in fact bread and butter of the entire Sulvasutra corpus, all the way from the most ancient Baudhayana sulvasutra, is referred by the author only to the Katyayana sulvasutra, which is the last among the significant sulvasutras that have come down to us, and post-dates the oldest one by about half a millennium! I may also add here, without elaboration, that the references given for (a) and (b) are strictly speaking not correct.

On page 78, the author states, 'Different versions of the Pythagorean result are found in the Sulbasutras' and proceeds to state the result for the diagonal of a square and the general one for the diagonal of a *rectangle*, attributing the former to 'Baudhayana and others', and the latter (only) to Apastamba, clearly conveying the impression that the general statement is not found in the other sulvasutras. Here again, actually the general assertion is contained in all the four major sulvasutras.

The above examples also indicate that the author has not always accessed the original sources he is referring to, or even standard redactions available (e.g. (ref. 3) in this case), and rather relied on dubious secondary or tertiary sources for information.

The editing also leaves much to be desired. For example, the diagram at the bottom of page 84 which is supposed to be 'self-explanatory', hardly conveys anything, certainly not the formula the author adduces to it; it also does not conform to the original description in the sulvasutras. There are also many errors of typographical nature, or with similar import, to reckon with. Here are a few that seem worth noting. On page 175 the number of sides of the regular polygon that Aryabhata is supposed to have used in the computation of π should be 384 ($= 6 \times 2^6$) and not 348 as stated; incidentally the statement that the number could be inferred from verse 10 is not justifiable. On page 430 the pseudonym of the group of scholars, Sarma, Kusuba, Hayashi and Yano, who translated and edited *Ganitasarakaumudi* of Thakkura Pheru, is given as SANKHYA, whereas it is actually SAKHYA, composed from some initial letters from each of the names, with the word signifying friendship! And here is an amusing one: on page 95 for the diagonal, parenthetically, in place of *karna* we face *karma*!

Notwithstanding these criticisms the book is a welcome addition to the literature in the area, on account of the insights that it brings in, a dispassionate attitude, cross-references to a variety of related material, and also the overall context of paucity of material, noted earlier.

1. Joseph, G. G., *The Crest of the Peacock. Non-European Roots of Mathematics*, Third edition. Princeton University Press, Princeton, NJ, 2011, pp. xxx + 561.
2. Joseph, G. G., *A Passage to Infinity, Medieval Indian Mathematics from Kerala and its impact*, Sage Publications, Los Angeles, CA, USA, 2009.
3. Sen, S. N. and Bag, A. K., *The Śulvasūtras of Baudhāyana, Āpastamba, Kātyāyana, and Mānava*, Indian National Science Academy, 1983.

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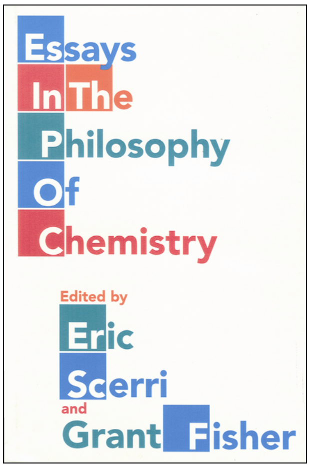

Essays in the Philosophy of Chemistry. Eric Scerri and Grant Fisher (eds). Oxford University Press, 198 Madison Avenue, New York, NY 10016, USA. 2016. ix + 410 pages. Price: £ 38.99.

The riddle that this collection of essays poses to the chemist, and to the interested general reader, is that while chemists seem to be inherently aware of the philosophical streams of thought that run through their subject, and while they are obviously the most adept at conducting their science and do not need advice from philosophers on how to do it, they are not particularly good at taking a step back from their work and describing and characterizing the nature of their work. The geniuses on the subject were different – they were fully aware of what they were doing in a broader philosophical context – but even here, there were differences in outlook. Lavoisier knew that he was starting a revolution in chemistry, perhaps the only revolution that the subject has ever seen, when he redefined chemistry as an oxygen-based subject. Mendeleev too knew what he was doing, when he stated probably the only law in chemistry, namely the periodic law of the elements, and I do believe he was sure that with his law, he was changing the subject forever. Pauling on the other hand was not willing to break ranks with traditional chemical orthodoxy when he postulated bond orbitals, resonance and electronegativity. He merely said in the 1930s that structural theory as it had developed from 1850 to 1915 still retained its validity but had become sharpened, and rendered more powerful by an understanding of the electronic structure of atoms, molecules and crystals.

This book is difficult reading. It is hard for the novice unless one has a philosophical bent of mind. I had to go through it several times, and analyse the nuances of argument among various authors. However, and as someone who has commented on similar matters in his own writings, I found it to be a worthwhile exercise. For a multi-author volume, it is surprisingly homogeneous, even when the points of view of several authors are in contradiction. The editors have done a good job and one of them, Eric Scerri is a well known proponent of the idea of the non-reducibility of chemistry into physics. Therefore, I was somewhat intrigued to read his essay on the 'changing views of a philosopher of chemistry'. While he concedes that not everything in chemistry is derived from quantum mechanics, he now says that the case for anti-reductionism is no longer so clear cut. He uses, what he calls the greatest triumph of reductionism in chemistry, Mendeleev's periodic table, to justify his changing stance!

