et al. in 'Neutron star mergers and nucleosynthesis of heavy elements' provide an overview of the latter. With the recent multi-messenger astrophysics due to Laser Interferometer Gravitational-wave Observatory (LIGO) which observed a neutron star merger, this article is bound to become a gold standard for investigations in this field.

Whereas elementary particle physics relies on man-made machines and detectors for its advance, astrophysics remains primarily an observational field as this is the domain where celestial objects produce radiation and particles that remain to be observed by humans. An ingenious experiment that relies on Antarctic ice which is very clear, in which a large number of photomultiplier tubes are embedded and observe light coming from the interactions of particles of cosmic origin which produce light in the ice is called IceCube. P. Mészáros in 'Astrophysical sources of high-energy neutrinos in the IceCube era' shows how the cubic kilometre of ice has helped establish that the very high energy neutrinos have an extra-galactic origin in cosmic-ray interactions along with co-production of high-energy photons. Low-energy neutrinos are a by-product of nuclear power stations and could also hold clues to our understanding of the masses and mixings between neutrinos. A large effort has been made from the earliest days to harvest these neutrinos and probe them. L. J. Wen, J. Cao and Y. F. Wang review our understanding in 'Reactor neutrino experiments: present and future'.

The nucleon–nucleon interaction remains one of the great unsolved problems of theoretical nuclear physics. There is a whole host of low-energy bound states of the strong interaction, all of which contribute to the forces between two nucleons. Separating out their contributions remains a great challenge. Nature has been kind and has provided other probes such as electromagnetism as well as the neutral current due to the Z boson. The latter leads to parity violation, an intrinsic feature of the weak interactions. New experiments that study the effects due to such hadron parity non-conservation and their theoretical understanding is one of the goals of future studies. The state-of-the-art in this subject is captured in 'A new paradigm for hadronic parity nonconservation and its experimental implications' by Susan Gardner *et al.*

In 'New results on short-range correlations in nuclei', Nadia Fomin *et al.* provide a review on recent theoretical and experimental progress in the studies of short-range correlations in the nuclei which are crucial in understanding the dynamics of nuclear interactions at very short distances. O. A. Hurricane and M. C. Herrmann in 'High-energy-density physics at the National Ignition Facility' (at the Lawrence Livermore Laboratory in California, USA) describe the advances in this field and the underlying physical principles when matter is subjected to extraordinarily high pressures, even if for very short periods of time.

Behind many dramatic discoveries in elementary particles lie advances in technology. These advances could well be in the quantum world, or in ultra-low temperature technology, or in massive advances in vacuum technology. Whereas it is known that the Universe must contain dark matter, matter rendered dark because of its very weak coupling to known matter, it may yet be that an occasional collision may be made by such particles with known matter leading to a deposition of large amounts of energy. Such energy could, for instance, raise the temperature of a sample from a superconducting to an ordinary phase. Other detection challenges lie in observing the photons from the cosmic microwave background, the ethereal remnant of the big bang that is ubiquitous and bathes all parts of the Universe, when the photons of that era decoupled from the 'surface of last scattering'. These photons may be polarized and their detection is crucial to our understanding of primordial inhomogeneities. S. Pirro and P. Mauskopf review these topics in 'Advances in bolometer technology for fundamental physics'. Other dark matter detection experiments are in the offing, and an example is the first phase in 'The China underground laboratory and its early science' by J-P. Cheng *et al*. The experiments are a natural sequel to the landmark Reno and Daya Bay experiments.

This volume presents a set of wonderfully written articles by world experts on several frontiers of elementary particle physics, nuclear physics and astrophysics, theory and experiment and application. In conclusion, this volume is a pleasure to read and an invaluable addition to the library of researchers as well as of institutions.

