Our cyborg progeny

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Reviewing: *Novacene: The Coming Age of Hyperintelligence*, by James Lovelock publisher Allen Lane, 160 pp., July 2020, ISBN 978 0 14 199079 8

When, as a teenager, I first heard about the Gaia hypothesis, all I knew was that it was somehow connected to the Whole Earth Catalogue, a thick edition of which haunted the piles of magazines and books lying around our living room, easily picked out by the image on its cover of Earth as seen from space – swirling cloud formations marbling the blues and greens of our tiny planet. Later, I came to know Gaia as the somewhat brilliant, somewhat bonkers idea that Earth can be understood as a living organism – a complex, self-regulating system which acts to ensure its own survival. This idea has new resonance in a time of climate crisis, and in Novacene, James Lovelock, the man who proposed the Gaia hypothesis (and who turned a hundred in 2019), has set down some thoughts about the possible future of life on this rapidly warming planet.

Lovelock, a prolific inventor and independent scientist who has done most of his work in a barn in Dorset converted into a laboratory, began to formulate the Gaia hypothesis when he was working with Nasa in the 1970s. Trained as a chemist, he had worked for the National Institute for Medical Research on everything from cryobiology to the transmission of the common cold, and had earned a reputation for his engineering skills, specifically the design of instruments capable of detecting tiny amounts of chemical substances, such as pesticides, in larger chemical mixtures, such as the atmosphere. In 1957, he invented the electron capture detector, an exquisitely sensitive device able to detect the presence of trace amounts of certain components – in particular, man-made chemical pollutants – in an air sample. In the early 1970s he used the device to show that manmade chlorofluorocarbons, or CFCs, were present in the atmosphere over Antarctica. It was discovered soon afterwards that CFCs react with ozone in the stratosphere, and that this process was creating a ‘hole’ in the ozone layer, which ordinarily protects life on Earth from ultraviolet radiation. International action to reduce CFC emissions followed a few years later, and stratospheric ozone levels have begun gradually to recover. Lovelock’s experiments with his electron capture device revealed that human pollution was to be found everywhere on Earth, revolutionising our understanding of the atmosphere and helping to spark what would become the environmental movement.

It was while working with Nasa in the early 1960s and thinking about how we might detect life on other planets by measuring the chemical composition of their atmospheres, that Lovelock formulated the Gaia hypothesis in collaboration with the visionary evolutionary theorist and biologist Lynn Margulis. ‘The Earth has an impossible atmosphere,’ Lovelock told the BBC in 2019. ‘For it to have happened by accident the odds against it run into countless billions to one against. So something’s going on.’

The Earth, so far as all our telescopes and missions and probes have been able to ascertain, is a strange planet. There is an unusually high proportion of oxygen in its atmosphere, and given its size and distance from the sun, the planet should be too hot to sustain life. Over billions of years, the sun has been getting hotter as it goes through the life and death cycle of an average star, using up its hydrogen and emitting increasing levels of solar radiation. According to Lovelock, over the last 3.5 billion years the radiative output of the sun has increased by 20 per cent, which 'should have been enough to raise the surface temperature of the Earth to 50°C and bring about a runaway greenhouse effect that would have sterilised the planet. But it didn't happen.' Although the Earth has passed through hot periods and ice ages, its average surface temperature has remained hospitable to life, in some form. According to Lovelock, 'Gaia does this.' Since it began, life has worked to modify its environment. All life on Earth (microbes, plants, animals) interacts with non-life (soil, oceans, atmospheric gases) to form a single planetary system, Gaia, that adjusts to change over very long timescales to ensure that the Earth's climate remains relatively stable and suitable for life.

