# Reviews

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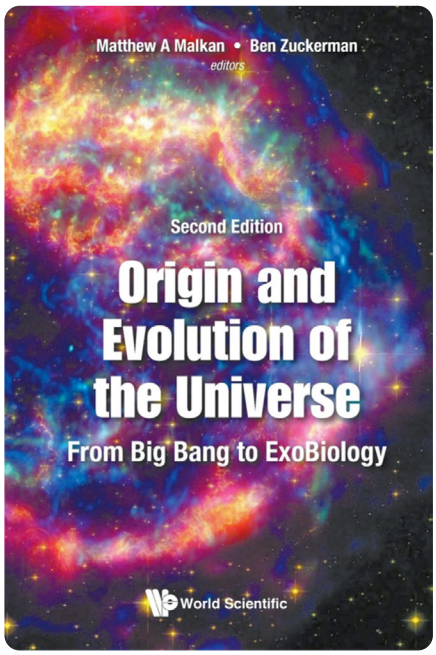



## Origin and Evolution of the Universe: From Big Bang to Exobiology


*2nd edn. Ed. Matthew A. Malkan and Ben Zuckerman*
*London: World Scientific Publishing, 2020*
*232 pp. £40.00*
*ISBN 978 981 120 772 3*


'Awesome' is the best word to describe this book. Whereas many popular science titles provide information and answers, the contributors to *Origin and Evolution of the Universe* admit the limits of our knowledge and, where appropriate, question what we currently 'know'. So don't be put off by the somewhat hefty price tag because within the covers are six authoritative and thought-provoking chapters by authors who are not just experts but exponents in their chosen fields.

The book begins with a chapter by Edward L. Wright, double NASA medal winner and recipient of the Breakthrough Prize in Fundamental Physics, 2017. Wright first guides the reader through Hubble's law, stressing that '*it is only an empirical statement about the observed motion of galaxies*' rather than proving the expansion of the universe, before going on to tackle the thorny issue of density.

As the universe expands, its density will fall (in the classical sense) and it was previously thought that the universe was decelerating but had just the right density to avoid the Big Crunch. We now know that the universe is actually accelerating: '*This hypothesis requires something that acts like antigravity on large scales… so* [Einstein's] *cosmological constant is back in a more modern guise called dark energy. This is a form of density that remains constant as the universe expands, unlike matter or radiation*.'

But that does not put an end to the density issue: '*Because the density of the universe must be close to the critical density to produce the observed clustering of galaxies, we find from the light element abundances* [which are about 25 times less than the critical density] *that most of the mass of the universe must be the mysterious dark matter*.' Thus, both dark energy and dark matter are introduced in their proper places to fill gaps that exist between theories and observations in the evolution of the universe.

In the middle of the book, Virginia Trimble provides a nicely paced review of chemistry in the universe. '*Not by chance*,' she observes, '*the chemical elements most important in living creatures are, with a few exceptions, the commonest ones in the universe*'. Trimble, who reveals that her thesis adviser was Subrahmanyan Chandrasekhar, goes on to consider the nature of dark matter, providing a useful cross-reference with earlier parts of the book in the same way that her mention of the anthropic principle will resurface in the final chapter.

Trimble's style is the lightest and her treatment of the neutron-based nucleosynthesis (also mentioned in Chapter 1) is particularly readable. The brief outline that she offers for calculating the incalculable provides a good example of her overall style: '*The standard way of cheating is called an adjustable parameter. Consider the rate of star formation. Choose a likely value, for instance, the one in our galaxy (a few solar masses per year). Use it in your model and see if you like the answer. If you don't, vary the parameter called "star formation rate" (SFR) until you do like the answer. And, if the rate you end up liking is not too unreasonable, you may have learned something.*'

Jumping to the back of the book, Christopher P. McKay reviews the current state of our knowledge in exobiology. McKay is eloquent and honest, admitting that all models of life in the universe are extrapolated '*from this single point of data*' (life on Earth). That extrapolation is all the more questionable given that we have not yet successfully shown how chemical reactions can generate life. '*Even setting aside the optimistic view that life only required 10 million years to begin… it remains problematical that, 60 years after the first experiment, life remains to be created in abiotic simulations*', writes McKay.

