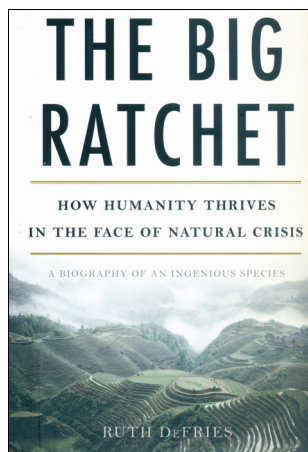


have detected this modulation, but there are some doubts whether or not they are spurious signals. Yet another idea is to look for high-energy photons from astrophysical objects or regions (such as the centre of the Milky Way), which may result from interactions of dark matter particles with themselves or decaying dark matter.

Freese's account is partly at the level of popular science books, and partly a memoir. Her style of writing is engaging, and the anecdotes of conferences and meetings in which new ideas regarding dark matter have come up, make the narrative very readable. Barring a few typos (for example, HESS telescope is mistakenly noted as being located in Europe), this is an interesting addition to the list of books that tells the story of modern physics from the point of view of an active practitioner.

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**The Big Ratchet: How Humanity Thrives in the Face of Natural Crisis. A Biography of an Ingenious Species.** Ruth DeFries. Basic Books, 250 West 57th Street, 15th Floor, New York. 2014. 273 pp. Price: US\$ 27.99.

The book under review by Ruth DeFries brings together fascinating dimensions of the human species and its ingenious interaction with nature's endowments in ways vastly different from those of other mammals, including the primates in exis-

tence today. Ruth describes the planetary beginnings about 5 billion years ago, and the fortuitous location of the Earth in the habitable zone of the solar system. Not just that. By pathways and processes as yet not fully understood, the Earth also acquired carbon, nitrogen, water and possibly phosphorus. High temperatures and energy provided by the Sun to the primeval Earth produced the primordial soup. It contained the ingredients of the incipient organic molecules that over a period of time developed self-replicating single-cell organisms. This was about 3.5 billion years ago. DeFries refers to it as the first pivot.

At this juncture of the review, a brief introduction to the three words, viz. 'ratchet', 'hatchet' and 'pivot' used extensively in the book would be useful. The *Oxford Dictionary* meaning of 'ratchet' is a wheel with a rim so toothed as to move in one direction only. The author perceives the turn of the ratchet to signify a 'rise' or 'success' of humanity. Availability of plenty of food leads to expansion/multiplication of numbers of the species until food deficit sets in. Food famines and degradation of the environment constitute the 'hatchet'. So, with a hatchet falling, the species once again faces the threat of a collapse unless a new 'pivot' (a new way to use or exploit nature's endowment) emerges. The book is a thought-provoking narrative of the cycles of ratchet-hatchet-pivot of the human (*Homo*) species, a descendant of an African tree-climbing ancestor several millions of years ago. The modern human species, *Homo sapiens* (sapiens = wise) is known to have existed in basic raw form about 500,000 years ago. The author describes that a few precursor *Homo* species, with distinguishing characteristic of large brains in proportion to their body weight, viz. *H. habilis*, *H. erectus*, *H. heidelbergensis*, *H. floresiensis* became extinct between 1.5 million and 17,000 years ago.

An interesting distinction between the human species and all the other mammals, including the primates that exist today, is the complexity of civilization subordinating the role of Darwinian natural selection. The author refers to Darwin's famous 1874 treatise, *The Descent of Man* and cites the statement, 'With highly civilized nations, continued progress depends in a subordinate degree on natural selection'. Several others (Theodosius Dabzhansky, Ashley Montagu)

who followed Darwin picked up the question of how human culture evolves, and tried to answer the puzzle of how genes and cultures intertwine and co-evolve. One view is that culture would never have evolved unless it could do things that genes could not. These considerations enable a working hypothesis that the human species uses its 'ingenuity' rather than its genes to develop a 'pivot'. The 'pivot' is essentially the outcome of Darwinian selection for all living beings, except the human species. Culture and ingenuity invent the 'pivots'. This basic difference between the human and all other species is possibly the underlying cause of the human dominance over all other forms of life and in fact, the planet itself. A significant pivot resulted about 10,000 years ago, when *H. sapiens* made a transition from foraging to farming. It had ratcheted up the human species, and everything associated with it.

Farming provided assured food security and leisure. It led to creative thinking, culture, arts and science, music, philosophy, religion, etc. Several civilizations rose (ratchet) and fell (hatchet) largely due to environmental degradation and socio-political conflicts. During the past several millennia, the human civilizations were spatially and temporally separated. There was no globalization that promotes uniformity (a kind of monoculture) than unity in diversity. Globalization reduces the diversity which is essential for adaptation and resilience.

The last three millennia of history of *H. sapiens* has been replete with several cycles of ratchets, hatchets and pivots. The invention of steam engine in 1780 by James Watt ushered in an era of Industrial Revolution. Advances in physics, particularly nuclear physics and chemistry in the 19th century greatly impacted the human civilizations and the environment. These provided uncommon opportunities to 'twist' nature in order to develop 'pivots' to ratchet up the human species in association with cultural ethos. However, it is not uncommon that a pivot of today becomes a hatchet of tomorrow. The author does not allude to this fact explicitly, but references in the book to the Haber-Bosch process to chemically fix the atmospheric nitrogen as ammonia and the indiscriminate use of dichloro-diphenyl-trichloroethane (DDT) and other chemical pesticides are suggestive

