



Empowering India: Ideas for Action by Scientists and Engineers. Thalappil Pradeep and Krishnan Narayanan. Indian Academy of Sciences, Bengaluru, in association with IIT Madras Alumni Association. 2023. xxvi + 463 pages. Price: Rs 399.

Government of India has initiated several programmes for empowering India. For example, Digital India is a flagship programme that aims to transform India into a digitally empowered society and knowledge economy. Several government schemes related to women empowerment, such as *Beti Bachao Beti Padhao*, *Ujjwala*; social defence schemes of Ministry of Justice and Empowerment; and many other programmes like Strengthening, Upscaling and Nurturing Local Innovations for Livelihood (SUNIL) Programme aiming at technology delivery and enterprise creation model for improving efficiency of livelihood system and Capacity Building of Community-based Organizations (CBOs), NGOs, Knowledge Institutions (KI) and social start-ups have been launched. These programmes have been analysed and elaborated in the form of multiple reports. However, there is a dearth of books related to the country's science and technology (S&T) programmes that aim to empower India as a global knowledge leader.

Here comes the book 'Empowering India – Ideas for Action by Scientists and Engineers' by Professors Thalappil Pradeep, Professor of Chemistry at IIT Madras and Krishnan Narayanan, former President of IIT Madras Alumni Association and President of the *Itihaasa Research and Digital*.

This book provides detailed, pragmatic recommendations and models for promoting science and our country's scientific environment for innovation. It is a comprehensive book that provides a road map

for harnessing the positive power of S&T to enable the growth of India to reach the top position of superpower. The authors have painstakingly researched and collected important data on different disciplines of S&T and provide the essence of their findings in this book. They humbly dedicate this book to 'To everyone who contributed to building the S&T edifice of India'.

The authors have chosen thirty recommendations and hundreds of case studies relevant to the seven pillars of Empowering India. The pillars include: (i) Information communication technology, (ii) Sustainability, (iii) Bioscience and biotechnology, (iv) Research and technology development, (v) Innovation and entrepreneurship, (vi) Academia–industry relations and alumni engagement, and (vii) Education and skill development. Their suggestions and recommendations are aimed towards the leading research and educational institutions in India, which have the opportunity to adopt and transform them to support India's aspirations by 2047.

Before I proceed with a detailed review of the book chapters, I must comment on the 'art' in the S&T book! I found the book cover captivating – a colourful peacock with a difference; a peacock with solar panels as wings and an electronic circuit on its head. The book has ten other illustrations interspersed between various chapters. Each illustration takes a concept/idea that symbolizes India, rural and urban, and visualizes it in a new context infused with various elements of S&T. Keeping in mind futuristic trends, many of these illustrations have been produced first by an AI engine and then improved upon by a human artist. The authors offer this reimagination to celebrate the Indian themes and hope that S&T will positively influence every aspect of our lives.

I like the three futuristic scenarios on online education, global research and planetary and societal impact that the authors provide in section 1, *Imagining India in 2047*. In an elaborate section 2, *Evolution of S&T in India*, they provide a brief history of S&T in India, including establishing IISc, IITs, CSIR and other S&T Institutions. It is interesting to note that the research publications in chemistry were topping even during the pre-independence era. The authors provide a table of several innovative technologies developed by the IITs in the early years, which even many IITians may not be aware of.

In section 3, *Context Setting for India in 2030 and 2047*, the authors highlight how

India's economic position as a low-middle-income country belies its elevated position in the Global Knowledge Index and Global Innovation Index. They articulate key business and technology objectives for India for the future and provide a comparative current context of S&T in the country. They emphasize that the number of researchers per 100,000 of the population is only 15 in India, while it is 111 in China, and 423 in the United States. Despite India's increase in scientific publications worldwide, with a rise from 3.1% in 2009 to 4.4% in 2013 and 4.8% in 2016, the US and China published four times more papers in 2016 individually. While India is ranked 5th in the world in terms of the total number of publications, it lags at the 11th in terms of citation. India has made progress in research, but there is still room for improvement. To encourage R&D and innovation, we must create an environment fostering growth. For India to stake its claim as one of the world's largest and most respected economies, it must move from being a net consumer of knowledge to becoming a net producer. R&D leading to innovation is critical to maintain growth momentum. It is also vital to India's security – the security of our people – and the resilience needed to address the prevailing challenges, from climate change to pandemics, from cyber warfare to autonomous military systems. The authors of the book make a sensible case for enhancing the funding for S&T programmes to empower India. Industry–academia co-innovation is another key element in this context.

In section 4, 'Context Setting and Way Forward in 7 Focus Pillars', the authors do an excellent job of analysing the current realities of each of the seven pillars in India. And they suggest the path forward in each area. These are detailed further across 30 recommendations in section 5. For each recommendation, the authors highlight successful exemplars of S&T institutions and practices from India and across the world.

- Under ICT, they cover different fields such as AI, data governance, IT hardware and other emerging fields like quantum computing and cyber security. The authors discuss ideas to harness and design technology for social good and digital inclusion, which is appreciable.

- Under Sustainability, they discuss the famous UN's SDGs (Sustainable Development Goals), imperatives and solutions for India's energy and water requirements, and

aspects of circular economy. The authors urge us to strive for future energy security, keeping in mind the needs of urban and rural India. The readers will learn about how advancements in materials science and digital technologies can solve the challenges of sustainability, water, energy and net-zero emissions. I strongly recommend their emphasis on sustainability-focused research and education in higher educational institutions.