And even if life exists elsewhere, advanced life is unlikely to exist elsewhere right now: '*The record on Earth suggests that intelligent life can arise very rapidly, millions of years or less, on a small planet with lucky evolutionary events but the record also indicates that the path is apparently random and not deterministic and thus could be so rare as to be consistent with human-like intelligence on Earth being singular in the history of the universe.*'

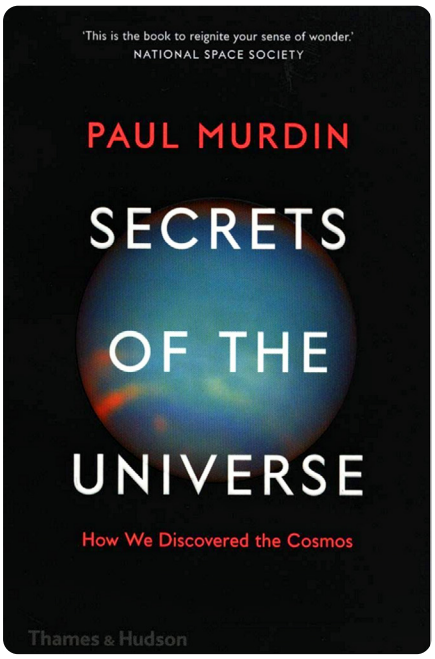
This may sound final but McKay has a sting in his tail, concluding with a computing analogy known as zero-one-infinity. We can prove, by our own existence, that there is not zero life in the universe. We can also prove there is at least one life form of the type that we seek and the analogy suggests that, '*if we are not the only intelligent species in the history of the universe then there are likely to be innumerable such species*'. Just one instance of extraterrestrial life could tip the balance – but it may not be life as we know it.

As may be surmised from the above, the content of *Origin and Evolution of the Universe* is likely to be most accessible to those studying A-level courses, but includes much that could spark the interest and fire the imagination of GCSE students and teachers across all three sciences. At the very least, *Origin and Evolution of the Universe* should be in the library of every school that seeks to stretch and challenge its science students. And if you still are not sure about value for money, the entire first chapter is available as a try-before-you-buy on the World Scientific website at: https://worldscientific.com/doi/10.1142/9789811206467_0001.

*Jon Tarrant*

## Secrets of the Universe: How We Discovered the Cosmos

*Paul Murdin*
*London: Thames & Hudson, 2020*
*336 pp. £10.99*
*ISBN 978 0 500 29519 9*




Encyclopaedic in its content yet minimalist in its presentation, *Secrets of the Universe* might easily be overlooked on a bookshelf. This would be extremely unfortunate as its information is bang up to date and comprehensive, while at the same time being very accessible for both teachers and students alike.

Its 300 pages, excluding glossary, extensive further reading list and index, are arranged in six sections, each containing a series of short chapters that could fairly be described as stand-alone essays. There is a small amount of repetition in a few places to avoid cross-referencing, but this is not obtrusive and greatly improves the readability of each essay. The illustrations, however, are a completely different story: the colour plates have been grouped into two meagre sections and are not in the same order as they are referenced in the text. Apart from these, there is just one monochrome line drawing (of the *Pioneer 10* plaque) in the rest of the book.

At first glance, this makes the book text-heavy but the shortness of the essays, typically around 2000 words running over just three or four pages, strikes a refreshing balance between the double-page spread and the 50-page-chapter formats commonly used elsewhere. I can easily imagine photocopying one of these essays onto an A3 sheet and listing questions underneath to test students' comprehension (all subject to the limitations of the school's copying licence, of course). The essay entitled '*The phases of Venus*' is an example that would work well as the phases are clearly described, as are the consequences of these observations for Galileo. Similarly, the essay '*Cosmic microwave background*' paints a much fuller picture than the work

of Penzias and Wilson, again over a mere four pages.

The book is fully titled *Secrets of the Universe: How We Discovered the Cosmos* but, as the above examples illustrate, it might have been better titled *Secrets of the Universe and the People Who Discovered Them*, for this is not a dry list of discoveries but a nicely woven tapestry of the tales of those who made the discoveries. Due recognition is given to the likes of Caroline Herschel, Jocelyn Bell, Henrietta Leavitt and Vera Rubin, but I was genuinely surprised to discover that Anders Celsius had contributed to our knowledge of the shape of the Earth.

The weakest part of the book is the final section, '*Future discoveries*'. Inevitably, since some of the discoveries have yet to be made, there is less about the people who have contributed to our knowledge. Nevertheless, I was surprised to find that, although '*Life in the universe*' includes the Fermi paradox, there is no mention of Frank Drake and his probability-based approach to the likelihood of communicating with extraterrestrial life.

Overall, I have no hesitation in recommending *Secrets of the Universe*. It is a very useful source of the stories behind the discoveries and would be a great suggested read for all students of secondary school age who want to know more about our universe. Best of all, Murdin's unobtrusive writing style and the brevity of his essays ensure that *Secrets of the Universe* is an easy and rewarding read from cover to cover.

