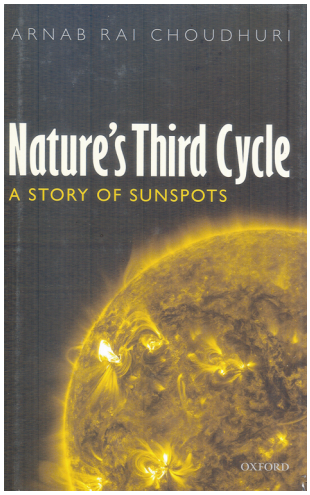


Nature's Third Cycle: A Story of Sunspots. Arnab Rai Choudhuri. Oxford University Press, Great Clarendon Street, Oxford OX2 6DP, United Kingdom. 2015. 304 pp. Price: £ 25.

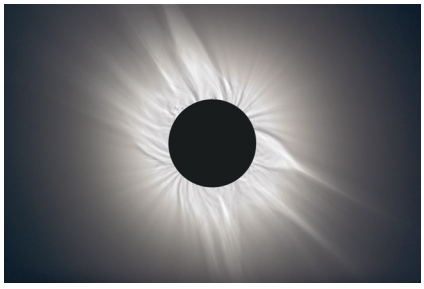
The Third Cycle in the title of this fascinating book is the 11-year solar cycle, the other two being the familiar diurnal and annual cycles. The book is unusual, because it defies the commonly used classifications: it is at heart a popular science book, but not just that, nor just a history; it is much more than an autobiography, and it tells quite a story about the strange ways in which science advances, and about the different actors that form part of the story. Beginning with the Vedic *gayatri* mantra (about *meditating on the glorious sun who inspires our Intelligence*), the book goes through chapters presenting a brief history of early observations of sunspots followed by that of the attempt to understand their physics, including connections with other solar phenomena such as the solar wind; an introduction to plasma physics; the concept of the self-excited fluid solar dynamo that is responsible for the magnetism in the sunspots and their cycles, and a critical history of the proposals concerning the dynamo; and, finally, broad conclusions in an epilogue.

The main scientific account in the text avoids mathematics, but there are eight appendices that touch on mathematical aspects for the interested reader. This keeps the main text a very readable and coherent narrative, for both expert and non-expert readers. While taking the reader through all this material, the author introduces every now and then accounts of the stars of the subject, and writes of his own involvement in the development of the subject in a style that is warmly human without ever becoming intrusive. The major part of the text presents the observational evidence and the reasoning that have gone into the evolution of the current understanding of sunspot cycles – an understanding that by the way is not yet complete. And the personal and historical interludes serve to maintain a light and attractive prose style while at the same time illuminating the internal workings of the world of science.

The historical account is interesting in itself as Rai Choudhuri traces it from the observations on a telescope due to Galileo, through the many controversies that emerged thereafter, the tragic stories about some of the early heroes, and the twists and turns in the 20th century regarding the dynamo theory. The last range from T. G. Cowling's 'anti-dynamo' theorem which was thought to have 'proved' that a dynamo was not possible, through the skepticism of scientists like Einstein who did not believe in anything that was *not* simple, and finally to the new ideas due to the author's guru Eugene Parker, which slowly but steadily gained wide acceptance. Recent controversies, involving the author himself, are also included, without either bitterness or celebration. These arguments have been generally around the idea of the solar dynamo: could a body of fluid experiencing magnetohydrodynamic forces excite itself into a kind of ordered motion that would lead to the observed magnetic field, oscillating in somewhat irregular 11-year cycles for example?

Every now and then, the author seamlessly weaves incidents in his own engagement with solar physics into the overall narrative. He tells us how the first three calculations he made as a Ph D student with Parker at Chicago University were all failures, and he had almost decided to give up astrophysics in favour of philosophy (also a strong Department at Chicago). Parker, whose career had its own interesting stories of ups and downs, told Arnab that he may not become a Chandrashekhar, but he *could* become one of the world's top solar physicist. So Arnab abandoned philosophy and went back to his calculations, and his very next effort bore fruit! He had a similar difficulty deciding, after his many years abroad, whether he should return to India or not, and his guru once again gave him decisive advice: 'Arnab, we each have only one life to live. Go chase your dream! I have confidence in you.' Such little personal tit bits scattered throughout the book give it unusual charm.

The heart of the story is in chapters 6–8, which describe first how the problem posed by the existence of a magnetic field on the Sun was solved, and secondly how the ideas led to an explanation of the 11-year cycle, as well as of the solar wind that explodes in the Sun and then streams across the solar system. These are essentially flow problems, and my own tribe of fluid dynamicists (apart from the astrophysicists) will be very interested in the way physicists went about solving them. Turbulence plays a key role, and we are on familiar ground when the author introduces the subject with the famous pipe flow experiments reported in 1883 by Osborne Reynolds, a professor of engineering at Manchester who introduced the non-dimensional number later named after him. These experiments were the first to make a clear distinction between laminar and turbulent flow, and showed that the 'Reynolds number' provides the criterion for the onset of turbulence in the flow. Twelve years later Reynolds went on to formulate the equations (also named after him) governing the mean flow variables in turbulent flow, taking explicit account of the effect of the strong and correlated fluctuations that characterize turbulent shear flows. Now Cowling's 'anti-dynamo' theorem of 1933 had assumed laminar flow. Using Reynolds-type 'mean-field' equations, Parker showed in 1955 that if the flow were turbulent instead, Cowling's theorem would not apply, because laminar-flow symmetries could be broken by turbulence. This was a big and imaginative step forward, but it took many years before the significance of Parker's work