A recurring theme in the chapters is the relationship of chemistry to physics. Is physics the standard science with which all other sciences should be related? While physics might have a special relationship with mathematics, does this mean that subjects like chemistry should be subjected to the reductionist yardstick that seems only appropriate to a physicist's view of science? The role of experiment and theory is completely different in chemistry when compared with physics. Chemists are open to using empirically determined parameters in constructing their theories, something which is anathema to physicists. Physics deals with phenomena while chemistry deals with transformations. Chemists are uncomfortable with both laws and theories and prefer models. Chemistry progresses in ways that are uniquely its own, and which is neither understood nor appreciated by non-chemists. The blend of the qualitative with the quantitative that one finds in the subject leads to its fascinatingly dualistic character. Its concepts are ill-defined, its rules and principles are full of exceptions, and chemists are often dangerously close to circular thinking. However shaky this theoretical background, the huge bedrock of experiment – and I will affirm that chemistry is an experimental subject only – has ensured that chemists have accumulated one of the great intellectual domains of humankind, enabling chemists to have great power over nature, for good or ill. Can such a subject and should such a subject even be compared, far less reduced, to a subject like physics which is fundamentally different in its approach and outlook? Dirac type reductionism, which most, if not all chemists, take as a failed prediction, is a concept that could only have originated from a physicist. That it should not even be applied to chemistry, was one of the important take home lessons for me when I read this book. Chemistry is different and chemistry is unique. If physics is the standard science, chemistry is the central science.

Particularly interesting, in this context, is the nature of physical chemistry, chemical physics and quantum chemistry in which the overlaps with physics are the greatest. One of the chapters describes these topics as 'in-between' subjects. In-between subjects are not unstable subjects. Rather, they take their foundations from one discipline and then develop them through the rubric of another. In the case of quantum chemistry, the foundations are clearly in applied mathematics and physics but its validation and acceptability within the chemical fold came about because quantum chemists were able to relate themselves to experimental chemistry in ways that are within the chemical mainstream. This is basically why Pauling, when he moved from quantum mechanics to quantum chemistry, did not need to break ranks with experimentalists; the same philosophy continues till this day. In an interesting section in one of the chapters, the development of quantum chemistry is described in terms of six successive clusters or stages: (1) why the subject appeared and what the initial difficulties were; (2) formation of a tribe which decided where it wanted to belong or not belong; (3) historical, social and cultural options available for the growth of the subject and why it went where it did; (4) big technical breakthroughs that enhanced the outreach and growth of the subject; (5) the role of philosophical arguments in the development of the subject and; (6) styles of reasoning that originated partly from cultural preferences and partly from methodological and practical realities. I would add a seventh stage where the in-between subject becomes a subject on its own and one is only dimly aware of the first six stages in its development! This seventh stage has happened in physical chemistry and perhaps it has happened in quantum chemistry as well, because one of the authors asks whether quantum chemistry today is chemistry at all, or a different subject. As a practitioner myself of an in-between subject, crystal engineering, I was struck by the parallelism between quantum chemistry and crystal engineering in terms of epistemology, autonomy, contingency, methodology and culture. Perhaps this kind of progression is particular to chemistry, with its experiment/theory, soft/hard and qualitative/quantitative dichotomies. Reading about philosophy of chemistry enriches one's ability to compare sub-fields in this manner, greatly to the benefit of the researcher.

The authors have said a lot about the nature of chemistry, but one of the omissions in the book is a clear and definite enunciation of chemistry as the central science, an idea that is already accepted widely in the chemistry community. There is an interesting chapter on mathematical chemistry; in other words, chemistry that is based on a mathematical grounding without the intervention of physics. I feel this new subject will have a limited shelf life in the same sense that an attempt to bridge biology and physics without a chemical stepping stone – in the form of biophysics – has had a limited life span. Biology, chemistry, physics and mathematics are in a natural reductionist sequence and it is difficult to jump subjects in this sequence. However, chemistry definitely has reducible and non-reducible parts. One of the chapters calls these parts somewhat facetiously as *φ science* as opposed to *science*. Does all science need to be a φ science and in this sense like physics? The answer is a resounding no, if one goes by the general consensus in these book chapters, but each science deviates in its own way, and chemistry is perhaps the science where the deviations are so large that they constitute in themselves the main corpus of the subject. Supramolecular chemistry for example has even been related to the social sciences in one of the chapters, because in both cases there is a clear connection between assembly processes and further network formation.

The conflicts between reductionism and holism are also brought in nicely in some of the chapters. Reductionist type chemistry would have it that a substance is defined in terms of its chemical composition and how it is built up from smaller units, be they atoms, ions or molecules. However, a holistic viewpoint would aver that a substance is defined as a bundle of properties, and one of the chapters does precisely this. Looking at property rather than structure as the basis for the description of matter is as old in chemistry as alchemy and even earlier, in the ancient civilizations of India and Mesopotamia. There are definite advantages in considering matter in this way, especially in the context of complex systems, supramolecular chemistry and systems biology. In my own work, I have expressed that since it is practically impossible to describe a hydrogen bond in terms of what it is, perhaps a more practical way out is to describe it in terms of what it does.