As an illustration, in 1983 Lovelock and the atmospheric scientist Andrew Watson devised Daisyworld, a computer simulation of a hypothetical world in which ecological competition between daisies of different colours affects planetary albedo, or the amount of solar radiation that is reflected back out into space – one of the ways in which global temperature is regulated. In Novacene, Lovelock explains how the simulation worked:

> A main sequence star like our sun gradually heats the planet Daisyworld until it is just warm enough for a species of black daisies to colonise the entire surface. Black daisies absorb heat so they thrive in these low temperatures. But there are mutant white daisies which reflect heat and, as the temperature rises even further, these begin to flourish. So Daisyworld is cooled by white daisies and warmed by black ones. A simple flower is able to regulate and stabilise the environment on a planetary scale. Moreover, this stabilisation emerges from a strictly Darwinian process.
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> Scale up this model to include all the flora and fauna of Earth and you have the system I have called Gaia.

In its weakest formulation, the Gaia hypothesis asserts merely that biota has a significant influence over certain elements of the abiotic world, including the composition of the atmosphere and global temperature. But in its strongest version, the hypothesis seems to be that life manipulates its environment with the express purpose of creating the conditions for the sustenance of life. While it may seem that where some see God, Lovelock sees Gaia ('Gaia looks after us'), he doesn't say Gaia is God. He has never claimed that Gaia is sentient, or benevolent, or anything so obviously woo-woo as that. Rather, he maintains that all the evidence suggests 'a planet bearing life will tend to modify its environment and climate in a way that favours the life upon it.' As we have yet to encounter another planet bearing life, we have no way to test this hypothesis.

When Lovelock and Margulis first published a series of papers on the Gaia hypothesis in the 1970s, the idea was adopted by environmentalists and quickly took root in the public imagination. But it also set some eyes rolling. Richard Dawkins and Stephen Jay Gould were critical, and scientists across the board argued that Gaia smacked of teleology or even new-age mysticism. Can we really say a planet is an organism? What if life just evolves and there's nothing that actually 'seeks' to keep it all afloat? Where does poetic language end and scientific hypothesis begin?

Some have argued that Gaia may describe an effect – the result of a set of processes, rather than the processes themselves. 'Among the wide range of effects that living things have on the physical and chemical nature of the planet, some may involve feedback that helps life itself to continue,' Peter Godfrey-Smith wrote in the LRB of 19 February 2015. 'If they come about, they do so as fortuitous by-products of the evolution of particular living things.' Andrew Watson, the co-creator of Daisyworld, later distanced himself from Lovelock's insistence on self-regulation of climate as an intrinsic property of a planet bearing life, suggesting instead – along the lines of the anthropic principle – that complex life wouldn't have evolved on Earth at all had climate regulation over long timescales not been one of Earth's properties. Today, many see Gaia in the way that Stephen Jay Gould once described it: 'a metaphor, not a mechanism'.

Lovelock has shrugged off these criticisms, appealing to the value of intuition ('Without it, we die') and the non-linear logic of 'dynamic, self-regulating systems,' which, he writes, 'wholly defy a logical explanation that uses step-by-step arguments'. This comes across as a bit hand-wavey and circular (you can't understand my theory because my theory can't be understood by you), but any mention of 'dynamic, self-regulating systems' is an invocation of cybernetics, and it's clear that the influence of cybernetics on Lovelock's thinking runs deep.

Defined by Norbert Wiener in 1948 as 'the scientific study of control and communication in the animal and the machine', cybernetics is understood today as the science of the control of complex systems. In both machines and living things, this means a focus on information processing – communication, automatic control and non-linear mechanisms like feedback loops – and the investigation of core concepts such as learning, cognition and adaptation. At a basic level, a cybernetic system contains a representation of the current state, a representation of a goal state, and the means to take actions that will move the system from the current state toward the goal state. So you and your cat are both cybernetic systems, and your thermostat is too (its 'goal' is to maintain temperature at a set level).

