Mars, as more and more sophisticated data and observations became available, and our perspectives have kept changing.

Three planets find a place in the Goldilocks zone in our solar system. Among them, Earth has its comfortable position compared to the other two terrestrial planets, viz. Venus and Mars. Nevertheless, of the two latter planets, Mars was always more important. Why was Mars more in the telescopic lens than Venus? What could be the driving force in the astronomers' pursuit of Mars? Did the astronomers limit themselves to Mars, or did they explore further beyond? If they could see beyond, then why does Mars matter more? Such questions go back to nearly 400 years of curiosity since optical lenses were used to observe celestial objects. It was a time when we had no definitive Goldilocks zone that could support life, because temperature estimates of other planets had not been done. Although the lenses used were able to pinpoint the new planets and their moons, the limitation imposed by instrumentation forced astronomers to focus on destinations close to Earth, especially Mars, for a detailed exploration. Perhaps, Venus was not interesting to the astronomers, as they could not see anything other than a bright disk with no changes observed over time. Until the end of the 19th century, most of the astronomers interpreted what they could see on Mars to what they wanted to see. Apart from scientific exploration, is there anything else behind chasing Mars? Quoting from the book: *Whatever the answer is, the answer matters. Mars matters*.

Martians, intelligent life on Mars, inhabit the planet and have been responsible for the changes noticed through the telescopic eyes, a driving force behind the constant pursuit for observations of the planet. Though no strong scientific proof existed, efforts for finding Martians never stopped. Books and movies, shorter and longer versions, in the early 20th century, fuelled the idea of Martians, who were considered to be much more advanced, intelligent and had the technology to invade and conquer Earth one day in the near future. Science fiction based on Mars and Martians was in fact, influencing the scientific interpretation of observations. An important breakthrough that came in the early stages of Earth-based Mars observations was that the best viewing time appears once every two years. Every astronomer had a good idea about this and was grabbing the opportunity. On the contrary, technological advancement was not in line with this the 'once every two years' opportunity. For around a century, there was little or no improvement in the telescopes, and this was a big loss. However, careful and dedicated observations made by astronomers led them to draw a similarity between the rotation of Mars and Earth, followed by the discovery of dark and bright patches at the North and South Poles changing over time. It was later learnt that this was due to seasonal changes in the ice caps, which made Mars in some ways closely similar to Earth. Hence, the idea of Martians did not fade, rather it gained momentum and Mars and Earth were considered as twins. Quoting from the book, *Together, a handful of astronomers transformed their beliefs about Mars into established Martian facts and Mars and Earth, they had established, are physical twins*.

The imagination grew over time, as scientists focused on the fame gained in studying Mars; indeed at times fame was in the forefront than scientific rigour. The idea to support the existence of life on Mars was predetermined. Water was reported to be the major Martian molecule and an atmosphere which can support life was imagined, without thoroughness of observations. One can argue that exploring unknown territory has the risk of misinterpreting the data. However, such mistakes are acceptable, if it is purely in scientific reasoning, rather than hastily arriving at a conclusion such as life is (not was) there on Mars, which was preconceived in order to attract the audience. Looking back at the arguments that were put forth supporting intelligent life on Mars, draws a big surprise where poor quality of observations leads to the misinterpretation that such intelligent life was building canals on the Martian surface. Perhaps spectroscopic observations, enabled by advancement in optics coupled with chemistry, also faced problems from molecules (even from minor constituents) in the Earth's atmosphere while observing Mars. These forced astronomers to climb altitudes to eliminate the water, to prove that water exists on Mars, irrespective whether it is on the surface or in the atmosphere. Quoting from the book, *Using the tools of astrophysical spectroscopy to prove that water is present in the Martian atmosphere turned out to be much harder*….

Other potential ways emerged to prove life on Mars, this time with the signatures



Mars Curiosity Rover self-portrait, obtained on 11 May 2016, at a drilled sample site called 'Okoruso', on the 'Naukluft Plateau' of Lower Mount Sharp. An upper portion of Mount Sharp is prominent on the horizon. For scale, the rover's wheels are 20 inches (50 centimetres) in diameter and about 16 inches (40 centimetres) wide. Image courtesy of NASA/JPL.

that we see every day during a morning or evening walk, the chemical contents present on the green leaves – Chlorophyll. Again, with red patches being dominant on Mars, the chlorophyll story had an add-on; red vegetation may be dominating or may represent lichens or algae. Whatever it may be, there is life on Mars; such a statement remained in the headlines, irrespective of how small the finding may be. Without doubt, the press releases were influencing scientific conclusion. Later, however, Earth-based observations at a different wavelength revealed that 'it's all wind-blown sand'. Quoting from the book, *No more trees; no more moss; no more lichens; no more algae. Just windblown sand*.

