

Books & arts

researchers and practitioners, the book charts a slow, steady, complex progress, with many lows and some incredible highs.

We meet people such as Rich Caruana, now senior principal researcher at Microsoft in Redmond, Washington, who was asked as a graduate student to glance at something that led to his life's work – optimizing data clustering and compression to make models that are both intelligible and accurate. And we walk along the beach with Marc Bellemare, who pioneered reinforcement learning while working with games for the Atari console and is now at Google Research in Montreal, Canada.

Christian shows researchers' growing realization that AI developments are affected by societal values – and, more importantly, affect them. They come with a cost and can have profound impacts on communities. At its core, *The Alignment Problem* asks how we can ensure that AI systems capture our norms and values, understand what we mean and do what we want. We all have different conceptions of and requirements for what such systems should do. As mathematician Norbert Wiener put it in 1960: "We had better be quite sure that the purpose put into the machine is the purpose which we really desire."

Crawford's collection exposes the dark side of AI success. It traverses the globe exploring the relationships between places and their impact on AI infrastructure. From Nevada and Indonesia, where the lithium and tin central to semiconductors are mined at great human and environmental cost, we travel to an Amazon warehouse in New Jersey. Here, labourers bend their bodies to the will of robots and production lines, instead of the automation adapting to human tempo. In an uneasy reminder of Charlie Chaplin's 1936 film *Modern Times*, we witness the hardship of "fauxtimation" – supposedly automated systems that rely heavily on human labour, such as that of workers paid below minimum wage in data-labelling farms.

Crawford concludes with the arresting reminder that AI is not objective, neutral or universal. Instead, it is deeply embedded in the culture and economic reality of those who make it – mostly, the white, wealthy men of California's Silicon Valley.

Both books are strong in their exposition of the challenges and dangers of current use and development of AI, and what sets it apart from 'classic' computing. Reading them side by side highlights three core issues: over-reliance on data-driven, stochastic predictions; automated decisions; and concentration of power.

Data dominance

As AI researcher Joy Buolamwini comments in the 2020 documentary *Coded Bias*, algorithmic decision-making is undoing decades of progress towards equal rights, reifying the very prejudices it reveals to be still deeply

rooted. Why? Because using data to inform automated decisions often ignores the contexts, emotions and relationships that are core to human choices.

Data are not raw materials. They are always about the past, and they reflect the beliefs, practices and biases of those who create and collect them. Yet current application of automated decision-making is informed more by efficiency and economic benefits than by its effects on people.

Worse, most approaches to AI empower those who have the data and the computational capability to process and manage them. Increasingly, these are big tech corporations – private entities outside democratic processes and participatory control. Governments and individuals are the users, not the leaders. The consequences of this shift are enormous and have the potential to alter society.

So, what now? Besides efforts to debias the data and explain decisions algorithms make,

we need to address the source of the bias. This will be done not through technological fixes, but by education and social change. At the same time, research is needed to address the field's perverse dependence on correlations in data. Current AI identifies patterns, not meaning.

Meticulously researched and superbly written, these books ultimately hold up a mirror. They show that the responsible – ethical, legal and beneficial – development and use of AI is not about technology. It is about us: how we want our world to be; how we prioritize human rights and ethical principles; who comprises this 'we'. This discussion can wait no longer. But the key question is: how can all have a voice?

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A physicist goes in search of our origins

CERN experimentalist offers sweeping history of the Universe, in science and culture. **By Andrea Taroni**

Physicist Guido Tonelli has spent decades constructing intricate instruments to probe the mysteries of matter. As part of one of the two main experiments at the Large Hadron Collider near Geneva, Switzerland, he vaulted to international attention in front of a packed auditorium in July 2012, when the group announced the discovery of the Higgs boson – the long-sought elementary particle that imparts mass to all others.

Now, Tonelli has turned his gaze from the very small to the very large – the history of the Universe. His ambition encompasses scientific insights, art, philosophy and religion. *Genesis* is not just a book about the cosmos as measured by giant telescopes and particle accelerators. It is also a story of humanity's interpretations of the beginning and evolution of creation.