Part of what was radical about cybernetics was that it proposed a notion of telos and 'purpose' that many scientists found a bit batshit but which seems to have struck a nerve with the young Lovelock, who has repeatedly ascribed his formulation of Gaia to an application of the cybernetics of physiological homeostasis to Earth's atmosphere. While the term 'cybernetics' derives from the Greek kybernetikos, 'good at steering' (referring both to the craft of the helmsman and the governance of people), its modern usage suggests a blurring of the roles of controller and controlled. 'In cybernetics, cause and effect no longer apply,' Lovelock wrote in Gaia: A New Look at Life on Earth (1979). 'It is impossible to tell which comes first, and indeed the question has no relevance.' Neither is it particularly important, from the perspective of cybernetics, whether a complex system is a houseplant, a human, a thermostat or a planet.

In the decades since Lovelock and Margulis first drew up the Gaia hypothesis, research has revealed that however improbable, teleological or untestable it may be, it contains a nugget of truth more axiomatic than almost anyone would have guessed. Earth system science, which considers the interactions and feedbacks among Earth's sub-systems (biosphere, geosphere, hydrosphere, cryosphere, atmosphere etc) is now a firmly established field of scientific inquiry and a widely accepted intellectual framework for understanding the planet. And at the ecological level, evidence has been accumulating that the links between life and non-life are far more profound than most scientists previously suspected.

We now know, for example, that the relationship between trees and the fungi that grow on their roots and share nutrients with them – a symbiotic relationship known as mycorrhizae – determines how much carbon dioxide trees will absorb from the air, and therefore how much they will contribute to cooling the planet (whose temperature in turn helps determine which kinds of tree can grow and thrive, and so on). We know that great whales dive down to the ocean depths to feed on plankton and krill, then swim up to the surface to breathe, and to defecate and urinate, releasing a nutrient-rich 'poo-nami' that stimulates the growth of phytoplankton, a type of marine algae that pulls carbon from the air via photosynthesis. When phytoplankton die, some of the carbon they have captured is recycled at the surface, but some of the dead algae sink to the bottom of the sea, taking captured carbon with them, which helps cool the planet.

Which is to say, it is now abundantly clear that the physical and chemical nature of the planet is shaped by living things. It is also clear that humans are the single most influential organism now doing that shaping, with the effect that our planetary systems are rapidly shifting away from conditions favourable to an astonishing amount of life on Earth.

Since 2006, Lovelock has written a string of variously apocalyptic books warning about the dire consequences of our present path for life on Earth – The Revenge of Gaia (2006), The Vanishing Face of Gaia (2009) and the slightly less dystopian A Rough Ride to the Future (2014). Novacene continues in this vein, but also offers up an oblique Hail Mary for the future of life: Gaia will save us. Sort of. This is where the cyborgs come in.

It's a hard time to be looking towards the future. For many of us, the near-term horizon is crowded by the ongoing pandemic, student debt, precarious work and the stressful circus of never-ending elections, while the long-term horizon is hazy with warnings about the collapse of global food systems, interminable war and the loss of a stable climate. Already, the water is rising, fires are burning, forests are dying, coral is bleaching, glaciers are calving, and living creatures are winking out of existence at mind-numbing rates. As Bill McKibben recently told the New Yorker, 'we're not playing for stopping climate change. We're playing maybe for being able to slow it down to the point where it doesn't make civilisations impossible.'

But Lovelock is here to tell us that salvation of sorts is on the way, in the guise of super-intelligent cyborgs that will take control of an overheating planet and cool it down so that life on Earth, including themselves, can be saved. But first, Gaia needs to evolve. As Lovelock sees it, Gaia has already gone through two major evolutionary leaps, which can be understood in terms of 'the planet's processing of the power of the sun'. The sun is key because, as he wrote in The Ages of Gaia (1988), 'the self-regulation of the system is an active process driven by the free energy available from sunlight.' Gaia's first evolutionary leap was marked by the appearance of photosynthesisers. These were the first organisms to use sunlight to split water molecules, thus converting solar energy into chemical energy, which photosynthesisers used to power internal processes. In other words, these were the first organisms to harness the energy of the sun to do work on Earth. The waste product of this complex biochemical process was oxygen, which back then was a nasty substance to release into the environment. But Gaia self-regulated and life flourished.