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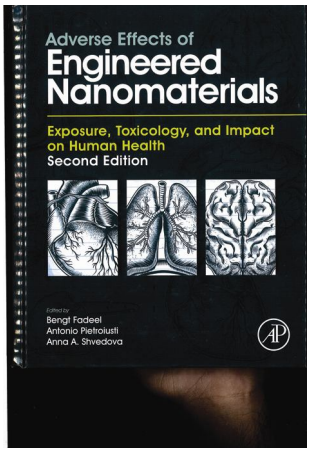
B. ANANTHANARAYAN

Centre for High Energy Physics,
Indian Institute of Science,
Bengaluru 560 012, India
e-mail: anant@iisc.ac.in



Adverse Effects of Engineered Nanomaterials: Exposure, Toxicology, and Impact on Human Health. Bengt Fadeel, Antonio Pietroiusti and Anna A. Shvedova (eds). Academic Press, an Imprint of Elsevier, 125 London Wall, London EC2Y 5AS, United Kingdom, 2017. Second Edition. xvii + 468 pages. Price: US$ 160.00.

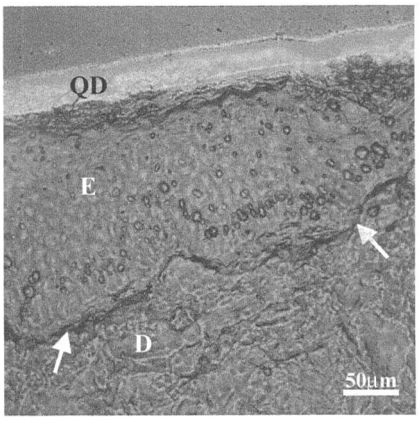
Nanomaterials have garnered significant attention over the last few decades for their potential applications in multiple fields such as electronics, energy generation and storage, industrial catalysis, clinical medicine and new consumer products. These applications are beginning to bring humans in close contact with nanomaterials on a day-to-day basis, leading to important questions regarding their effect on our health. In this context, the book under review is timely.

Understanding the effect of nanomaterials on human health requires basic knowledge of both materials science and physiology. While providing sufficient background on these two different topics is difficult, the editors have done a remarkable job by dividing the book into two broad sections, one dealing with

characterization of materials and interaction of nanomaterials with biological components, and the other dealing with different physiological systems. Additionally, a few important chapters on regulation and risk management are also included, but a separate section for these could have been created.

The book begins with well-referenced chapters discussing physico-chemical as well as biological characterization of nanomaterials. These are descriptive and easy to read, making them an ideal starting point for a beginner to the field of nanotechnology. The tables in chapter 2 are particularly noteworthy as they provide a comprehensive overview of techniques used to characterize nanomaterials. These tables could be used as a teaching tool in both classrooms and laboratories, and may help researchers design experiments to study nanomaterials. Following characterization, one chapter is devoted to laboratory assessment of biological toxicity. The literature on this topic is quite vast and the authors cover only a part of the investigations. They describe cytotoxicity studies in *in vitro* cell culture systems and evaluate portions of *in vivo* tissue toxicity assessment, but do not discuss immune reactions in detail. However, the section on physiological reactions to nanomaterials has an entire chapter on the interaction of the immune system with nanomaterials, where the mechanisms of action of individual immune components are succinctly described.

A majority of the physiological systems that are likely to come in contact with nanomaterials are described in detail. Importantly, a couple of chapters are devoted to explaining the interactions of these substances with the respiratory system. The probability of exposure to nanomaterials at production and work sites as well as unintended exposure following their use is highest through inhalation. Hence, it is important to understand how these nanomaterials might deposit themselves in the lung, the reactions of different types of cells to this deposition, and the likely methods of removal from the lung tissue. One of the chapters discusses all three of these concepts in detail. Another chapter on the respiratory system describes the development of allergies, a common problem associated with inhalation of nanomaterials. Allergic inflammation is a complicated process involving a number of different immune cell subsets. While this chapter highlights some of the common molecules and cells involved in the development of allergies, its brevity showcases the relative paucity of information in this vital area.



Laser confocal microscopy of tape-stripped human skin exposed to QD565-COOH for 8 h in flow-through diffusion cells.

