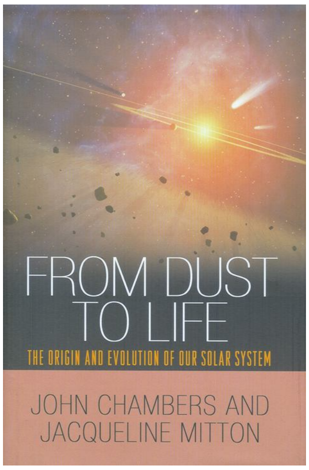

From Dust to Life: The Origin and Evolution of our Solar System. John Chambers and Jacqueline Mitton. Princeton University Press, 41 William Street, Princeton, New Jersey 08540, USA. 2014. xvi + 299 pp. Price: US$ 29.95/£19.95.

Thanks to the resurgence in the area of planetary exploration during the last decade and new results from studies of samples from the Moon, Mars, asteroids and comets, we now have a better understanding of the origin and evolution of the solar system than at the turn of the century, little over a decade back. These events coupled with the unprecedented discovery of hundreds of other planetary systems in our galaxy, even though none of them resembles our solar system, led to an increased level of inquisitiveness and interest among general public, young and old, to know more about the origin and evolution of the solar system. As generally happens in such a scenario, several new books along with a couple of revised editions of earlier published books, dealing with this topic, have appeared in print in recent time. The present book is one of these, aimed at general readers having some basic understanding of science. Such a book needs to be written in an easy-to-read, lucid style with captivating photographs and simple figures and tables to explain scientific ideas, avoiding scientific jargon and intricate details. The authors of the book should be complimented for their effort to adhere to these tenets as much as possible and the book will appeal to anybody who is curious and interested to know the latest ideas about the evolution of our solar system. Unfortunately, the main title 'From Dust to Life' is a bit misleading, as there is very little in the book that tells the readers about the plausible pathways for this progression to appreciate the stated connectivity.

The book will guide the readers through a journey starting much before the Sun was born, little more than four and half billion years back. Of course, the journey is not a smooth one; the authors focus primarily on the origin and early evolution of the solar system and then on the inner solar system objects, the Earth, Moon, Mars and asteroids, and devote only a couple of chapters to the outer solar system, the residence of the giant planets – Jupiter, Saturn, Uranus and Neptune. However, in a sense, it is also desired in a book like this, as most of our current ideas about origin and evolution of the solar system are primarily based on exploration of the inner solar system and laboratory studies of planetary samples from this zone, coupled with analytical studies and computer simulations of solar system processes.

The book starts with a general outline of the solar system as we see it today, and then rewinds the clock backward a couple of centuries to tell the fascinating account of the observation of 'transit of Venus' in the 18th century that completely changed the perception of the scale of the solar system and its overall structure. The debate on the Earth-centric versus Sun-centric solar system, in which philosophers as well as avid observers and scientists, including Ptolemy, Aristotole, Aristarchus, Copernicus, Kepler, Tycho, Galileo and others participated, was resolved with the Sun getting its right place at the centre of the solar system. The theory of gravitation, proposed by Newton, finally provided a solid base for explaining many of the observations related to movement of planets around the Sun and why all the planetary orbits are not similar.

The authors then dwell on the evolutionary processes that could have led to the present configuration of the solar system and discuss the nebular hypothesis proposed by the French scientist Pierre Simon de Laplace, based on the concept that a cloud of gas rotating around the early Sun evolved into a planetary system. It is interesting that a similar proposal suggested earlier by Imanual Kant was never acknowledged by Laplace and it was left to Herman Von Helmholtz, who put both these ideas together in the Kant–Laplace theory of the solar system formation. A proposal that the planetary system was formed out of material pulled out of Sun due to its close encounter with another star was discarded, as it could not stand much scrutiny. It is interesting to note that a proper framework as to how this rotating gas and dust cloud could slowly evolve into dust aggregate, rocks, planetsimals and finally planets was based on a proposal put forth by the Russian scientist Viktor Safronov only 50 years back.

In any natural system, like our solar system, that goes through various stages of evolution spanning a long time, it is important to know the time-span associated with each of these stages. The authors dwell on this aspect and bring in the concept of using the naturally occurring radioactive nuclides, particularly the radioactive uranium isotopes, as clocks for inferring timing of past events and also to find the ages of rocks on our own planet, Earth. This field evolved rapidly following the development of mass spectrometry techniques in USA and Europe and yielded ages greater than 4 billion years for some rocks on Earth and an age exceeding 4½ billion years for pieces of meteorites that are fragments of asteroids.

Certain primitive meteorites host early formed solar system solids that hold clues for deciphering the early history of the solar system. Radiometric dating of solids formed in the evolving solar nebula indicate formation age close to 4.7 billion years for our solar system. Properties of different types of meteorites, from less compact to more compact silicates to a mix of silicate and iron to nearly pure iron, provide information on their parent bodies, the asteroids. These topics as well as meteorite-asteroid relationship and the two groups of meteorites that are fragments of the Moon and Mars are then discussed by the authors to set the stage for discussion of the sources of all the constituent elements present in the early solar system solids.