The solar corona photographed during a total solar eclipse on 26 July 2009. Credit: Koen van Gorp.

was realized, and a convincing and mathematically more rigorous foundation was provided by the East German team of Steenbeck *et al*. in 1966. In the final analysis the solar dynamo has to do with the emergence of coherent structures in a magnetohydrodynamic turbulent flow, due to what may legitimately be called a 'Reynolds e.m.f.' – the kind of situation that is still the stuff of a great deal of research even in such simple fluids as nonmagnetohydrodynamic air and water. The author's subject therefore *is* complex, and he deserves our compliments for hacking a route through that complexity in a convincing, simple and pleasant narrative.

Chapter 8 discusses the solar wind phenomenon in similar terms – predicted by Parker in 1958, and confirmed by newly emerging satellite sensors a few years later – and with its own stories of supersonic flow in the solar system.

The book is strongly recommended to anybody who is interested in solar physics, but in particular also to fluid dynamicists who may like to see how some of the ideas they are playing with can work out in the extreme situations prevailing in the Sun (and elsewhere in the universe). The book should also interest every physical scientist as an excellent account – historical, scientific and autobiographical all at the same time – an account that is not only illuminating about the Third Cycle but also makes an extremely well-told story. And it gives young students, at the threshold of their scientific careers, a feel for the nature of the human enterprise called science – from its often-strange beginnings, its tragic heroes, its skeptical insiders … till finally an overall consensus emerges magically among the community of its practitioners – and all of this told from a perspective that is at once both global and Indian.

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Flowering Plants of the Western Ghats, India. T. S. Nayar, A. Rasiya Beegam and M. Sibi. Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram 695 562, India. Hardcover. 2014. Volume 1: x + 1–934 and Volume 2: vi + 935–1684 = 1700 pp. Price: Rs 3,500/ US$ 200.00. ISBN: 978-81-920098-9-6 (set), 978-81-920098-2-7 (Volume 1), 978-81-920098-3-4 (Volume 2).

The first ever work on plants of the Western Ghats (precisely) from Goa was published by Garcia de Orta (Conversations, 1563). It was after more than a century, Heinrich van Rheede brought out his famous work *Hortus Malabaricus* in 12 volumes (1678–1703) which dealt with the plants of the Malabar (present day Kerala) area in the Western Ghats. The Western Ghats had been a hub of botanical research, especially in the field of collection, identification and classification of plants, for more than a century before independence, starting from Graham and Nimmo to Gamble and Fischer (1839–1936). Independent India witnessed an upsurge in floristic exploration and taxonomic research in the Western Ghats with the reorganization of Botanical Survey of India in 1954, and establishment of different R&D centres and universities in the six states with the Western Ghats (Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu). As a result, thousands of small and big publications have come out on the floristics and taxonomy of the plants of Western Ghats, especially angiosperms, imparting a good deal of knowledge on their distribution and conservation status. However, the fact remained that we never had an 'authentic' and comprehensive work on the flowering plants of the Western Ghats, an important phytogeographical area; besides, now a global hotspot and a heritage site. The two-volume work under the present review befittingly fills the gap that has existed for so long.

The Western Ghats occupy an area of 1,64,280 sq. km and cover fully or partially 53 districts in six states. The work records 7,402 species, 117 subspecies and 476 varieties from these areas and brings 66 species, 5 subspecies and 14 varieties under the category of Doubtful Occurrences. Altogether, the work deals with 8,080 taxa. This account shows the surprisingly rich flowering plant diversity in the Western Ghats not estimated before. So far, we were tuned to hearing differently projected figures that ranged from 4,000 to 5,000 species in different publications.

Details provided in the work for each species follow a unique system not very familiar to Indian taxonomy. This pattern has been elaborated in the diagram given under Users' Key. Each species is provided with the accepted name, relevant synonyms, habit of the species, references to three good descriptions and illustrations, distribution in the world and the Western Ghat states, phenology, IUCN threat categories and other threat categories given in related publications, economic importance, uses and local names in Gujarati, Hindi, Marathi, Kannada, Malayalam and Tamil. A maximum of three references have been cited for each of these characters. This precisely means up to 55 characters for a species. These references are represented by numbers in brackets in the text and the full references are given at the end along with the corresponding numbers. This shows how elaborately the details of a species or taxon have been worked out. As stated in the Preface by the authors, the work accommodates about 23,000 scientific names, 13,000 local names, up to 55 character references per species, about 3,000 references and almost 1.5 lakh times their citations in the text in different combinations. Cultivated and planted species are treated under separate sub-heads. General arrangement follows the alphabetical order: species under genera, genera under families and families under Dicotyledons (Volume 1) and Monocotyledons (Volume 2 + indices to scientific and local names) with names of families and genera appearing as page headers. All these features help one to easily reach the desired species.

The work highlights the fact that though the Western Ghats represent only 5% of the total area of India, the region