The Spirit of Green: The Economics of Collisions and Contagions in a Crowded World. William D. Nordhaus. Princeton University Press, 41 William Street, Princeton, New Jersey 08540, USA. 2021. vi + 355 pages. Price: US$ 29.95/£25.00.

William D. Nordhaus is best known for his pioneering contributions to the economics of climate change. He developed the dynamic integrated climate economy (DICE) model, an efficient and optimal strategy to control emission of greenhouse gases (GHGs) through carbon taxes[1]. Nordhaus was awarded the Nobel Prize in Economics in 2018 'for integrating climate change into long-run macroeconomic analysis'[2]. Through his book *The Spirit of Green*, Nordhaus advances his vision and plan for a green planet.

Economics of climate change is a deeply divided area of study. Environmental economists, Nordhaus being one of them, typically take a neoclassical, market-centric view, keeping economic growth and efficiency at the centre, in looking at environmental questions, including climate change. On the other hand, ecological economists, environmentalists and natural scientists point to environmental limits or thresholds, and are generally skeptical about the efficacy of the market mechanism. More recently, an influential group of scholars has been advocating degrowth to bring down the increasing pressure that economic growth has put on the environment. It is no surprise then that the announcement of the Nobel Prize to Nordhaus was received with criticism from some quarters[3].

In 2006, 'The Stern Review', a voluminous report on the economic impact of climate change was released. The Review commissioned by the Government of United Kingdom called for urgent and immediate action on climate change. Nordhaus argued that the Review used a low discount rate that did not correctly reflect the prevailing market conditions[4]. A high discount rate would mean that the future is valued less compared to the present. The implication for climate policy is that this would delay climate action projects, thereby slowing down the progress towards reducing GHG emissions. Ecological economists and environmentalists point out that the approach of Nordhaus would not help fix the current mode of economic growth, which has been the primary driver of global climate change[5]. The uninitiated in the field should read this book against the backdrop of these debates.

The book has 25 chapters organized in six parts. The prose is simple, arguments clear and devoid of unnecessary jargon and technical detail. It could very well be considered a thorough, yet accessible introduction to environmental economics for non-specialists. The book, which was in the making for a decade (as pointed out in p. 1), is as up-to-date and as relevant as it can be. It arrives in the public domain less than three years after the Nobel recognition to Nordhaus, but the world now looks vastly different from what it was then with the COVID-19 pandemic posing fresh and immediate challenges to humanity. Nordhaus speaks to these emerging 'low-probability, high-consequence' tail events and discusses the ongoing pandemic in detail in the book (p. 110).

Almost a third of the book is spent on introducing and illustrating the fundamental principles of efficiency and sustainability, the concepts of growth and externalities and the technique of green national accounting. Drawing upon behavioural economics, Nordhaus acknowledges that people generally have high discount rates. This can lead to investments that are not in the interest of the environment and here he advocates regulation by the government. In making his case, Nordhaus claims to steer clear of ideological extremes and follows what he calls the Goldilocks rule – that regulation should not be too much, not too little, but just right (p. 307).

While the broad pointers are assumed to have implications elsewhere, the perspective of the book and the examples used are primarily United States-centric. Considerable attention has been given to political and policy choices, including a chapter on 'The Green New Deal' (GND). Nordhaus views GND as more of a replication of the New Deal of 1930s, emphasizing '…policies to enhance equality and fairness rather than Green policies' (p. 176). He draws upon Mancur Olson's collective action theory to argue why a minority 'moneyed interests' dominate environmental policy-making (p. 151). Garrett Hardin finds mention early on in the book (p. 12); common property resources (pp. 43–45) and collective action are discussed multiple times. However, potential solutions other than the market and (state) regulation are not explored. Most noticeable is the omission of the views of Elinor Ostrom, another economics Nobel laureate[6], who showed how commons could be managed without command-and-control regulation or privatization.

The debatable relationship between environment and development (the Kuznets Environmental Curve (KEC)), and the links between environment and democracy are discussed (pp. 155–157). A neat 'dome-shaped' KEC is presented, plotting per capita gross domestic product (GDP) on the horizontal axis and CO_2/GDP on the vertical axis, which Nordhaus agrees is not the norm for other environmental indicators. He argues that democracies are, on the whole, more pro-environment. PM2.5 concentrations are lower for democracies and countries with higher democracy scores have seen larger declines over time in air pollution. However, empirical literature on the effects of democracy on the environment is still sparse (p. 154).

Fairness, inequality and environmental justice are discussed within the framework of a market system (pp. 57–69). Nordhaus contends that thinking about 'fairness of market forces is a matter of values' (p. 61) and that green fairness cannot be separated from social fairness, with 'generational fairness' being a crucial add-on. The implications of this come out prominently when he discusses the science, economics and policies of global climate change much later in the book (pp. 267–293). Nordhaus uses the DICE model to show the different possible paths for carbon intensity – continuing the current trend would result in 4°C or more warming by 2100. He states that decarbonization should happen at the rate of 10% per year to achieve the 2°C goal, which is unrealistic given the current rate. To show that reduction in emissions has been inadequate, he uses data from China, the United States and 'world less China'. The primary argument is that commitments (and by implication, efforts) by countries have been modest. However, global climate policies must recognize the huge differences between the United States and countries like China and India in their

historical and current living standards. Climate action should be based on the normative concerns (or values) of fairness and justice as well as the principle of 'common but differentiated responsibilities' between countries.

