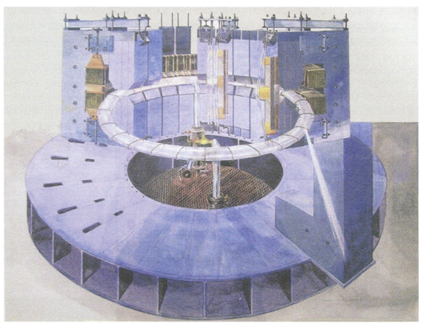
Annual Review of Nuclear and Particle Science, 2015. Barry R. Holstein, Wick C. Haxton and Abolhassan Jawahery (eds). Annual Reviews, California, USA. Vol. 65. Price: US$ 99.

The year 2016 saw a most dramatic scientific event in the month of February with the announcement of the observation of gravitational waves by the Advanced LIGO collaboration. This complex experiment uses as its principles, laser inteferometry with two constituent ultra-quiet laboratories separated by thousands of kilometres. The 'chirp' that was seen by one in the State of Louisiana in USA was followed by another almost identical chirp in the State of Washington, which demonstrated the disturbance in the fabric of space-time, travelled at precisely the speed of light. This was the first confirmation of the prediction made by Albert Einstein in 1916 when he worked out the consequences of the General Theory of Relativity that was established by him the preceding year. The event had been caused by the merger of gigantic black-holes weighing in the range of tens of solar masses millions of years ago in the southern part of the sky and the event had been seen soon after the Advanced LIGO had been turned on in the middle of the year 2015. The members of the collaboration and their team leaders were honoured with the Breakthrough Prize for this most dramatic discovery. Thus, it may be fitting for us to review the present collection of articles that contains the article of Stefan Ballmer and Vuk Mandic (which is the last in the collection of articles!), entitled 'New technologies in gravitational-wave detection' which was written before the discovery. The abstract of the article contains the oracular sentence 'Second-generation detectors are currently being commissioned and should produce the first observation data as early as this year' which is worth noting. The article reviews the physics, the technology as well as the important instrumental aspects of the effort, which makes it a very useful article, and also the limits on gravitational-waves that came from the first generation of experiments that ran between 2005 and 2007 and later between 2008 and 2010.

Of the dramatic events in the history of physics in the recent past, besides the discovery of gravitational-waves, none other captured the imagination of the public as much as the discovery of the Higgs Boson in 2012 at the Large Hadron Collider. In 2013 the Nobel Prize for Physics was awarded to P. Higgs and F. Englert for their 1964 work on the subject, in which Higgs had predicted the existence of such a spinless particle that arises during the process of turning force carriers which are typically massless (such as the photon of the electromagnetic force) into massive particles (such as the W and Z bosons of the weak force), via the introduction of a scalar field, which had been exemplified in the work of Englert in collaboration with late R. Brout, through the phenomenon of symmetry breaking. In this collection, we have the article of Chris Quigg entitled 'Electroweak symmetry breaking in historical perspective' where the author begins by tracing the experimental evidence for the existence of massive force carriers from radioactivity, and then the postulate of the existence of neutrinos to rescue energy and angular momentum conservation, and then the inference of an underlying 'gauge' symmetry principle, and the path to symmetry breaking with insights garnered from an entirely different sector of superconductivity, where the photon behaves as if it were massive, the construction of the Standard Model, and the eventual discovery of the Higgs. The author leaves us with a set of issues for future studies, such as to the true nature of the Higgs Boson, and its couplings to other Standard Model particles, whether there is only one Higgs Boson and/or whether there are others, and whether all these lie in a larger unified theory. A natural (!) companion to the article above is the one by Michael Dineq entitled 'Naturalness under stress' where the principle of 'naturalness' requires that in field theory, small quantities should remain small even in the presence of quantum mechanical corrections. In a theory with Higgs fields, it becomes difficult to respect this Principle, as regards the low mass of the Higgs Boson, and it becomes necessary to extend the theory by inclusion of more fields, associated with far heavier ('supersymmetric') particles not yet discovered in nature, or through the existence of other strongly interacting sectors of the theory, which in turn provide a symmetry principle for protecting the Higgs mass, or perhaps that there are additional (warped) compact dimensions, which provide a different mechanism for protecting the mass of the Higgs. Another key unexplained feature of the Standard Model happens to be the so-called 'strong CP problem', which requires a certain parameter to be very close to zero, an unnatural state of affairs. A possible symmetry known as the Peccei-Quinn symmetry then predicts the existence of a particle, known as the axion. [In the foregoing, 'CP' stands for the joint operation of replacing all particles by their charge conjugates (C) (an operation which swaps, e.g. an electron with a positron, a proton with an anti-proton) and the laws of physics by their counterpart in a mirror-reflected version ('P' that stands for parity).] Each of C and P are discrete symmetries, and so their another important discrete symmetry known as time-reversal 'T' where one imagines the laws of physics when time runs backwards. The Special Theory of Relativity says that the laws of physics are invariant under the joint operation of P, C and T, but says nothing about them one or more at a time.

