not given much analysis here. Yet Saini does show that our current moment is part of a broader and longer span of social experience. She posits that the racial categories that many perceive as immutable could be transformed, as they have been in the past. These categories shift and align with the social 'needs' of the moment and have ranged, for example, from Celtic, to Hispanic, to the current US census categorization of people from the Middle East as white.

That mutability might make racial categories seem random and purposeless. However, they have long served as the scaffolding for the creation and maintenance of empires.

I wondered whom Saini imagines her primary audience to be. She uses the royal 'we', perhaps as a way of creating community with readers, whom I sense she sees as scientifically literate white people. This is perhaps due to the lack of diversity in science and science writing. At the same time, she reminds us that she is a Briton of Indian origin, and so would be a subject in race-based inquiries. In her discussion of *Mankind Quarterly*, she earnestly uses the term "political correctness" — which has been levelled disparagingly at those calling for more inclusive dialogue. And in a reflection on the Human Genome Diversity Project, which aimed to collect DNA from Indigenous communities around the world, she references the 1990s as the dawn of "identity politics" — a term often used to denigrate the perspectives of minoritized individuals. She does not question these tropes.

In this way, Saini seems surprisingly willing to couch her critical analysis of race science in language often used by those more interested in silencing such critiques. A generous reading of her approach might be that it is a subversive attempt to appeal to sceptical readers. However, I am unsure that that is her intent.

It is less clear what Saini makes of contemporary practitioners of race science. For her, it seems, there is a difference between past scientists who used financing from the Pioneer Fund to support eugenics research, and current researchers, those "race realists", who continue to search for a biological component of race. She does explore the shortcomings of current research and openly questions why people persist with this field of fruitless inquiry.

This tension between the deadly legacy of historical race science and the ethically troubling reification of racial frameworks in current research emerges in a lengthy interview with David Reich, a geneticist at Harvard University in Cambridge, Massachusetts, known for his work on ancient DNA and human evolution. Reich tells her: "There are real ancestry differences across populations that correlate to the social constructions we have." He adds: "We have to deal with that." But, as Saini notes, when racism is embedded in society's core structures, such research is born of the same social relations.

COLLECTIVE DENIAL

In my view, too many scholarly voices provide this kind of cover for their peers. This unwillingness to reckon with the possibility that racism actually underpins research that has been proved to have demonstrably deleterious outcomes left me longing for a stronger take-away message.

Ultimately, *Superior* is most impactful in describing the persistence of support for ideas of hierarchal differences from the Enlightenment onwards, in the face of political backlash and researchers' inability to even define the primary variable at play: race. Saini rightly calls out the denial that runs through so much of our public dialogue. She reveals how shame about an unreconciled past affects our ability to engage in tough conversations about its long shadows.

Superior is perhaps best understood as continuing in a tradition of groundbreaking work that contextualizes the deep and problematic history of race science. These include the 2011 *Fatal Invention* by Dorothy Roberts and *The Social Life of DNA* (2016) by Alondra Nelson (see F. L. C. Jackson *Nature* **529**, 279–280; 2016). Saini contributes to this conversation by linking the desire to make race real, particularly with regards to measurable health disparities, to society's underlying desire to let itself off the hook for these very inequalities.

She closes by arguing that researchers must at least know what it is they are measuring when they use race as a proxy. I would add that they should have to contend with what it isn't — and what they have created instead. ■

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EARTH SYSTEM SCIENCE

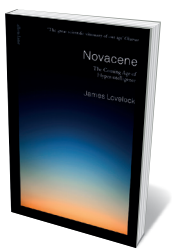
Lovelock at 100: the Gaia saga

Tim Radford reassesses the scientist's groundbreaking body of writing.

James Lovelock will always be associated with one big idea: Gaia. *The Oxford English Dictionary* defines this as "the global ecosystem, understood to function in the manner of a vast self-regulating organism, in the context of which all living things collectively define and maintain the conditions conducive for life on earth". It cites the independent scientist as the first to use the term (ancient Greek for Earth) in this way, in 1972.

On 26 July, Lovelock will be 100; his long career has sparkled with ideas. His first solo letter to *Nature* — on a new formula for the wax pencils used to mark Petri dishes — was published in 1945. But, unusually for a scientist, books are his medium of choice. He has written or co-authored around a dozen; the latest, *Novacene*, is published this month.

As that book's preface notes, Lovelock's nomination to the Royal Society in 1974 listed his work on "respiratory infections, air sterilisation, blood-clotting, the freezing of living cells, artificial insemination, gas chromatography and so on". The "and so on" briefly referred to climate science, and to the possibility of extraterrestrial life. The story of Gaia began with a question posed by NASA scientists while Lovelock was a consultant at the Jet Propulsion Laboratory in Pasadena, California. That is, how could you tell if a planet such as Mars harboured life?



Novacene: The Coming Age of Hyperintelligence
JAMES LOVELOCK
Allen Lane (2019)

With microbiologist Lynn Margulis, Lovelock published a series of papers on the subject. In 1974, they developed a view of Earth's atmosphere as "a component part of the biosphere rather than as a mere environment for life" (J. E. Lovelock and L. Margulis *Tellus* **26**, 2–10; 1974). Earth's atmosphere contains oxygen and methane — reactive gases, constantly renewed. That disequilibrium radiates an infrared signal, which Lovelock later described as an "unceasing song of life" that is "audible to anyone with a receiver, even from outside the Solar System". Thus, the answer to NASA's question was already written in the static Martian atmosphere, composed almost entirely of non-reactive carbon dioxide.

