– a God of small things, so to speak – in excellent agreement with experiments, so much so that any tiny deviation, for example, a small non-zero neutrino mass, is considered a major breakthrough. There is no competing alternative theory on the offer. An introduction to the subject addressed to the young and the curious is therefore very timely. But this is a daunting task as many sophisticated concepts of physics have to be dealt with, along with the associated mathematics. Not many particle physicists have come forward to take up this challenge. Instead, they have made it more difficult by introducing quirky terminology and often confusing jargon.

G. Venkataraman is well known for science popularization through his earlier writings. In this book, he writes with panache and consummate skill, bringing in, when useful, appropriate analogies from other areas of physics and extracting the maximum from well-chosen diagrams. His style is chatty rather than pontificating, and is interspersed with warning signs, apologies and assurances when the going gets a shade heavy. In places, he gently guides the reader through difficult, new ideas while in some parts (e.g. the formulation of the ($V - A$) theory of weak interactions by E. C. G. Sudarshan and others, or the discovery of the J/y particles) the book achieves the racy style of a mystery novel. I was in two minds when reading the book. On the one hand, it was a fascinating read and hard to put down. On the other, I did not want to rush through and miss any of the details. Venkataraman shows how a theory is gradually woven from strands based on empirical evidence, brilliant insights and heroic collaborative ventures. He deftly captures the excitement of frontline research. The book should spur some to choose science as an exciting career option.

'Volume I' sounds a shade forbidding for a paperback of less than 300 pages addressed to non-experts. This is no tome. Venkataraman traces the historical development of the subject through the discovery of the pions, muons and the 'strange' particles, the overthrow of parity, the introduction of SU(3) and quarks, the parton model and on to gauge theories. He does an excellent job in discussing the standard model of particle physics, going into concepts like spontaneous symmetry breaking and non-abelian gauge theories with illuminating examples. Interspersed in the text, as side attractions, are thumbnail sketches of the people and personalities involved in the game. Topics which do not find mention include string theory, supersymmetry, *b*-quark physics and neutrino physics. Their mention, even sketchily, would have made the book really up-to-date. It is possible that some of these topics are slated to appear on stage in the promised second volume.

A jarring note is sounded by the large number of misprints and errors. As a few random samples: Table 2.A1.4 (p. 15): M_W, M_Z, are about 80 and 91 GeV (*not* MeV), 'Donald Glazer' for 'Glaser' (p. 123) – the inventor of the bubble chamber, etc. There are also a few serious physics flaws: e.g. Parity conservation implies that $P_{\text{initial}} = P_{\text{final}}$ and not '$P|\text{initial}\rangle = P|\text{final}\rangle$' (p. 33); $\Delta^{++} \to pp$ (p. 133) is not permitted (by baryon conservation). In Table 8.2 (p. 142) pions are suddenly denoted as $p^{+,0,-}$, $K^{\pm}$ are assigned the same strangeness, and the r meson listed as an isospin singlet! In the Higgs mechanism, the erstwhile Goldstone bosons become the longitudinal modes of massive gauge bosons, as correctly explained. But to say that the Goldstones leave behind ghosts (p. 208) is a trifle unfortunate, since the term 'ghosts' is used for other quantum fields which appear in the quantization of gauge theories. These examples are only indicative and certainly not exhaustive. There are quite a few more. Perhaps, they can be corrected in future editions and more care will be taken in subsequent additions to this series.

Who, other than practising physicists, will enjoy the book? Scientists from other disciplines will surely find it of interest. For even the brighter high-schooler, stuff like the Euler–Lagrange equation, group theory, etc. I daresay, will put the book beyond range. But smart physics (and allied subjects) undergraduates will surely lap it up. I also feel that postgraduate students will love this book.

Venkataraman and the Universities Press are to be commended for this addition to the now widely known, low-priced, excellent *Vignettes in Physics* series. The book leaves the readers eagerly looking towards the forthcoming second volume which bears the sub-title 'From the Microcosm to the Macrocosm – The Fascinating Link between Particle Physics and Cosmology'.

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The Handicap Principle: A Missing Piece of Darwin's Puzzle. Amotz Zahavi and Avishag Zahavi (eds). 1997. Oxford University Press, New York. 286 pp. US $30.

The works of immense proportions and great importance in art and music are often conceived as small, simple ideas; later to attain their magnificence. The main theme in Beethoven's glorious Symphony No. 3 – the 'Eroica' – began as a small piece in a ballroom, was later modified for a ballet, evolved as a piano piece, and finally achieved its grandeur in the Finale of the Symphony. Do scientific theories develop like this? Do the theories of evolution themselves evolve from their apparent initial insignificance to all the later importance? At least one biological theory stands in a good stead as illustration of this: Amotz Zahavi's theory of signal selection. In 1975 Zahavi gave birth to 'handicap principle', which appeared as a short paper in *Journal of Theoretical Biology*. It is now an all-inclusive, all-pervasive theory of signal selection, best explained and elevated to a new height in a book by Amotz Zahavi and his wife Avishag Zahavi.

We owe the theory of sexual selection to Darwin, who argued that traits such as the decorative feathers of peacocks and antlers of deer evolve because females prefer males with these characters, and that they endow their bearers with higher reproductive success. Although Darwin argued for the existence of these traits as being involved in sexual selection, he did not explain the mechanisms that may bring about their evolution or maintenance. In 1930, R. A. Fisher proposed a mechanism for their maintenance, but not a cause for their evolution. He argued that the traits involved in sexual selection are maintained in a population of organisms merely because females find them attractive. When females mate with their bearers, their sons have the same traits that impress other females, and thereby increase the sons' reproductive success. This is called Fisher's runaway process or 'sexy-son' hypothesis. However, Fisher did not attach any importance to *which* traits would be attractive, he simply assumed that *certain* traits are attractive.