The second evolutionary leap was made, as Lovelock sees it, in 1712, with Thomas Newcomen's invention of the atmospheric engine. In itself, this modest apparatus doesn't suggest the dawn of a new era: a small fire heats water, driving steam into a cylinder; the steam is then quickly condensed, creating a partial vacuum that allows atmospheric pressure to push a piston down into the cylinder. Newcomen's engine was so significant because of the particular problem it was designed to solve: how to get more coal out of the ground. In Britain in the early 1700s, coal production was limited by frequent flooding in the mines, and something was needed to pump the water out. 'Newcomen had simply made coal, and with it energy, more easily accessible.' Lovelock argues that by enabling 'the exploitation of a hitherto inaccessible fossil fuel', Newcomen's engine ushered in the Industrial Revolution with its attendant glories and horrors, including humans' new capacity to release massive amounts of carbon dioxide into the atmosphere, drastically reshaping the Earth's climate. Much as life on Earth rebounded from the early oxygen dump by photosynthesisers, so too it might yet recover from this carbon dioxide dump, though whether this will happen in time to ensure continued human survival remains in question.

Lovelock believes that humanity has a fighting chance only because Gaia is on the verge of a third evolutionary leap, which will usher in an age he calls the 'Novacene'. In the Novacene, 'solar energy is converted into information.' This conversion of sunlight into bits will be carried out by 'cyborgs', a term he lifts from cybernetics. As he envisages it, once today's rudimentary AI becomes self-replicating and self-designing, silicon-based cyborgs made entirely of engineered materials – no flesh, so not your typical sci-fi cyborg – will rapidly appear. They will evolve according to Darwinian principles and soon become 'thousands then millions of times more intelligent than us'. In other words, the singularity. But the singularity as viewed through the lens of Gaia. The cyborgs will be our children. Our descendants. Our self-regulating salvation. If they are to survive, these silicon-based cyborgs will need planetary temperatures similar to those we carbon-based lifeforms need today, and because they will recognise that Earth's carbon-based life is necessary to keep the climate stable, they will save it, using life to cool down the planet and save themselves in turn. Once again, Gaia will self-regulate and life – redefined to encompass our cyborg progeny – will flourish.

To be clear, Lovelock is not suggesting that human civilisation will be saved. It's too late for that. In his vision of the future, which seems to be rooted in a mix of fatalism, techno-optimism and wishful thinking, it is a foregone conclusion that humans will not stop runaway climate collapse and that without an intervention on the scale of a cyborg ex machina, we are doomed to extinction. ('Don't you consider it possible that we've had our time?' he said in a recent interview.) With our limited capacities, humans will appear to the cyborgs as plants now appear to us – as a slower form of life. They'll keep humans around the same way we keep houseplants. The playful reference to photosynthesisers is a nice touch, but it's not at all clear that humans are necessary to help Gaia control the climate, so perhaps the cyborgs will keep us around for nostalgic reasons? Or because they have a sense of humour?

What gives the future-gazing in Novacene at least a dull glow of optimism is the notion that the special human ability to understand will survive our civilisational demise. 'The distinguishing feature of human intelligence,' Lovelock writes, 'is that we use it to analyse and speculate about the world and the cosmos and, in the Anthropocene, to make changes of planetary significance.' This is a rather narrow view of what makes human cognition interesting or unique, but Lovelock believes the ability to understand – as he defines it – is special because 'only we do this, only we are the way in which the cosmos has awoken to self-knowledge.' In this scenario, the ability to understand makes humans an evolutionary link in a much longer chain: cyborgs will evolve to save life on Earth because the universe itself may be destined to attain consciousness.

