NOVACENE

The Coming Age of Hyperintelligence

JAMES LOVELOCK

originator of the Gaia theory

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Preface

It is a great honour to have helped James Lovelock finish what will probably be his last book. I say 'probably' because experience has taught me never to guess what Jim will do next. Though he is now a very old man, a quiet retirement seems the least likely prospect, but he is toying with the idea, as he admitted in an email.

'Now that I am approaching 100 years it is easy to believe that I have little more to contribute. Like running a marathon, I know the agony of running that last hill that faces me. I might as well stop trying and let the young runners complete the course.'

I laughed when I read this; first, because I find it hard to imagine any young runner replacing Jim and, secondly, because I did not believe him. The truth is there could always be another book, just as there are always new ideas, new ways of looking, new ways of thinking. While working with him on this book, I actually had to ask him to stop thinking and start explaining, otherwise the task would never have been completed.

Jim's imagination is as thrillingly unexpected as it is alarmingly incisive. I once saw him sitting silently at a dinner party full of very bright, very serious people and then stun them into silence with a single sentence that overturned everything they had just been talking about.

And he always grows suspicious when he finds people agreeing with him – 'What have we got wrong?' he asks. He constantly looks for refutations and for different perspectives and he insists on the inherent uncertainty of scientific ideas. This makes his own ideas very robust indeed; they have been tested to destruction so many times. It is, of course, how all scientists should think and work, but many don't, which is why, in recent years, Jim has taken to calling himself an engineer.

He can be bewildering on first contact. I first met him many years ago at his laboratory in Coombe Mill. I just didn't understand him and I remember thinking I had fallen through a looking glass into a world utterly different from the one I thought I knew. He told me about his Gaia hypothesis, but I did not grasp the idea, perhaps because, as he says in this new book, it is not expressible in ordinary logical forms. This is not because it is complex – though, in detail, it is – but because at its core is a pristine simplicity. Life and the Earth are an interacting whole and the planet can be seen as a single organism; there you have it. Once I understood this it seemed so blindingly obvious that I assumed nobody could possibly disagree. In fact, back then, everybody did. Some still do, and some are Gaians but pretend they aren't, but most now acknowledge that Jim has altered forever our understanding of our lives and our planet.

People often talk of the value of 'thinking outside the box', but they seldom mention the much greater value of thinking, as Jim does, as if there is no box. He is so widely qualified – primarily in medical science and chemistry, but, seemingly, in everything once he starts talking – that no one discipline can ever hope to contain him. He is, as far as the institution of science is concerned, an outsider, a maverick, but that has not stopped him being garlanded with awards and honours. His nomination for the Fellowship of the Royal Society listed his work on the transmission of respiratory infections, air sterilization, blood-clotting, the freezing of living cells, artificial insemination, gas chromatography, and so on.

That was in 1974 and only briefly mentioned is the discipline that made him famous: climate science and his associated work on the possibility of extraterrestrial life. Then there is his ability to invent and construct his own gadgets – notably the revolutionary electron capture detector, maybe even the microwave oven and the numerous secret gadgets he created while working for the intelligence service.

Now, forty years after he introduced us to his goddess in his book *Gaia: A New Look at Life on Earth*, he introduces us to a new idea just as astounding and just as radical. 'Novacene' is Jim's name for a new geological epoch of the planet, an age that succeeds the Anthropocene, which began in 1712 and is already coming to a close. That age was defined by the ways in which humans had attained the ability to alter the geology and ecosystems of the entire planet. The Novacene – which Jim suggests may have already begun – is when our technology moves beyond our control, generating intelligences far greater and, crucially, much faster than our own. How this happens and what it means for us are the story of this book.

This is not the violent machine takeover seen in many science-fiction books and films. Rather, humans and machines will be united because both will be needed to sustain Gaia, the Earth as a living planet. As Jim put it to me in an email, 'The important concept, as I see it, is life itself. Perhaps this explains why I see the Earth as a form of life. The nature of its individual components, so long as they share a common purpose, seems unimportant.' Embodied in the concept of life is the possibility of knowledge, of creatures that can observe and reflect upon the nature of the cosmos. Whether humans continue living with or are superseded by their electronic progeny, we shall have played a vital and necessary part in the process of cosmic self-knowledge.

Jim is no anthropocentrist. He does not see humans as supreme beings, the summit and centre of creation. This was implicit in the idea of Gaia, which made it clear, to those who understood, that the biosphere has its own values of survival that lie far above and beyond any humanist values. It is explicit here: if life and knowing is to become entirely electronic, so be it; we played our part and newer, younger actors are already appearing on the stage.

Finally, a note on Jim's use of certain words. He uses 'cosmos' rather than 'universe' because he takes the former to mean everything we can know or see; he sees 'universe' as potentially meaning something larger of which we know and can know nothing. He uses 'cyborgs' to mean the intelligent electronic beings of the Novacene. In common usage this is taken to mean entities that are part flesh, part machine. But Jim thinks his usage is

PART ONE

The Knowing Cosmos

1

We Are Alone

Our cosmos is 13.8 billion years old. Our planet was formed 4.5 billion years ago and life began 3.7 billion years ago. Our species, *Homo sapiens*, is just over 300,000 years old. Copernicus, Kepler, Galileo and Newton appeared among us only in the last 500 years. For all but a brief moment of its existence the cosmos knew nothing of itself. Only when humanity developed the tools and the ideas to observe and analyse the bewildering spectacle of the clear night sky did the cosmos begin to awaken from its long sleep of ignorance.