While a majority of the text focuses on adverse reactions of nanomaterials, the chapter on cardiovascular system also describes the application of nanoparticles as disease diagnostics. One of the major clinical applications of nanoparticles is their use as contrast agents in imaging, and nanoparticle-based imaging agents are now routinely used to study cardiovascular disorders. A list of nanoparticles currently in clinical use is presented in this chapter; additionally, a summary of a few systems that are in advanced stages of development or in clinical trials is also provided. Further, the applications and clinical use of nanomaterials discussed here are a refreshing change from the rest of the text, and readers may have appreciated a longer description of the applications of nanoparticles in other physiological systems as well.

Besides the discussion of scientific literature, an interesting aspect of this text is the presence of chapters that describe the risks of using nanomaterials, assessing exposure, monitoring health following exposure, and regulation across the world. These are especially important concepts in the field of nanotechnology, and readers will greatly benefit from the information provided.

Over the past few decades, a comprehensive set of rules and guidelines have been established to measure exposure to chemical and biological agents, and practices to follow after exposure such that health of the exposed individual may be improved. Unfortunately, these rules and guidelines are not directly applicable to nanomaterials. While nanomaterials may be chemical and/or biological agents, their complex composition, size and shape pose unique risks. Hence, evaluating exposure to nanomaterials, and assessing the impact they may have on human health is challenging. One of the chapters in this book is devoted to exposure assessment. This provides a broad summary of current practices to determine exposure to engineered nanomaterials, with a number of step-by-step approaches to measure the amount of nanoparticles at any work-site. Another chapter is dedicated to assessing the impact of engineered nanomaterials to health. The suggestion by authors of this chapter is to measure impact using specific biomarkers. A few blood-based biomarkers have been identified to assess exposure or toxicity associated with nanomaterials, but these methods are unlikely to establish the genotoxicity or carcinogenicity of a nano-object. Long-term studies are required for these assessments, some of which are currently underway in laboratories around the world.

With the increased use of nanomaterials, societies and governments are beginning to recognize the need for formal rules to regulate their production, utilization and disposal for risk mitigation. The European Union, Japan, Korea and the United States have all established a set of regulations (in the form of legislation) with regard to nanomaterials. A thorough description and discussion of these regulations is provided in an exceptionally well-written chapter of the book. India does not have a legislation regulating nanomaterials yet. However, a core committee of editors from the Indian Society of Nanomedicine developed a set of guidelines for evaluation of nanopharmaceuticals in the country, which was officially released in December 2017. Though these are guidelines specifically meant for pharmaceutical nanomaterials, and are not yet regulations, they still provide a framework to begin developing a legislation for regulating nanomaterials in India.

To summarize, this book describes our current understanding of the potentially harmful effects of materials at the

nano-scale. The book is light on the recent advances in the medical applications of nanotechnology, but covers a wide variety of literature related to characterization of nanomaterials and their interaction with biological and physiological systems. An interesting aspect of the book is that each chapter ends with a few succinct take-home messages that are helpful in understanding the complex material. Additionally, an extensive set of references is included, which makes this book a must-have for researchers in the area of nanotechnology.

SIDDHARTH JHUNJHUNWALA

Centre for BioSystems Science and Engineering,
Indian Institute of Science,
Bengaluru 560 012, India
e-mail: siddharth@iisc.ac.in

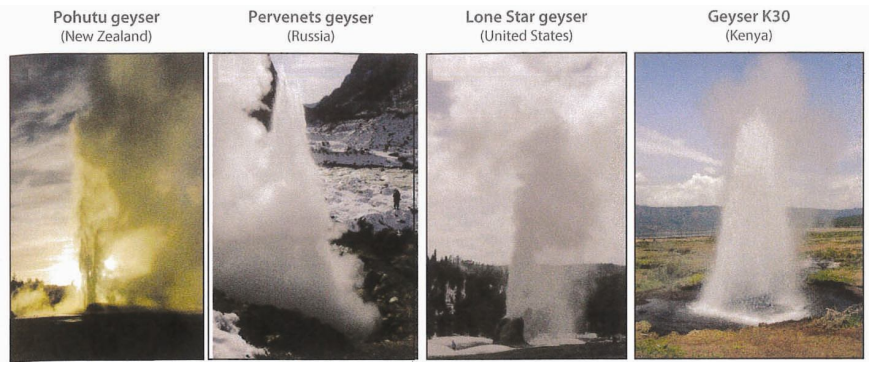
Annual Review of Earth and Planetary Sciences, 2017. Raymond Jeanloz and Katherine H. Freeman (eds). Annual Reviews, 4139 El Camino Way, P.O. Box 10139, Palo Alto, CA 94303-0139, USA. Vol. 45. xii + 709 pages. Price: US$ 114.