The failure so far to find any evidence in support of these ideas, thus leads to a stress on the idea and Dine surveys in turn, the notion that we are one out of a 'landscape' of possibilities born in String Theory, which requires our Universe to be 'just-so'. A less esoteric but equally compelling article is the one by William Murray and Vivek Sharma entitled 'Properties of the Higgs Boson discovered at the Large Hadron Collider'. It takes us on a voyage of discovery of how the two experiments ATLAS and CMS tuned their search strategies and discovered the Higgs Boson and measured its mass, constrained its lifetime and studied its couplings to the Standard Model particles. It is a highly accessible article. That there are heroic searches for the predictions of theorists in the axion sector is reflected in the article by Peter W.



The first Cornell electron synchrotron: 300 MeV.

Graham *et al.* entitled 'Experimental searches for axion and axion-like particles'. Axions are a generic term and can differ in detail depending upon the precise theoretical model which can give rise to different environments which they may be produced or lead to different manifestations of their properties. They could well be dark matter candidates or even be produced in the Sun. The search strategy would depend upon the chosen scenario. Many experiments have probed these scenarios, as reviewed in the article. The 'young and rapidly developing field' of gamma-ray astronomy is reviewed in a delightful article by Stefan Funk entitled 'Ground- and space-based gamma-ray astronomy' which among other scientific goals also provides valuable limits on dark matter annihilation. Thus the largest to the smallest length scales of the physical world are covered in this article.

While there has been a lot of excitement about the discoveries at massive laboratories with huge collaborations, it is still possible to test the laws of physics on a more modest scale, with table top experiments, albeit with the most modern technologies to achieve high precision. For instance, in their article 'Parity and time-reversal violation in atomic systems' B. M. Roberts, V. A. Dzuba and V. V. Flambaum review the manifestations of parity violation present in the weak interactions in atomic systems in exotic phenomena such as the existence of nuclear anapole moment and, nuclear Schiff moments, where the latter arises due to the possible presence of electric dipole moments, the existence of which implies T-violation. On the other hand, E. Mereghetti and U. van Kolck in 'Effective field theory and time-reversal violation in light nuclei' review the manner in which T-violation can be probed in light nuclei by constructing the suitable effective field theory for this purpose. José Bernabéu and Fernando Martínez-Vidal in their contribution 'Time Reversal Violation', take the reader through T-violation in elementary particle systems, which involve a quark and anti-quark pair (meson), that are the only systems wherein T-violation has actually been observed in high precision laboratories that collect a large number of mesons and their decay products, and show how simple observables can be constructed from the measurements of their kinematic configurations. In the above, mesons containing the second heaviest quark, namely the b-quark play a central role in establishing the T- and concomitant CP-violation predicted in the Standard Model. Whereas the ATLAS and CMS experiments of the LHC have played a tremendous role in the discovery of the Higgs, a less flamboyant cousin is the so-called LHC-b experiment, which probes the properties of systems containing a b-quark that are produced copiously at the LHC. T. Blake, T. Gershon and G. Hiller survey the discoveries in this sector in 'Rare b Hadron decays at the LHC' by these three experiments.