> our reign as sole understanders of the cosmos is rapidly coming to an end. We should not be afraid of this. The revolution that has just begun may be understood as a continuation of the process whereby the Earth nurtures the understanders, the beings that will lead the cosmos to self-knowledge. What is revolutionary about this moment is that the understanders of the future will not be humans, but what I choose to call 'cyborgs' that will have designed and built themselves from the artificial intelligence systems we have already constructed.

Gaia's fledgling ability to understand, incubated in humans, will be passed on to cyborgs that 'will, of course, be far better equipped for the task of understanding'.

The first photosynthesisers converted light into chemical energy to do work on Earth; humans converted solar energy stored in fossil fuels into work on Earth; the cyborgs will convert solar energy directly into information which they will use to do work on Earth, and humans will cede the world to a non-carbon-based form of life that will geoengineer the climate and attain exponentially greater and greater understanding of the cosmos. So the news from the frontier of human civilisational collapse isn't all bad! 'We must abandon the politically and psychologically loaded idea that the Anthropocene is a great crime against nature,' Lovelock writes. 'The truth is that, despite being associated with mechanical things, the Anthropocene is a consequence of life on Earth. It is a product of evolution; it is an expression of nature.' The violence and ecological collapse of the Anthropocene isn't a wrong turn, a death spiral by which we have doomed life on Earth, but part of the evolution of Gaia. The next evolutionary stage awaits.

Which is to say, this book is a bit nuts. The story Lovelock is telling here falls within the realm of speculation, not prediction, which he acknowledges with a generous peppering of 'maybe' and 'perhaps', as well as some winking flights of fancy ('No such assumption can be made about the cyborgs of the Novacene ... But what would they look like? Anything is possible, but I see them, entirely speculatively, as spheres'). In this story, the Novacene is the next stage in the cosmos awakening to consciousness, and in our current age of climate catastrophe it is not individuals, or communities, or even human civilisation that must be saved, it is the possibility of this awakening.

With its meandering and aphoristic style, Novacene reads somewhat like a patchwork transcription of conversations and occasional rants in which Lovelock's wit and erudition, as well as his obvious annoyance at the other humans with whom he is forced to share the planet, are on full display. Academia and the scientists who work in it are particular targets, behaving 'like the church in Galileo's time'. Maddeningly, the book contains no citations, which would be only slightly less troublesome if Lovelock wasn't sometimes a poor purveyor of facts. As George Monbiot pointed out in his review of A Rough Ride to the Future (2014), Lovelock has supported erroneous claims cooked up by anti-environmentalists that a ‘ban’ on DDT after the publication of Rachel Carson’s Silent Spring in 1962 resulted in a massive increase in deaths from malaria around the world. It did not. In fact, the US specifically allowed companies to manufacture DDT for export and facilitated its continued use in disease control. Malaria rates rose in many countries because mosquitos developed resistance to the pesticide, a problem Carson herself had foreseen. There are similar issues in Novacene. For example, Lovelock believes cyborgs will appear as the result of an acceleration of technological development at the exponential rate predicted by Moore’s Law. (This development will be fuelled, incidentally, by nuclear power; no fan of renewable energy, Lovelock insists that our reluctance to embrace nuclear power is an act of ‘auto-genocide’.) Moore’s Law states that every two years the number of transistors that can be installed on an integrated circuit doubles, allowing for exponential growth in the processing speed and capacity of silicon chips. In recent years, however, this growth has shown signs of slowing. But this doesn’t deter Lovelock, who claims ‘Moore has been proved right,’ and breezily asserts that as artificial intelligence develops, ‘the continued working of Moore’s Law means that ... big steps will be taken in a few years, then a few months and, finally, in a few seconds.’

