

▶ valuations of the percentage of GDP accounted for by the 'domestic' economy — unpaid caring, cooking and cleaning in the home — range from 26% (estimated by the US Bureau of Economic Analysis) to 50%. Yet GDP largely ignores this form of labour, along with women's central role in it.

That omission has not been lost on a number of organizations. The International Association for Feminist Economics, the Caring Economy Campaign and the Institute for Women's Policy Research, for instance, are working to end inequality and misogyny in economics. It is also true that male authors in this field (myself included) haven't covered this in the detail it deserves. In October, more than 1,000 economists signed a petition urging the American Economic Association to tackle misogyny. There are issues of methodology to resolve, but the principle of including household labour in the nation's books is unanswerable.

Comparatively more work has been done in valuing the cost of environmental degradation as a loss of 'natural capital'. In 2011, monetary values of natural capital and ecosystem services were conservatively estimated to be at least equal to GDP and possibly worth twice as much (see go.nature.com/2h0aro6 and R. Costanza *et al.* *Glob. Environ. Change* **26**, 152–158; 2014). Yet this does not get a mention in *Capitalism Without Capital*. Biodiversity and ecosystem processes still languish outside GDP's remit, although as much as a decade ago, researchers Niu Wenyuan and Wang Jinnan came close to persuading China's leadership to create a green GDP.

When it comes to valuing research and development, Haskel and Westlake make a sobering observation. Now that science is an investment, its funders will expect it to behave as such. That means that there will be extra strain on the principle by which politicians don't interfere in the setting of academic research priorities — known in Britain as the Haldane principle, after First World War minister and troubleshooter Richard Burdon Haldane. The era of scientists being left to run their own show may be drawing to a close if science is expected to make economic returns. You have been warned. ■

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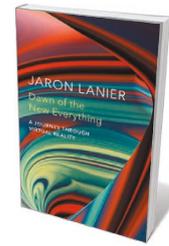
COMPUTER SCIENCE

Visionary of virtual reality

Aldo Faisal explores the immersive journey of technology pioneer Jaron Lanier.

Virtual reality (VR) and its child, augmented reality, have long exerted a pull on the collective imagination. The ability to 'paint' 3D, interactive, computer-generated worlds believably is hugely reliant on the technology's capability to embody a user's perception. Actions such as turning the head or standing up in the virtual world must precisely mimic the visual and auditory changes experienced in the real world. Now, VR pioneer Jaron Lanier recounts his part in the evolution of this extraordinary technology in *Dawn of the New Everything*.

Although concrete ideas about VR from the likes of computer artists Ivan Sutherland and Myron Krueger have been around since the 1960s, the technology began to take off only around two decades later. In 1984, Lanier and Thomas Zimmerman were researchers at computer-game company Atari when it shut its labs. The two set up VPL Research in a corner of Lanier's house in California's San Francisco Bay Area, creating an idea pool that invented the



Dawn of the New Everything: A Journey Through Virtual Reality
JARON LANIER
Bodley Head: 2017.

technologies forming much of today's conceptual toolkit. These included the EyePhone — a VR headset that strapped coarse-resolution LCD display video monitors to the user's head — along with the DataGlove and DataSuit, wearable sensor systems that track limb movements and enable 'manual' interaction in VR.

Lanier is also credited for the term virtual reality, later popularized by the influential 1992 technothriller film *The Lawnmower Man*. In it, a Lanier-like researcher played by Pierce Brosnan saves the day in 'cyberspace' (a coinage of science-fiction writer William Gibson), or networked VR. Lanier beautifully describes his fascination with VR as the technology that "highlights the existence of your subjective experience. It proves you are real."

Yet by the 1990s, that first wave of VR was already fizzling out. Targeted users failed to take to a technology that was costly, heavy and offered poor visual immersion. Computers needed to speed up considerably to allow head movements to be rendered fast enough in the 3D virtual world (a human-computer loop that took longer than a few dozen milliseconds was notorious for causing VR 'seasickness'). By the 2010s, well-funded start-up companies including Oculus of Menlo Park, California, had developed faster graphics, lower-cost motion tracking and flat-panel displays that enabled a VR renaissance. That has been largely facilitated by the capabilities of current smartphone platforms, which act as lightweight, low-power, high-resolution screens.

Now, VR applications span science and society, from clinical rehabilitation treatments that enable people missing a limb to 'feel' it, to immersive journalism that can transport readers to a refugee camp (see go.nature.com/2yobrnc).



An early datasuit from Jaron Lanier's virtual-reality lab in 1989.



Lanier in 1990 wearing a glove containing fibre-optic sensors that converted movements into a computer-generated virtual environment.

PETER MENZEL/SPL

Silicon Valley's 'big four' technology companies have invested in VR: Facebook, for instance, bought Oculus; Google has made a no-cost VR solution available to the hundreds of millions of people who own its Android phones. We are also seeing buy-in from creative and media professionals who now have the software tools and ability to craft innovative VR contents for storytelling purposes. Three decades after Lanier and his team seeded the first commercial VR technology, the medium is seen as key to future interactive storytelling on a mass-market scale.

Very few of these recent developments appear in *Dawn of the New Everything*, making it seem curiously anachronistic. But this is not its purpose. Lanier has written a very personal scientific autobiography focusing on an era long before many current consumers of VR were born, interspersed with chapters on VR history. He emerges as an exceptional and engaging character with many unusual dualities. Born in New

York City to refugees from Central Europe, he grew up in New Mexico but attended a private school across the border in Mexico. Leaving school early, he took advanced mathematics courses at New Mexico State University in Las Cruces. His tale takes us from the tragic early death of his mother to childhood years spent living in tents with his father. We learn how Lanier's personal history shaped VR history, and vice versa, as we travel with him from his youth to his start-up days through to his evolution into a computer philosopher on the *TIME* 100 list of the world's most influential people.

The diversity of the topics with which Lanier engages reveals his intellectual breadth and depth. He is a composer, VR artist, entrepreneur and non-fiction author, as well as the first technologist to win the influential Peace Prize of the German Book Trade. Lanier's previous books, such as *You Are Not a Gadget* (Knopf, 2010), revealed a thoughtful, critical view of social digital technologies that warns against "cybernetic totalism" and a "digital Maoism". *Dawn of the New Everything*, by contrast, emphasizes VR as a technology for good.

What struck me most was the originality of Lanier's trajectory as a research pioneer. His technological trailblazing and vision have led to him sitting on the faculties and boards of big universities. But the book shows that a conventional academic career might have hindered him considerably. As he reveals with tales of his development of VR programming languages and the VPL experience, he carved out the freedom to follow his scientific curiosity, unlike many a postdoc or tenure-track faculty member. That is a useful insight at a time when technology research is thriving outside academia, as Google's DeepMind and other technology companies lead the way in quantum computing, artificial intelligence, autonomous vehicles and, of course, VR. ■

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