If one wishes to have a broad view of the cosmic scene and processes leading to the formation of our solar system, it is necessary to understand the formation of the basic building blocks, the elements present in solar system objects. The chapter on 'Cosmic chemistry' takes the readers on a trip to the stars and the stellar processes that could provide the abundances of the various elements present in the Sun. In fact, many of the elements that we know are not from processing happening in the stellar interiors during their lifetime, but are products of explosive deaths of massive stars. It is also interesting that the two most abundant elements, hydrogen and helium, are vestiges from the very early stages of evolution of our universe itself. The authors do cover this vast topic in a short span in an admirable manner.

The Sun holds the centre stage in our solar system. Any understanding of the solar system cannot be complete without knowledge of how the Sun came into being. The chapter 'A star is born' deals with this issue adequately by considering the star formation in one of the well-studied stellar nurseries, the Orion molecular cloud, and then leading the readers through the various steps involved in the formation of a star in a dense cold molecular cloud. Illustrative images of the various stages up to the formation of gas and dust disk around the central star are also provided. Even though what exactly triggered the collapse of the proto-solar molecular cloud is difficult to tell, the authors mention various suggested possibilities. They also note that analytical studies suggest progressive growth of objects in the dust-disk leading finally to formation of planetesimals. In fact all our ideas about the formation of the solar system are based on what we primarily know about the inner solar system objects that may not be correct for the icy world of the outer planets, and the authors do discuss this in a later chapter entitled 'Worlds of gas and Ice'.

A smooth transition from gas and dust to planetesimals and their accumulation to form planets may seem logical, but it is not simple. This is discussed in some detail in the chapter 'Nursery for planets', emphasizing the fact that one cannot conduct a laboratory experiment on Earth to mimic the conditions of low-gravity environment in which these transitions take place. Nonetheless, at present this scenario appears reasonable at least for the planets in the inner solar system.

Any book dealing with the evolution of the solar system has to provide one or more mandatory chapters on the general properties of the planets. The Chapter, 'Worlds of rock and metal' does that for the inner planets in an economical manner, which is easy to read and contains the essential ingredients for a general reader. The chapter on the Moon was perhaps added in view of the renewed interest on lunar exploration. It adequately covers our present knowledge about the Moon and presents a nice summary of the various hypotheses on the formation of the Moon, including the 'giant impact hypothesis' which suggests formation of the Moon from debris produced by a huge impact on the Earth.

It is surprising that in a book with the title 'From Dust to Life', one finally sees the word 'life' in a chapter title that is more about evolution of the Earth and its climate over time and their compatibility for harbouring life on Earth. The oldest geological record of our planet is preserved in samples of 4.4 billion years old sturdy mineral named 'zircon' found in Australia. Signatures of primitive life, in the form of fossils, are found in different continents dating back to about 3.5 billion years. Proxy signatures for life seen on Earth could be from even an earlier era. The classic Urey–Miller laboratory experiment that succeeded in producing amino acids, starting with basic components expected in the atmosphere of the primitive Earth subjected to electric sparks is described. A discussion on the various terrestrial environments (climate and temperature), and pathways that could lead to complex organic life is also presented. The possibility of certain meteorites, which contain organic chemicals and amino acids, bringing in some of the basic building blocks of life, is also noted.

The planets in the outer solar system, termed as 'giants of the solar system', have been described in a single chapter in adequate detail that includes possible mode(s) of their formation, the difference between the two groups of gas giants and the question of relatively massive cores of the two smaller planets, Uranus and Neptune. The possibility that all of them initially formed closer to the Sun than their current position and plausible scenarios for accounting for the large number of satellites in all of them are also discussed. Shortcomings of some of the plausible scenarios proposed only reflect the present status of knowledge in the field.

The asteroids, ranging in size from close to a thousand kilometres to less than a kilometre, populate the solar system space between Mars and Jupiter. Any book on our solar system will be incomplete without a discussion of this group of objects. The authors have noted that even though the asteroids may be classified into groups based on their properties, their current orbits around the Sun suggest post-formation event that led to their redistribution. Asteroids are the parent bodies of most of the meteorites in our collections, and some of the asteroids could be identified with specific groups of meteorites. However, there are several meteorites that do not belong to any known asteroid group, which suggests the presence of additional parent bodies (asteroids) that are yet to be identified. Remote sensing exploration of asteroids, coupled with sample return and landing missions, initiated during the last decade, will hopefully improve our knowledge of these minor objects in the solar system.

Although all the known comets cannot be considered as primary members of the solar system, the authors do justice by including a chapter on the outermost solar system. The connection between comets and the Oort Cloud, discovery of the large number of trans-Neptuian objects, with Pluto as its first member, that are now considered a part of the Kuiper Belt, are discussed. Resonance in the orbital periods of many of these objects with either Pluto or Neptune is narrated as well as the possibility of the presence of some yet unseen planets in this zone, while discussing the peculiar orbit of the object 'Sedna'.

The book ends with an 'Epilogue' that provides a crisp summary of plausible scenarios and processes leading to the formation of our solar system, emphasizing the role of collisions, along with an approximate time-line for the prominent events during the early evolution of the solar system, starting from the formation of the first solids, the so-called Ca–Al-rich refractory inclusions (CAIs) to the formation of the Moon. Some of the unresolved issues are also discussed. One can hope that the results from the on-going and upcoming planetary exploration missions as well as studies of extra-solar planets coupled with laboratory studies of planetary materials will improve our current understanding of the origin and evolution of the solar system. Given the fast pace of activity in the studies of our solar system and other solar systems, one can look forward to a new edition of this book from the authors before the end of this decade.

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