The editors of the 2017 *Annual Review of Earth and Planetary Sciences* in their introductory piece, to drive home their point, quote from a song *Once in a Lifetime* sung by David Byrne and his music band *Talking Heads*: 'How did we get here?'. The volume, as the editors tell us, is an attempt to address this fundamental question about how we got here. To me, it is a generic question, not necessarily applicable in the context of this volume. This is a fundamental question that drives the entire enterprise called science and motivates us to keep asking difficult questions about our existence and endlessly explore for answers. Each of the articles in this volume, no doubt, is expected to provide the current status of some aspects of this grand undertaking. We only need to see if this compendium meets those expectations.

In some respects, the prefatory article by Susan Werner Kieffer, a geological physicist and planetary scientist, with varied interests like volcanology, meteoritic impacts, geysers and planetology to thermodynamics and river hydraulics sets the stage for the rest of the pedagogical reviews in this volume expectedly on apparently disparate topics but united at a fundamental level – to gain knowledge of evolution of the Earth, its biological entities and the mysterious little-known worlds beyond the Earth. This article is followed by a review that overlaps one of her own research interests. Here, Shaul Hurwitz and Michael Manga analyse the complex dynamics of geysers – the hot springs characterized by interminable or continuous discharges of water and vapour. Susan Kieffer's planetary research interests also find their match in a bunch of articles in the volume that essentially deals with the evolution of solar system. Among these, Erik H. Hauri and co-authors discuss the origin and evolution of magmatic water based on accumulated analytical results on the lunar rock samples during the last 40 years. In an article titled, 'Forming planets via pebble accretion', Anders Johansen and Lambrechts review aspects of early stages of planet formation by pebble accretion. Thorsten Kleine and Richard J. Walker present the latest research on tungsten isotopes – a new kind of radiometric chronometer for planetary accretion and differentiation. In another review William F. Bottke and Marc D. Norman track the research developments in the late heavy bombardment – an event of elevated impact flux, believed to have happened between 4.1 and 3.8 billion years ago. It still remains controversial whether there was indeed a phase of cataclysmic planetary instability that heavily cratered the terrestrial planets or an artifact of sampling materials. Keke Zhang and co-authors review recent advances in data generation on high-precision gravitational measurements by orbiting spacecraft and use such data as a means of determining the basic shape, internal structure and gravitational field of the outer planets.

Two articles in this volume are devoted to the understanding the drivers of global change. For the last two decades the aerosol–cloud–climate interactions have been a topic of active research, but they have not been fully understood. Using the data derived from laboratory experiments, field observations, satellites, and numerical modelling, Storelvmo reviews the recent progress in our understanding of how aerosol affects the cloud properties, and how such processes result in climate forcing. Another area of interest in this regard has been the science of glacier–climate interactions, though they are comparatively fairly well understood. Andrew N. Mackintosh and co-authors show the usefulness of studies on the world's glaciers in reconstructing climate since the ice ages. C. Kevin Boyce and Jung-Eun Lee go further back in time and review the evolution of terrestrial flora from the Proterozoic through to the Neogene in the context of how vegetation influenced climate through time.

In the category of articles that review our understanding of life across Earth's history, Mary T. Silcox and Sergi López-Torres present the research developments in understanding the origin and evolution of primates, with whom humans have a shared ancestry. Their review centres on new fossil discoveries, molecular data and related technological advances. One of Darwin's major concerns when he proposed the theory of evolution was the fragmentary nature of fossil records. The last 160 years since Darwin witnessed phenomenal improvement in the documentation of the species in time and space, thanks to the tireless efforts of palaeontologists. Mark E. Patzkowsky provides a deep-time perspective on the origin and evolution of regional biotas of



Examples of geysers from each of the major geyser fields.