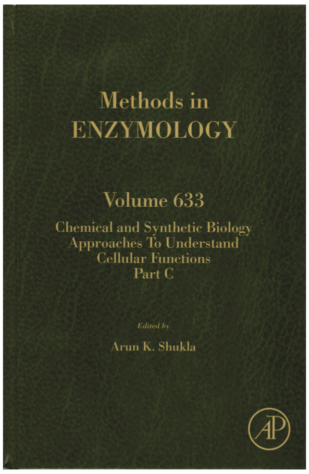
As the era of modern exploration on the surface of Mars from its orbit began, the stage was set for the next set of results. This time the news that triggered the debate was methane, another biomarker. By mid-20th century it became clear that macro-Martians could not be seen but the idea of micro-Martians, however, remained in the debate. The thought for plausible presence of micro-Martians was strengthened when bio-signature gases were released, while water and labelled chemicals carried from Earth were made to interact with the Martian soil. Abiotic and biotic processes can synthesize the same product(s) through different pathways. Therefore, extra care must be taken in the scientific analysis. However, the important moment in announcing the definitive confirmation that 'there is life on Mars' masked the unbiased analysis by many scientists. This was reflected when the Martian meteorite was shown to contain a structure, few tens of nanometres in size, that was straightaway considered to be fossil remain of a once-formed microbe on the Martian surface without any strong support that can be tested over time. Quoting from the book, *We do not yet have the extraordinary evidence… and The search goes on*.

Methane on Mars was not easily forgotten as it reappeared over and over again. The orbiter and measurements using the sophisticated lander and rover, played their role in keeping the methane story alive, despite the very low abundances of the gas. This was in a way convincing because we were examining the biomarker on the Martian surface or atmosphere avoiding terrestrial molecules; so whatever was measured was devoid of any terrestrial contamination. The real surprise came when it was confirmed that gases from the Earth were carried along with the rover. While eliminating the contamination was one part of the story – the sudden presence and absence of methane, based on sensitive and reliable measurements, is still unclear. What pumps it to the Martian atmosphere and where does it get lost? Only experiments, either *in situ* or laboratory-based can help answer this. Nevertheless, it must be a thorough and scientifically rigorous work rather than doing the same mistakes in understanding Mars over the centuries. Quoting from the book, *On the critical question of whether life exists on Mars, the jury is still out*.

One aspect is clear; scientists at any moment must stick to their science rather than rushing to make catchy headlines. This is most important while exploring unknowns. Quoting from the book, *Scientists don't always discover what they are looking for when they design their experiments, but once an experiment is under way, they almost always discover things worth knowing*. This book is an interesting account of how our understanding about Mars constantly changed and advanced with better and new observations.

Anil Bhardwaj*
Bhalamurugan Sivaraman

Physical Research Laboratory,
Ahmedabad 380 009, India
**e-mail: abhardwaj@prl.res.in*



Methods in Enzymology: Chemical and Synthetic Biology Approaches to Understand Cellular Functions – Part C, Vol. 633. Arun K. Shukla (ed.). Academic Press, an imprint of Elsevier, 50, Hampshire Street, 5th Floor, Cambridge MA 02139, USA. 2020. 308 pages. Price: US$ 199.00.

The *Methods in Enzymology* series has served the signal function of presenting detailed protocols for a range of biochemical experiments and assays – not limited to the study of enzymes. This book is one among three that describe methods and tools of chemical and synthetic biology for the study of structure, function and dynamics of proteins and physiological processes. In a departure from the early norms, topical reviews of areas which have seen multiple approaches develop in the recent past are included. There are 15 chapters, all useful and informative, a few of them are discussed in this review.

Biotinylated molecules are used extensively in bioanalysis. (Strep)avidins bind biotin with high affinity and have been used to detect, locate and quantify biotinylated molecules. However, the assays show variability for different derivatives, and also poor sensitivity and accuracy. The competitive binding assay described enhances the robustness of the assay as well as its sensitivity. Hytonen and his group have developed avidin variants with differing ligand specificity. The newly expanded range of ligands includes some that are currently detected using either more complex methods or more expensive reagents. As a case in point, a variant binding progesterone is shown to be a promising alternative to antibody-based detection and quantitation of the steroid hormone.

Much as (strep)avidins have been the biotechnologists' tool for detecting biotinylated molecules, siderophores have been utilized by bacteria for complexing and accumulating Fe^{3+}, which is poorly soluble. They also serve as virulence factors. Rutscher and Bottcher present protocols for enzymatic engineering of siderophores with a range of ring sizes which can be tuned to inhibit the swarming of pathogenic bacteria, such as *Vibrio alginolyticus* by blocking their access to Fe^{3+}. Another approach to tackling pathogenic bacteria is to inhibit the enzymes required for the synthesis of metabolites used for quorum sensing, virulence and interspecies competition. Bottcher and Prothwa describe a competitive inhibitor profiling strategy to screen for inhibitors of an enzyme central to the synthesis of such metabolites in *Pseudomonas aeruginosa*.

A particularly intriguing chapter by Tzakos and his group is the NMR tube bioreactor. Saturation transfer difference NMR is used to identify potential substrates of an enzyme under conditions where the substrates can bind, but the reaction