of their detrimental effects (hatchet). The nitrogen cycle in nature is kept in balance by the opposing activities of the nitrogen-fixing bacteria and denitrifying bacteria. The former fixes the atmospheric nitrogen as nitrates, whereas the latter reconverts the nitrates into nitrogen. Without a chemical process to reconvert nitrates into nitrogen, the planetary boundary with regard to the nitrogen cycle has already been exceeded. Of course, the author cites the paper by Johan Rockstrom *et al.* (*Nature*, 2009, **461**, 472–475), but does not treat it as the fall of a hatchet that no pivot in the future can undo. The long-term detrimental effects of DDT and other chemical pesticides on the health and environment of non-target organisms were brought out by Rachel Carson in her book *Silent Spring* (Houghton Mifflin, Boston, 1962). She was criticized for her anti-pesticide and pro-nature views. Urban vis-à-vis indigenous cultures and vested interests mould the viewpoints and actions of the human species. The book *Limits to Growth* (Meadows Donella *et al.*, Chelsea Green Publishing Company, 1972) describes how the humanity is slurping up the natural resources and how that it would finally put an end to development. Gro Harlem Brundtland in her 1987 report, 'Our common future' (Oxford University Press, Oxford, 1987, p. 383) was concerned about an ever-expanding inter-generational inequity to access resources for the successive generations to meet their own developmental needs. Rockstrom has shown how the anthropogenic ingenuity has resulted in exceeding the planetary boundaries with regard to nitrogen cycle, biodiversity loss, climate change, etc. Paul Curtzen (*Nature*, 2002, **415**, 23) coined the term 'Anthropocene' to the present in many ways human-dominated geological epoch, supplementing phase of the 'Holocene', the inter-glacial warm period of the past 10–12 millennia. DeFries cites Julian Simon's *The Ultimate Resource* (Princeton University Press, New Jersey, 1981, p. 734), which states that human ingenuity not only stretches natural resources, but can make them infinite. The balancing of opposing views does not help deduce the future of life on a planet at the cross-roads.

Several events which took place in the middle of the 20th century have rightly deserved much attention. The Second World War, the Bengal famine, and the

cold war era were clearly the hatchets at the global level. The Borlaug–Swaminathan Green Revolution of the 1960s emerged as a powerful pivot to ratchet up the food security of the developing countries in general, and India, in particular. It is noted that Paul Ehrlich in his 1968 bestselling book, *The Population Bomb* had stated that 'the battle to feed humanity was already lost and India would never be self-sufficient in food'. The Paddock brothers, American economists, had also written-off India. Yet, the big ratchet, the Green Revolution in the 1960s changed the image of India then as a 'begging bowl' to a 'bread basket'. DeFries elegantly describes the environmental and socio-economic problems associated with the Green Revolution. Yet, she brings up for discussion some perceived differences in views between Swaminathan and Borlaug on the Green Revolution. Achieving dramatic increase in the productivity in a short period and building food security at the national level was indeed a major 'pivot'. But that came at an environmental and social cost. First of all, it did not eliminate food insecurity and hunger at the individual household level of millions of people. The paradox, 'mountains of grains on one hand, and millions of hungry people on the other' explained the social outcome of the Green Revolution. As Swaminathan had cautioned as early as January 1968, the Green Revolution gradually degenerated into a 'Greed Revolution'. What are seen today are the pockmarks of hundreds of thousands of tubewells for irrigation, high levels of residue of chemical fertilizers, depletion of agro-biodiversity, and sharp increase in the incidence of cancer among members of the farming families in Punjab, etc. The fatigue in the yield gains had set in by the late 1980s. Borlaug either did not notice these negative effects (hatchet), or else ignored them. Swaminathan, on the other hand, chose to eliminate the 'hatchet' that was attached to the pivot, and hence developed the concept of an 'Evergreen Revolution', which he defined as 'achieving productivity in perpetuity without causing ecological and social harm'. The sentence in the book, 'whether the future veers toward Swaminathan's or Borlaug's view, one message is clear; the Green Revolution was yet another experiment in feeding humanity', does not take into account the fact that Swaminathan had noted that

the Green Revolution was necessary only to get a 'breathing space', and that it would not be suitable for sustainable agriculture and rural development. Surely, DeFries could have noted that for a sustainable food security in the future, the Green Revolution is more of a 'hatchet' than a 'pivot', while the Evergreen Revolution is a more refined 'pivot'. She does not cite E. O. Wilson, a Harvard biologist, who, in his epoch-making book, *The Future of Life* (Vintage Books, London, 2002) observes that Swaminathan's Evergreen Revolution is the best option available to feed the burgeoning human population and save the rest of life as well, since it is pivoted on a systems approach.

*The Big Ratchet* concludes that 'there will surely be more ratchets and pivots in the never-ending cycle of our species' manipulations of the planet's endowments'. This view is rather contentious in the light of unprecedented environmental degradation (including 'peak oil point', exceeding the planetary boundaries with regard to nitrogen cycle and biodiversity loss, diminution of nature's endowments limiting economic growth, etc.) and growing social inequalities and violence in the hearts of people as well as persistent hunger and malnourishment in the world. Further, the human population growth beyond the Earth's carrying capacity and unsustainable lifestyle are also hatchets. Most important of all is the climate change. The global warming is rapidly approaching the 'tipping point', which would take the planet into a different and altogether unknown stable equilibrium which could be hostile to the welfare and survival of living organisms, particularly the human species. Finally, no cycle goes on forever; surely there is a break-point. Addicted to technology-driven economic growth, *H. sapiens* is rapidly evolving/degenerating into *H. destructus*. The economic compulsions mask the ecological truth. The book opens up a debate whether the human species now is unknowingly developing more powerful 'hatchets' than pivots. Given the same information contained in the book, entirely different interpretations and hence conclusions appear feasible.

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