The twentieth century saw the rise of elementary particle physics as the fundamental science as the possibility of doing controlled experiments at ever increasing energies and precision became possible. In this quest, with LHC perhaps being the crowning glory to the historic process, in which many laboratories posted milestones. A special pride of place must be accorded to the effort that took place at the Cornell University in the US. The article M. Tigner and D. G. Cassel titled 'The legacy of Cornell accelerators' takes the reader through the history of this exciting story. This is the first article in the present collection, and the first article is normally reserved for a semi-historical account of a facility or an autobiographical piece, and that continues to be the case in the present collection as well. While the science is often known to the public mind, one forgets that there is a huge accelerator science that must keep the beams in focus, and this has led to ever increasing improvements in the technology of magnets that must supply the strong magnetic fields to focus charged particles and keep them in their orbit.

Giorgio Apollinari, Soren Prestemon and Alexander Z. Zlobin take the reader through a guided tour on this aspect in 'Progress with high-field superconducting magnets for high-energy colliders'.

Before the advent of elementary particle physics as the Queen of Physics, nuclear physics had laid claim to this title for over half a century, because it was of great importance from the point of view of harnessing energy as well as from the point of view of understanding how stars are powered. A precise knowledge of the properties of a complex system of several nucleons (protons and neutrons) using experimental probes and theoretical probes was vital in pinning down the properties of stars. It is of great importance even today to have up-to-date calculations as well as measurements of energies and rates of reactions. For instance, in the present collection we find the article by Carl R. Brune and Barry Davids who educate us on the present state of the art in the article entitled 'Radiative capture reactions in astrophysics'. In the article by K. Hebeler *et al.* we are presented with a comprehensive review of the eponymous article 'Nuclear forces and their impact on neutron-rich nuclei and neutron-rich matter', with special emphasis on the three-nucleon forces that contribute to special kinds of nuclei not far from the nuclear drip line. It is known that stable nuclei form only for certain combinations of proton and neutron numbers and these are also of significance to neutron stars, thereby tying up the astrophysical with the microscopic once again. Indeed, Stefano Gandolfi, Alexandros Gezerlis and J. Carlson in 'Neutron matter from low to high density' review an intriguing new field that links neutron matter which is modelled as a fluid to topics in condensed matter physics and links the insights from this latter to properties of neutron-rich nuclei and the nuclear crust and discuss the implications to neutron stars. Dimitri E. Kharzeev reviews the interesting topic of 'Topology, magnetic field, and strongly interacting matter', whereas L. Patrizzi and M. Spurio review the 'Status of searches for magnetic monopoles'.

At the next level of description of matter, we find that even today there is much to be learnt about the properties of the nucleons themselves. A nucleon is made up of three light quarks bound together by the strong interaction through the exchange of virtual gluons. This problem is impossible to solve and one has to resort to computers to unravel their structure or carry out detailed measurements on how they obtain their spin structure from the individual half-integral spin constitutents, namely the quarks. Matthias Grosse Perdekamp and Feng Yuan take us through a tour of the present day experiments in their article entitled 'Transverse spin structure of the nucleon'. What do we know about the behaviour of quarks and gluons when they are squeezed together or heated up in extreme conditions? How do their complicated interactions reveal themselves and are we justified in treating them as a thermodynamic system when there are a large number of them present? This is answered at the present day state-of-the-art from computer simulations in the article 'Lattice QCD thermodynamics with physical quark masses' by R. A. Soltz *et al.* The authors show how improvements of computer performance and algorithms allow us to actually reach realistic quark masses, which are only becoming possible now. In the past, the quark masses were always taken to be much larger than their physical masses due to limitations of memory and clock speed.

In this collection, we also find three articles that form a coherent whole in the state-of-the-art knowledge of the properties of neutrinos, those weakly interacting particles on which, performing experiments are notoriously difficult. While today we know that there are three types, we also know the squares of the mass differences between them; taken two at a time, we do not know their individual masses, nor do we know their ordering.

R. B. Patterson reviews the 'Prospects for measurement of the neutrino mass hierarchy', whereas Soo-Bong Kim and Kam-Biu Luk review the status of the mixing angle between the first and third type of neutrinos in their article 'Measurement of θ_{13}. Finally, in the article by David Adey *et al.*, we read about 'nuSTORM and a path to a muon collider'.

In conclusion, this collection of important articles is a timely one, that brings the reader up to date on virtually every branch of elementary particle physics and nuclear physics at the frontier. The quality of the articles is of the highest calibre by the leading experts in the world and is a pleasure to read. A must for every library.