One might be more inclined to take Lovelock more seriously if his assertions were backed up with references, and if he wasn’t making such strong, often eyebrow-raising claims about science and technology. We are asked to accept, for instance, his view of information as ‘the fundamental property of the cosmos’ and, correspondingly, of the bit – a unit of information with one of two possible values, 1 or 0 – not just as a substance on a par with any chemical element, but as ‘the fundamental particle from which the universe is formed’. As Bruce Clarke has written in a thoughtful exploration of the differences between Lovelock’s cybernetic Gaia and the ‘autopoietic’ Gaia later formulated by his former collaborator Margulis, ‘Reading information as substance rather than pattern indulges information theory’s tendency to hypostatise its primary entity. Information is given ontological status on a par with energy and matter.’

Novacene is a weird, dissonant book, brimming with lively insight yet locked into a Darwinian form of fatalism. Nowhere does Lovelock consider the possibility that we might stop using fossil fuels and curb CO2 emissions fast enough to allow human civilisations to continue. He can come across as sanguine about the prospect of vast human suffering. Lurking in the background of his cybernetic techno-fantasy is a naturalisation of the bloodletting that has occurred throughout human history, and which threatens to accelerate in a not so distant future shaped by the climate crisis. Lovelock seems to accept the violence of climate change and of the policies we use to manage our relationship with Earth as part of an inexorably unfolding natural process. Framing history in this way renders events inevitable and removes the possibility (and burden) of considering the suffering that a relatively small proportion of humanity has inflicted on the planet and on the rest of us. This framing leaves no room for justice. You can ignore politics and power because, hey, it’s nature.

While fatalism has recently become passé among the climaterati, a vigorous and sometimes vitriolic culture war continues to be waged along the continuum between hope and despair. But Lovelock’s book, read as a story about climate, departs along a different axis. Novacene is about what is left once you have given up on humanity’s ability to curb a runaway climate, but you still have faith in the future of life on Earth. Lovelock offers salvation by evolution, and promises redemption for what he rather bluntly and ahistorically depicts as humanity’s sins against life on

Earth. ‘Whatever harm we have done to the Earth,’ he writes, ‘we have, just in time, redeemed ourselves by acting simultaneously as parents and midwives to the cyborgs. They alone can guide Gaia through the astronomical crises now immanent.’ As Lovelock’s friend Stewart Brand, founder of the Whole Earth Catalogue and, like Lovelock, a proponent of Big Tech fixes for the climate crisis, recently tweeted, Novacene’s ‘message is more profound even than his Gaia Theory and even more comforting and discomfiting’.

This reach for redemption seems all the more poignant when you consider its source. ‘Also, perhaps, we can hope that our contribution will not be entirely forgotten,’ the centenarian Lovelock writes, ‘as wisdom and understanding spread outwards from the Earth to embrace the cosmos.’ A charitable reading of Novacene is that it represents one man’s attempt to make meaning out of his life in the face of a deeply held belief that humanity is doomed. It is, in essence, a rejection of nihilism. Ever the contrarian, Lovelock’s ‘last word on the Anthropocene’ is a ‘shout of joy – joy at the colossal expansion of our knowledge of the world and the cosmos that this age has produced’. Brutal as it may be, he’s taking the long view. Because, as he points out repeatedly in the book, we are doomed to extinction however the climate crisis unfolds. A couple of billion years from now, the sun will be so hot that it will melt all the ice on Earth and turn the planet into a scorcher not unlike Venus. Eventually it will go through the convulsive death throes of any average star, expanding to become a red dwarf, then tearing itself apart to become a much smaller white dwarf about the size of Earth. Then, as it cools, it will crystallise, eventually becoming a multi-trillion-ton diamond at the centre of our solar system. All life on Earth will long since have been incinerated.

Looking forward across this vast timescale, Lovelock seems to take comfort in the idea that something of life as it evolved on Earth might remain embedded in the cosmos. But maybe he’s right. Maybe our cyborg progeny will salvage something of our existence, and we will all be happier when, in the words of Richard Brautigan, we are ‘all watched over/by machines of loving grace’. It wouldn’t be the worst outcome to the planetary crisis we now face.