Zahavi's theory of signal selection is an exciting improvement over Fisher's process. It explains evolution of signals and 'wastefulness' in all types of communications and myriad interactions, including non-sexual ones. It proposes mechanisms of not only how traits begin to evolve into signals and what are the conditions under which only certain traits evolve into specific signals, but also circumstances under which a signal loses its importance and therefore stops being a signal.

Yet, it was this very theory that had to face acute criticism in the beginning. In the next issue of the journal in which Zahavi's paper appeared, the leading biologist Maynard Smith (1976) concluded through his mathematical model on Zahavi's theory that '… the proposed mechanism does not produce the results claimed for it, even allowing for sex-limited inheritance'. In his famous book Dawkins (1976) wrote, 'So far, mathematical geneticists who have tried to make the handicap principle into a workable model have failed. This may be because it is not a workable principle, or it may be because they are not clever enough. One of them is Maynard Smith, and my hunch favours the former possibility'. (but see its second edition). Despite these denunciations, the handicap principle remained in discussion, and controversial, for 15 years. The wheel turned in 1990 when Allen Grafen published two papers in *Journal of Theoretical Biology*. His was the first mathematical model that showed that handicap principle *can* work. It was now that the scientific community began considering the principle seriously. In the intervening period, however, Zahavi had continued unperturbed to expand his theory, which resulted in the writing of the present book.

The book is arranged in four parts. The opening chapter of the first part: Partners In Communication, deals with that most antagonistic of the interactions – the prey-predator interactions. Here the authors argue that certain physical characters or behaviours such as alarm calls, stotting run of a gazelle when a wolf chases it and white patches at the back of tiger's ears, have evolved as means of across-species signals rather than within-species signals. The second chapter reviews various signals and physical aggression among rival individuals of the same species. It perceives threats such as approaching the rival, vocalization or stretching the body, as substitutes for physical aggression. It ponders upon aspects of mate selection in animals, e.g. sexual pheromones, ornate organs and feathers, dances, territoriality and the conflict inherent in courtship.

The first part stresses the point that only costly signals which handicap a signaller can be reliable, and that the handicap is a crucial part of reliable signalling. However, the signals are not random – there is a logical relationship between the nature of the signal and the specific adaptive trait of the bearer it reveals. At the end of the first part, Zahavis argue that the displays and signals beyond the domain of sexual selection can also produce extravagance and consequent 'wastefulness' in traits. Therefore they make a strong case for recognising 2 types of selections: Darwin's natural selection ('utilitarian selection') and their own signal selection, treating sexual selection as a subset of the latter.

The second part: Methods of Communication, is perhaps the most important in the book, for it brings home the generality of the theory of signal selection and its power of explaining a phenomenal range of signals. Its first chapter revolves around an important theme – all the 'species-specific' characters accentuate most important sexual or otherwise adaptive features of that species that help the observers reliably assess crucial qualities of the bearers. These characters bring about calibrated comparisons among individuals. The remainder of the second part highlights the vast variety of ways in which animals communicate. Chapter 7 throws up an excellent example, one of the many to be found in the book, of Zahavis' apparently inverted thinking that makes it so exciting and thought-provoking. Traditionally it is believed that animals bristle up their body and facial hair or feathers in order to make them look bigger. Zahavis think otherwise. They argue that although bristling up of hair and feathers enlarges the overall dimensions, it makes the *actual* size of the animal's body or face *look smaller*, '…only a large individual can afford to make itself look smaller in the eyes of rivals or collaborators'.

The third part applies rules of handicap principle to social interactions. Although this whole part is thought-provoking, two chapters in it are particularly remarkable. The first is about Arabian babblers. These are group-living birds that the authors have been studying for almost 3 decades. In fact, the seeds of handicap principle were sown during their study of babblers. In an interesting way, this chapter is a detailed illustration of working of rules of handicap principle in a species of bird that the authors know so well. It discusses competition for various altruistic acts – the key handicap among babblers – and consequent prestige and ranking in social hierarchies of babblers. In this connection it also discusses the theory of reciprocal altruism and its limitations.

The second is about social insects such as ants and bees, which breed in large colonies with a single reproducing queen and innumerable sterile workers. This set of insects has intrigued biologists for several decades now because the evolution of sterile workers and their untiring working for the queen seems difficult to explain. The authors attempt to explain it using their 'prestige model' and predict that seemingly sterile or suppressed workers of social insects are more likely to successfully breed at rare occasions in their colony rather than on their own. This chapter in its course questions the validity of many important earlier theories on evolution of sociality in insects, including Hamilton's theory of 'kin selection'. It throws up many crucial new questions and working hypotheses. It is sure to spark off a fresh line of research on social interactions.

The book's last part, which is the smallest but perhaps the most fascinating one, addresses human behavior. It discusses signals as wide-ranging and subtle as hair-styles and eye-lashes, red cheeks and lips, breasts and body fat, suicide as a cry for help ('One could even redefine successful suicides as unsuccessful calls for help'!), aesthetics and the evolution of art, 'altruism' and moral behaviour in human society, and so on.

Incidentally, apart from being an important theoretical work, this book also has special conservation significance. The income from its original Hebrew edition is dedicated to a fund meant to continue Zahavis' study of the babblers and to maintain their home – the Shezaf Nature Reserve. Zahavis hope that 'the English version and other translations of this book will widen the circle of friends of the Shezaf Nature Reserve and its babblers'.

Afterthought: Zahavi's theory is an important milestone in evolutionary biology which has influenced our thinking and will continue to do so. However, neglect by peers or delay in wide acceptance/publicity seems to be its chronic ailment. Four years had to pass before a review of this book could be written for *Current Science.*

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