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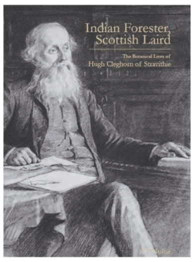

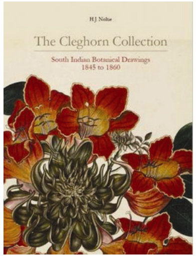

Indian Forester, Scottish Laird: The Botanical Lives of Hugh Cleghorn of Stravithie. Henry J. Noltie. The Royal Botanic Garden, Edinburgh, Scotland. 2016. xii + 324 pp. Price: £15 (ISBN: 978–1–910877–10–4). **The Cleghorn Collection: South Indian Botanical Drawings, 1845 to 1860**. Henry J. Noltie. The Royal Botanic Garden, Edinburgh, Scotland. 2016. vii + 176 pp. Price: £20 (ISBN: 978–1–910877–11–11).

Henry Noltie, no stranger to Indian botanists, is an adorable botanist and avid plant and botanical-art historian of colonial India and of the Madras Presidency in particular. Many, I am sure, will recall his magnificent volumes on Robert Wight, another Scot, who revolutionized the understanding and management of economic plants of the Indian subcontinent[1,2].

This review pertains to Noltie's latest 2-volume set on Cleghorn, who was a contemporary of Edward Green Balfour in Madras[3]. Hugh Francis Clarke Cleghorn was born in Madras on 9 August 1820. In 1824, the Cleghorns returned to Scotland. He qualified for M.D. from the University of Edinburgh (UE) in 1841 (ref. 4). During his stay at UE, he became interested in plants. He returned to Madras as an Indian Medical Servant. He first served in the Madras General Hospital, and later in Mysore (Shimoga). While at Shimoga, economically important plants fascinated him. In 1848–1851, he went back to Britain on sick leave. His association with John Forbes Royle – especially when Royle was busy cataloguing natural materials for the Great Exhibition in London in 1851 – enabled Cleghorn to get interested in plants. While in Britain, Cleghorn lectured on the reasons for the failure of Indian agriculture in different forums. He attributed tree loss in natural forests as the key reason. These observations stimulated the Government of India to think of introducing forest management and conservation practices to improve agriculture. The Government of Madras requested Cleghorn to organize a new Forest Department in Madras in 1855. He was appointed the Conservator of Forests of Madras in 1856. Cleghorn considered railways, which were being developed in India then, a major threat to forests. His foresight in calculating that a mile (1.6 km) of train tract would utilize about 1800 wooden sleepers, given that each sleeper would weigh between 75 and 100 kg, is admirable. He was equally concerned with the quantity of wood that would be burnt to run steam locomotives[5]. In 1861, he was appointed the Joint Commissioner of Forest Conservancy of India, along with another distinguished forester of German roots, Dietrich Brandis. He was later requested to plan forest management in Punjab. During his secondment to Government of India from Madras, he explored the natural forests of North-western Himalaya and its neighbourhood. The forest-conservancy methods he had launched in Madras Presidency during his leadership were of high value and relevance in all-India forest management[6]. He officiated as the Inspector-General of Forests of India for a while, when Brandis was on leave. On retirement in 1869, Cleghorn returned to Scotland and lived in Strathivie, until his end in 1895. *Cleghornia* (Apocynaceae) erected by Robert Wight and *Capparis cleghornii* (Capparaceae) erected by Stephen Troyte Dunn, for example, celebrate the life and work of Cleghorn of Madras.

Cleghorn believed in preserving natural forests, since he was convinced that they encouraged better hydraulics and therefore better landscapes. He was conscious how private timber enterprises in Burma indiscriminately destroyed forests and the consequences of such destruction impacted negatively on the hydraulics and landscape of Burma[6]. Brandis[6] writes:

> 'He (*sic*. Cleghorn) justly laid great stress upon the necessity of acquiring a good knowledge of the principal trees and shrubs, as well as of the climate, soil, and forest growth in the different forest tracts; and in regard to the protection of the forests, he studied the chief sources of injury, indiscriminate cutting, fires, and Kumri cultivation.'

Kum(a)ri cultivation was the shifting cultivation practiced in the slopes of Western Ghats of the Peninsular India,