*Jon Tarrant*

**Reviewer**

**Jon Tarrant** is Head of Sciences at Grainville School, Jersey.

**Safeguards in the School Laboratory (Twelfth Edition)**

**By the ASE Health & Safety Specialist Group**
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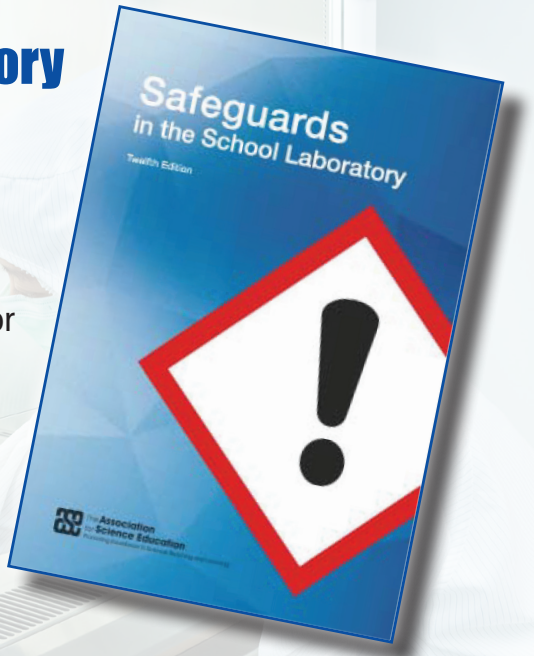
The 12th edition of this invaluable ASE publication is for all those involved in 11-19 science education. It seeks to provide an overview of health and safety issues in science education; it flags up areas where there are significant misconceptions and where problems commonly arise, and draws attention to situations which, although rare, may have serious consequences.

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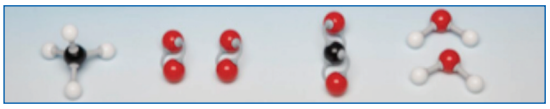

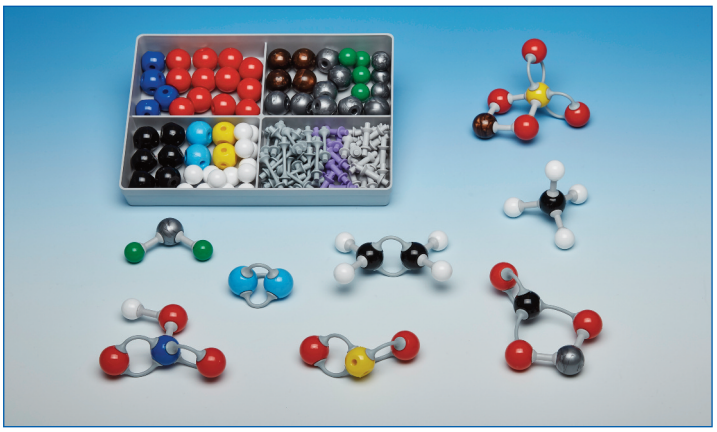

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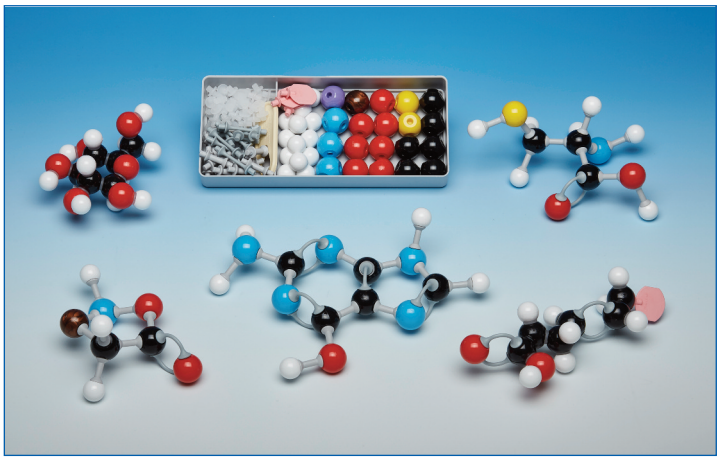

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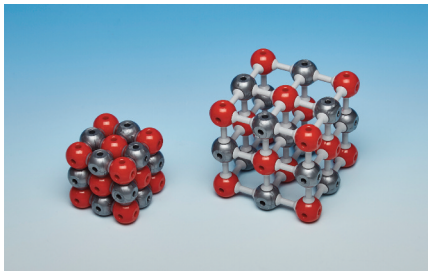
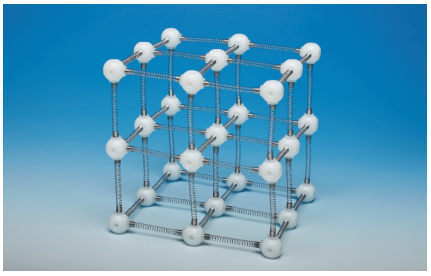
**Clear Diamond model 30 atoms**



**MKO-150-27 Metal Oxide**
**(MgO / FeO) Crystal Lattice**



**MVAM-27-UN**
**Vibrating atoms kit**

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