Nordhaus sets out to provide a blueprint for a green planet by proposing a vision that goes by the title of this book (pp. 2–3). For the informed reader following Nordhaus and his work, the idea and its articulation offer little or no surprises. As a conceptual framework and an operational plan, this book rests on the principle of competitive markets but '…balanced with the philosophy required to correct market and nonmarket flaws' (p. 3), through the Goldilocks Rule of 'just enough regulation'. Ideologically, Nordhaus positions this book somewhere to the left-of-centre between the extremes of what he calls 'muck brown' or pure profit seekers on the right and 'deep green' or deep ecologists on the left (pp. 297–301). Nevertheless, Nordhaus stands committed to his unshaken faith in 'free-market environmentalism' as he states at the outset and demonstrates through the book (pp. 310–313).

One may not share the ideological positionality of Nordhaus, but this book is a compelling read, and a highly recommended up-to-date guide to the economics of the environment and climate change.

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3. Cho, A., *Science*, 2018; https://www.sciencemag.org/news/2018/10/roles-ideas-and-climate-growth-earn-duo-economics-nobel-prize (accessed on 13 July 2021).
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5. Hickel, J., *Foreign Policy*, 2018; https://foreignpolicy.com/2018/12/06/the-nobel-prize-for-climate-catastrophe/ (accessed on 13 July 2021).
6. Ostrom, E., *Econ. Theory*, 2012, **49**, 353–369; doi:10.1007/s00199-010-0558-6.

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'My career ended with the ascent of genomics and its accompanying megadata analysis. This development has been transformative and can be greatly interesting to read about, but not my thing to do. In my era, if an experiment required statistics for its analysis, you needed to find a new experiment – a saying I believe is attributed to some luminary I don't remember. One could imagine an experiment, discuss it with a graduate student, and see the result in a day or two; there might be 10 data points giving an unequivocal answer. For the student, as for me when I began, it was a largely individual endeavor, with logic, methodology, and experimental devices all plainly exposed and applied to some question of basic interest. No longer – prominent papers tend to be multigroup collaborations with tens of authors and distinct areas of expertise, often containing a plague of unmemorable acronyms. Likely no one understands everything. I was very lucky to arrive near the beginnings of molecular biology.'

This quote from the opening article 'A tale of good fortune in the era of DNA' by Jeffrey Roberts in this volume of the *Annual Review of Microbiology* (*ARM*) could readily initiate a good debate. However, rather than getting into the debate, I must say that I enjoyed reading the article by the discoverer of Rho, the transcription termination factor. Some would also know Roberts as an author of the fourth edition of the James Watson's *Molecular Biology of the Gene*. He has provided a motivating description of his life in science. Teachers/mentors have always played a special role in charting the paths of their students/mentees in research, and the article emphasizes how they influenced the Robert's interests to pursue biology during his undergraduate training at the University of Texas in Austin, USA, and then in specializing in molecular biology of the λ phage at Harvard University, USA, during his graduate studies in the research groups of Walter Gilbert and James Watson in 1964. The research that Roberts initiated on λ phage at Harvard University remained with him for his entire scientific career (including a short stint at MRC, LMB, Cambridge) to work on the mechanistic details of transcription initiation and transcription termination/anti-termination at Cornell University, USA, from 1974 onwards.

The editors of this volume of *ARM* have done a splendid job of bringing it out with a total of 39 articles (perhaps the largest so far in any of the volumes of the *ARM*). In the times of SARS-CoV-2, while all of us are confined to our homes or offices with no offline interaction, the importance of socialization and personal discussions has come to the fore. Coincidence as it may be, this volume of *ARM* provides a special collection of articles that focus on the social life of microbes. Understanding their lifestyle is, of course, key to target or promote them. Many bacteria make use of their secretion systems to release toxins or virulence factors. Mechanistic details of these secretion systems are crucial to intervene in the host–pathogen relationships, and one would find descriptions of different secretary systems in different bacteria in this volume of *ARM*. The phenomenon of communication among the individuals is complex, and as the authors of one of the articles put it, 'The tower of Babel narrative is an origin story meant to explain the puzzling diversity of human languages. This review presents our own (evidence-based) narrative meant to explain the puzzling diversity of bacterial communication systems'. Languages that the microbes use comprise diverse small molecules produced and sensed by them (dubbed as quorum sensing) in the wild or in their hosts. The articles discuss the roles of the secondary messenger signals, including cyclic dinucleotides (c-di-AMP and c-di-GMP) in decision making for unicellular growth or biofilm formation, in exopolysaccharide synthesis or in the stimulation of host immune response by interaction with STING (stimulator of interferon genes). To respond to the chemical gradients, bacteria make use of flagellum and appropriately an article is devoted on its assembly and dynamics. The natural world of microbes provides an excellent system of chemical ecology.

Chemical communications are also responsible for the relationship of plants with the microbes in their habitat, and in the plants influencing and enriching distinct microbiota in their habitat. Fungi emit volatile organic compounds, which we know mostly as obnoxious odours, but some are important as flavouring agents and yet others serve as developmental hormones for fungal species or are even important as pheromones for arthropods. Likewise, chemical