Many other physicists, from Stephen Hawking to Janna Levin, have explored this space in popular writing. Most cater to an Anglophone audience. Tonelli's contribution – a bestseller in his native Italy – has a different flavour. It combines the humanistic approach that underpins much Italian education with scientific facts gleaned from a career

as a nuts-and-bolts experimentalist.

Tonelli argues that the search for the origins of the cosmos arises from humans' need to be rooted. His biblical title nods to the idea that current scientific understanding is part of a much wider cultural history. And the picture of creation built up by twenty-first-century science is as astonishing and mysterious as any ancient myth.

His starting point is Hesiod's *Theogony*, a poem from around 700 BC on the birth of

"Stories allow us to make sense of the void from which all things began."

the Greek gods. In the beginning, there was chaos. Tonelli uses 'chaos' in its original sense – a chasm or void so enormous that it could swallow and contain everything – rather than with its more modern connotation of disorder. Just as silence can be understood as a superposition of opposite-phase sound waves that cancel one another out, the void can host unlimited quantities of matter and antimatter, yet have a net energy of zero. The



Part of the Large Hadron Collider, where author Guido Tonelli worked on the Higgs boson, foundational to the structure of the Universe.

Universe was born 13.8 billion years ago from a random quantum fluctuation in this void.

A sweeping description ensues. First came the unfathomably quick inflation through which the Universe ballooned in size. Next came cooling, in which hierarchies of forces, symmetries, particles, black holes, stars and galaxies emerged. Each chapter represents a 'day' in Tonelli's genesis, capturing an important phase as the Universe acquired structure. Here lie phenomena such as baryogenesis (the mysterious process that led to the asymmetry between matter and antimatter); the primordial soup of quarks and gluons from which the building blocks of atoms were born; and the uncoupling of matter from radiation.

Matter and mythology

Tonelli references all manner of mythology and literary sources. He is also scrupulous in explaining how scientists arrived at their conclusions. The chapter on the Big Bang describes the work of researchers including Albert Einstein, Georges Lemaître and Henrietta Swan Leavitt, and refers to the Hindu deity Shiva, the Buddhist doctrine of emptiness, or *Śūnyatā*, and Jorge Luis Borges's 1945 short story 'The Aleph'. Although fascinating, the conceptual

leaps between scientific detail and cultural references are demanding to follow.

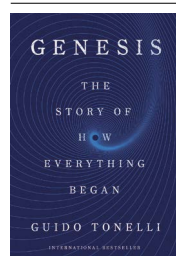
The book's most vivid passages are its more scientific ones. The description of the Higgs boson, and its foundational importance in the development of the structure of the Universe and our understanding of it, is clearly home turf for Tonelli. He makes deep and lucid connections with concepts such as spontaneous symmetry breaking, the process through which a physical system enters its lowest-energy state by seemingly disregarding all the other possible states with the same symmetry. And the chapters examining the formation and structure of stars and galaxies are spellbinding – it would be a joy to listen to these while gazing at a starry sky.

Yet Tonelli leaves a gap between the very

small and the very large. Considering that so much of his story pertains to the transformation of matter across phases, it is striking that he makes no explicit connection with branches of physics developed to understand these phenomena, such as the theory of phase transitions that explains the structural rearrangement when water becomes ice. This omission exposes a cultural gap in physics. But some pioneering physicists, such as Robert Brout, Murray Gell-Mann and Ken Wilson, have managed to connect high-energy particle physics with its 'low-energy' condensed-matter cousin. Tonelli misses a trick here.

Ultimately, however, his goal is to bridge a much wider gap – the one between science and the humanities. For Tonelli, everything in the evolution of the Universe, culture and the human condition follows from the need to understand our origins. Stories allow us to make sense of the void from which all things began. It is fitting that his own story is complex, mysterious and, at times, even messy – a bit like the Universe itself.

Andrea Taroni is chief editor of *Nature Physics*. He is based in London.



Genesis: The Story of How Everything Began

Guido Tonelli (transl. Erica Segre & Simon Carnell)
Profile (2021)