While practising chemists seem to be outwardly indifferent to the philosophical undercurrents of their subject, their everyday actions and experiments implicitly guide these philosophies, which in turn enforce and enhance future developments in the subject itself. Philosophy is an inherent part of the development of chemistry and this is why the subject has an almost limitless future. Perhaps this is also what makes chemistry so unique. Enjoy this book slowly and quietly. In this modern era where there is so much pressure on a researcher to do chemistry with a purpose, sustainable chemistry, applied chemistry, chemistry for the societal wellbeing, and goodness only knows what else, it was a refreshing excursion for me to read a book in hard copy form, over a few months, on a topic that many would term old fashioned or even unnecessary. However, these unnecessary things are, to my view, a vital part of academic scholarship and this is what happily distinguishes academics from the rest of the world.

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Annual Review of Biophysics, 2016. Ken A. Dill and Xiqowei Zhuang (eds). Annual Reviews, 4139 El Camino Way, P. O. Box 10139, Palo Alto, California 94303-0139, USA. Vol. 45. vi + 401 pages. Price: US$ 102.

In recent days, biophysical techniques are very popular for scientific research areas where theoretical and practical physics and mathematics are used to study biological systems. These days biophysical methods have emerged as a dependable option for researchers working in the areas of computational and experimental biology to answer diverse biological questions, such as transcription dynamics, protein folding, structure and function of biomolecules.

The past two decades have witnessed tremendous advancements pertaining to scientific research in biophysical techniques, like spectroscopy, different types of imaging techniques, molecular dynamics and so on. However, there are very few books in existing literature that would serve as a comprehensive guide for the current biophysical techniques and applications for scientific researchers. A uniform review book in Biophysics is the need of the day for researchers. Several excellent papers and review articles are available on applications and methods of biophysical techniques, which cover biophysical application in medical sciences, membrane biophysics, protein crystallography, and different kinds of spectroscopy techniques, but most of them are scattered in different journals. Simultaneously, many biochemistry books cover certain chemical and structural aspects of bio-molecules. However, none of these papers, reviews or textbooks is sufficient to learn about modern aspects and approaches of newly developed biophysical techniques and applications. It is also very hard to find all of the new techniques together. The annual review book is an excellent resource for graduate, undergraduate and postgraduate students, researchers, educationists, and scientists, that will assist them in understanding the advanced biophysical techniques.

More of these kinds of biophysical review books are required for undergraduate students or researchers from different biological backgrounds, who work/enter into the discipline of biophysics. These biophysical review books will help researchers understand the newly developed biophysical techniques and their applications in biology and will also help reduce the high cost of the books, making them easily available to many researchers.

The book *Annual Review of Biophysics* by K. A. Dill and X. Zhuang is an excellent review book for researchers on recent technological advancements in biophysics. As a faculty scientist working in the field of biophysics, I appreciate the fact that the book covers most of the advanced biophysical topics, ranging from their usage in genomic studies to protein structure determination. This book illustrates how scientists are using biophysical techniques for imaging the specific genomic DNA in living cells, transcription dynamics in living cells, *in vivo* and *in vitro* protein folding and protein structure determination. This book also covers all aspects of using biophysical techniques for genomic studies to protein expression, folding and structural studies, which is an excellent effort by the authors and editors. These multidirectional views may help researchers and scientists to obtain all the advanced concepts of biophysical techniques in one book.

The book consists of 401 pages. It covers important areas in basic biophysics, bioenergetics, bioimaging techniques, computation biophysics and experimental membrane biophysics, which gives researchers adequate knowledge about current biophysical techniques.

The first part of the book covers mostly *in vivo* genomic studies. Recent biophysical experiments like single-molecule spectroscopy and microscopy, single-molecule imaging and live cell imaging give excellent dimension of the study of various biological problems, like nucleic acid dynamics, DNA–protein interaction, and imaging of specific genomic DNA. The second part of the book focuses on protein folding using some traditional biophysical methods like NMR, FRET, mass spectrometry, etc. Most of the reviews in this book focus on newly developed or modified aforesaid methods. The third part of the book focuses on recently developed computational methods, like Molecular Simulation, MDFF to determine atomic structure from cryo-EM and X-ray crystallography data. Also computer simulation study of nascent protein behaviour is an advanced concept in structural and functional studies of biomolecules which have been captured in this book. At the end of the book, the chapter on recently developed biophysical technique 'The Radical-Pair Mechanism of Magnetoreception' would have a high impact in sensory biology research. This chapter explains in details the chemical and physical aspects of the radical-pair mechanism. This could assist many biologists while studying sensory biology.

There are some inadequacies in the book. There is no preface for the book. Sometime this makes it difficult for the reader to understand the levels in the book. For high school graduates or undergraduates attempting to enter into this new field (e.g. biophysical research), it is quite difficult to understand the main targets of this book without a proper preface. This book is not a basic biophysics study textbook. This book is