- Under bioscience and biotechnology, I like the attention given to new and emerging areas like brain research. India has to develop affordable medical products and technologies, and we are already seeing how the top engineering schools in India have begun interdisciplinary programmes in medicine and healthcare.

- Indian institutions should adopt innovative models for augmenting the quality and funding of institutional-level research. They should experiment with the 28 different ideas/models proposed under the categories of Prizes, Challenges, Grants, Knowledge Dissemination, STI Infrastructure Set-up and STI Capability and Policy Development.

- India will immensely benefit from nurturing entrepreneurship ecosystems focused on deep-tech and social innovations.

- The recommendations relating to Academia–Industry–Alumni engagement are well-grounded. While industry collaboration has been an area of interest for some time, the focus on alumni is refreshing.

- Finally, the recommendations pertaining to human enablement – education and skill development – are critical for India. Digital technologies must be embraced to scale our aspirations for higher Gross Enrolment Ratios. We need to bear in mind when it comes to the skilling and reskilling of Indian talent that they service two distinct needs – the needs of an increasingly digitalized world and the social entrepreneurship needs of the hinterlands of India.

The authors' concise summary in section 6 was particularly noteworthy. The appendix provides intriguing and interesting data on the performances of both IITs and IISc, publication trends, *h*-indexes for all IITs, and detailed scientometric information. The authors argue that if 30 recommendations in the book are taken up by S&T institutions in India, then the following dream of 2047 is possible to achieve, namely India is among the top three economies in the world. It is also in the top three nations in global research, and tech-

nologies like AI, EV and green hydrogen, and spends 3% of its GDP on R&D. It is in the top 10 in the Global Innovation Index, has achieved Gross Enrolment Ratio of over 50%, and Human Development Index of 0.9.

I strongly recommend this book to every researcher in our country. It motivates every individual involved in S&T to contribute more towards Empowering India.

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Annual Review of Entomology, 2023.

Nicole M. Gerardo, Christina M. Grozinger and Myron P. Zalucki (eds). Annual Reviews, 1875 S. Grant Street, Suite 700, San Mateo, California 94402, USA. Vol. 68. Xiv + 469 pages. Price: US\$ 122.

As always, the present volume of the *Annual Review of Entomology* contains articles of great merit and interest. It has 23 articles touching upon various fields of entomology, such as insect–plant interactions, chemical ecology, biological insect control, ecology, behaviour, plasticity, molecular mechanisms, pollinator dynamics and resistance development.

Insect–plant interaction is an area of bewildering intricacies, and some related articles highlight the various dimensions of such interactions. Related to this is the field of chemical ecology with its implications in the biological control of insects.

The use of pheromones to attract insects and reduce the population size has been a critical method in integrated pest management programmes. In the article ‘Complex and beautiful: unraveling the intricate communication systems among plants and insects’, James H. Tumlinson shares his personal experience and sheds light on the existence of chemical communication systems between plants, herbivores and natural enemies. He narrates how he and his research group identified and synthesized many chemical lures used to trap insects. When herbivores attack, the plants produce volatile compounds that help parasitoids associate themselves with herbivore hosts.

He recommends collaborating with other experts to develop new hypotheses, approaches and questions.

Stefano Colazza, Ezio Peri and Antonio Cusumano, in their article ‘Chemical ecology of floral resources in conservation biological control’, enumerate the intentional provision of flowering plants as food resources to enhance populations of natural enemies of insect pests in crop habitats. The role of floral volatiles as semiochemicals and nectar-inhabiting microbes in mediating parasitoid responses to flowering plants is explained lucidly.

Even though there is no consensus on the use of genetically modified crops throughout the world, genetically engineered corn and cotton that produce insecticidal toxins derived from the bacterium *Bacillus thuringiensis* (*Bt*) have been cultivated to manage insect pests in many parts of the world. The article ‘Management of insect pests with *Bt* crops in the United States’ by Aaron J. Gassmann and Dominic D. Reisig points out the successful suppression of pest population and increased profits for farmers in many cases and the evolution of resistance and damage to crops in some cases. They recommend using novel pyramiding of genes, coupled with adequate use of refuges and integrated pest management systems for sustainable farming.

In the article ‘The biology and ecology of parasitoid wasps of predatory arthropods’ Minghui Fei, Rieta Gols and Jeffrey A. Harvey state that many parasitoids of predators exhibit intricate physiological interrelationships with their hosts, adaptively manipulating host behaviour, biology and ecology in ways that increase parasitoid survival and fitness. Although most parasitoids exploit insect herbivores as hosts, others parasitize predating insects and arthropods.

Meta Virant-Doberlet, Natasa Stritih-Peljhan, Alenka Zunic-Kosi and Jernej Polajnar, in their article ‘Functional diversity of vibrational signalling systems in insects’ narrate how insects generate vibrational signals primarily by tremulation, drumming, stridulation and tymbalation. These are part of multimodal communication. Signalling by substrate-borne mechanical waves is the most common form of mechanosensory communication in insects.

Invasive species are a threat to natural habitats. The article ‘Biology and management of the spotted lanternfly *Lycorma delicatula* (White) (Hemiptera: Fulgoridae) in the United States’ by Julie M. Urban and Heather Leach states how this insect