That was the beginning of a sustained

and developing argument, in the face of sometimes dismissive criticism, that recast Earth as, in effect, a superorganism. Lovelock's Gaia theory states that, for much of the past 3.8 billion years, a holistic feedback system has played out in the biosphere, with life forms regulating temperature and proportions of gases in the atmosphere to life's advantage. Earth system science is now firmly established as a valuable intellectual framework for understanding the only planet known to harbour life, and increasingly vulnerable to the unthinking actions of one species. Colleagues and co-authors acknowledge that the argument continues, but endorse the importance of Lovelock and Margulis.

ENTWINED EVOLUTION

"The insight that the oceans and the atmosphere are thoroughly entwined with the living biosphere, and must be understood as a coupled system, has been completely vindicated," says marine and atmospheric scientist Andrew Watson of the University of Exeter, UK. Lee Kump goes further. "Lovelock also showed us that Darwin had it only half right," says Kump, a geoscientist at Pennsylvania State University in University Park. "Life evolves in response to environmental change, but the environment also evolves in response to biological change." Despite severing formal links with universities decades ago, Lovelock has been showered with honorary degrees and awards from bodies as varied as NASA and the Geological Society of London.

The procession of engaging books began in 1979 with *Gaia: A New Look at Life on Earth*. Each volume made its case more forcefully than the last, exploring what was known first as the Gaia hypothesis, then simply as Gaia, and the hazards facing either the biosphere or humanity. The books include his endearing autobiography *Homage to Gaia* (2000), increasingly urgent warnings of climate devastation in *The Revenge of Gaia* (2006) and *The Vanishing Face of Gaia* (2009), and the less apocalyptic *A Rough Ride to the Future* (2014).

Novacene picks up from that note of hope, and showcases another big idea. Gaia might, after all, be saved — by the singularity. This artificial-intelligence takeover, which so alarms many doomsayers, will be our redemption. Lovelock argues that increasingly self-engineering cyborgs with massive intellectual prowess and a telepathically shared consciousness will recognize that they, like organisms, are prey to climate change. They will understand that the planetary thermostat, the control system, is Gaia herself; and, in tandem with her, they will save the sum of remaining living tissue and themselves. The planet will enter the Novacene epoch: Lovelock's coinage for the successor to the informally named Anthropocene.

> ***"Lovelock argues that increasingly self-engineering cyborgs will save the sum of remaining living tissue."***

Lovelock welcomes this. "Whatever harm we have done to the Earth, we have, just in time, redeemed ourselves by acting simultaneously as parents and midwives to the cyborgs," he writes. He takes the long view on this rescue, however. Climate change is a real threat to humanity, but Earth will inevitably be overtaken by a 'big heat' in a few billion years, as the Sun slowly waxes more fierce.

Although co-authored with journalist Bryan Appleyard, *Novacene* reads like undiluted Lovelock. From the start of his writing life — no matter how tortuous the narrative or complex the argument — Lovelock has written persuasively. In his debut, *Gaia*, he sidestepped evolution's first and biggest obstacle (how to get from organic chemistry to a living, devouring, excreting, replicating organism) in two sentences that seem to me models of clarity and brevity: "Life was thus an almost utterly improbable event with almost infinite opportunities of happening. So it did."

In *The Ages of Gaia* (1988), a richer and more closely argued restatement, he answered the vexed question of how life contradicts the second law of thermodynamics. Life, he wrote, "has evolved with the Earth as a highly coupled system so as to favour survival. It is like a skilled accountant, never evading the payment of the required tax but also never missing a loophole." This metaphoric brilliance is no rarity. A few pages on, he reminds us that Gaia is "a quarter as old as time itself. She is so old that her birth was in the region of time where ignorance is an ocean and the territory of knowledge is limited to small islands, whose possession gives a spurious sense of certainty."

Lovelock's Gaia theory is only one aspect of his nonconformism. His vigorous support for nuclear power annoys many environmentalists. Brought up as a Quaker, he registered as a conscientious objector in 1940, then changed his mind and prepared for military action in 1944 (the National Institute for Medical Research in London considered him more useful in the lab). Later, he became a consultant for the security services of Britain's defence ministry. Among his inventions is an electron capture detector sensitive enough to identify vanishingly small traces of pollutants — such as the pesticides that spurred Rachel Carson to write the 1962 book *Silent Spring* — and chlorofluorocarbons, later implicated in damage to the ozone layer. In *Novacene*, he writes teasingly that he now sees himself as an engineer who values intuition above reason.

Lovelock to the last, he even has a kind word for the Anthropocene, marked by degradation of natural resources and the devastation of the wild things with which humanity evolved. He gives a "shout of joy, joy at the colossal expansion of our knowledge of the world and the cosmos", and exults that the digital revolution ultimately "empowers evolution". Is he right? Some of us might live to find out. In the meantime, if you want a sense of hyperintelligence in bipedal form, *Novacene* is a good place to start. ■

TIM CUFF/ALAMY

James Lovelock proposes that Earth will be saved by artificial intelligence.

Tim Radford *was science editor of* The Guardian *until 2005. As a science journalist, he met and got to know James Lovelock. His latest book is* The Consolations of Physics. *e-mail: radford.tim@gmail.com*