Or did such an awakening also happen elsewhere? The inexhaustible flood of literature and films about aliens suggests we like to think so. It is difficult to believe we are alone in a cosmos which contains perhaps 2 trillion galaxies, each containing 100 billion stars. Some think that there is, surely, a chance that there have been or are highly intelligent species on at least one of the quadrillions of other planets that must orbit these stars. They would be, like us, understanders of the cosmos; or maybe their alien senses perceive an entirely different cosmos.

I think this is highly unlikely. These huge numbers of cosmic objects are misleading. It took the blindly groping process of evolution through natural selection 3.7 billion years – almost a third of the age of the cosmos – to evolve an understanding organism from the first primitive life forms. Furthermore, had the evolution of the solar system taken a billion years longer, there would be no one alive to talk about it. We would not have had time to attain the technological ability to cope with the increasing heat of the Sun. Seen from this perspective, it is clear that, ancient as it is, our cosmos is simply not old enough for the staggeringly improbable chain of events required to produce intelligent life to have occurred more than once. Our existence is a freakish one-off.

But our planet is now old. It is a curious fact that the lifespan of the Earth is easier to understand than our own lifespan. We do not yet know why humans rarely live beyond a maximum of 110 years and mice not much more than one year. It is not a matter of size – some small birds live to an age comparable with ours. In contrast, the lifespan of a planet is easily determined by the properties of the star that warms it.

Our star, the Sun, is what the astronomers call a main sequence star. It gave us life and it sustains us. Its warmth and regularity consoles us amidst the myriad uncertainties of our own lives. As that great truth-teller George Orwell wrote in 1946 in 'Some Thoughts on the Common Toad', 'The atom bombs are piling up in the factories, the police are prowling through the cities, the lies are streaming from the loudspeakers, but the earth is still going round the sun . . .'

But this great consoler is also lethal. Main sequence stars slowly increase their brightness as they grow older. Increasing heat from the Sun threatens life on our planet. We have so far been protected by the planetary system I call Gaia which cools the Earth's surface.

There are several reasons why the Earth's temperature could become uninhabitably high. If there were no vegetation to absorb carbon dioxide (CO_2) it could not be lowered to its present levels. There would be a runaway greenhouse effect. We see evidence of this process around us all the time. If on a hot day you compare the temperature of a slate roof with that of a nearby black conifer tree, you would find the roof is 40 degrees hotter than the tree. The tree cools itself by evaporating water. Similarly, the sea surface is cool because life keeps it below 15°C; above that temperature there can be no sea life and sunlight is absorbed, heating the water.

Gaia must continue her work of cooling the planet, because it is now old and frail. With age, as I am all too well aware, we become more fragile. The same is true for Gaia. She could now be destroyed by shocks to her system which, in previous ages, she would have simply shrugged off.

I am pretty sure that only Earth has incubated a creature capable of knowing the cosmos. But I am equally sure that the existence of that creature is imperilled. We are unique, privileged beings and, for that reason, we should cherish every moment of our awareness. We should now be cherishing those moments even more because our supremacy as the prime understanders of the cosmos is rapidly coming to end.

rock blundering through space on a deadly collision course and, much more than this, it will have evolved the means and the power to deflect its dangerous trajectory and save itself. In cosmic terms, this is a highly significant development.

Not all survival plans are quite as promising as that. One truly crazy idea for human survival appears at regular intervals in the media and in the minds of the venturesome. This is the notion that Mars could be a refuge for humanity if our life on Earth was in danger of being terminated. The assumption seems to be that the surface of Mars is not so different from that of the Saharan or Australian deserts. All that will be needed would be to drill down to an aquifer, just as they do in cities like Phoenix or Las Vegas in the United States. Then we could lead a comfortable civilized Martian life replete with casinos, golf courses and swimming pools.

Unfortunately, one thing the unmanned expeditions to Mars have told us is that the Martian desert is wholly inimical to all conceivable forms of Earth life. The atmosphere is about a hundred times thinner than the summit of Everest and it provides no shield against cosmic radiation or the ultraviolet radiation of the Sun. The thin air of Mars is 99 per cent CO_2 and utterly unbreathable. There are traces of water on the planet, but it is as salty as the waters of the Dead Sea and undrinkable. The pioneer and would-be spacefarer Elon Musk has said he would like to die on Mars, though not on impact. Martian conditions suggest death on impact might be preferable.

Perhaps Mars could provide hermit cells for the ultra-rich who might spend half their fortunes on voluntarily travelling there. Whatever cash was left could be spent on building and maintaining a tiny capsule of life from which escape would be impossible. It would actually be far less cruel to allow them to build their prison cells on the ice cap of Antarctica. At least the air is breathable.

To plan such ventures while ignoring the true state of the Earth seems extraordinarily perverse. The hope of finding some tiny Martian oasis does not really justify its enormous expense, especially when research costing a mere fraction of that of planetary exploration could provide crucial data about the Earth. We must never forget that this is the planet on which we live and that information about the Earth, although less exciting than news from Mars, may be the one thing that can ensure our survival.

So what do we need to know about the Earth to ensure that an understanding of the cosmos endures? We need to concentrate on heat, the most pressing and probable threat to our home and our existence.

I shall deal with this in more detail in the next part of this book, but I need to make a few points here. In recent years we have discovered thousands of 'exoplanets' – planets beyond our solar system. This has caused great excitement, not just among astronomers. Many have begun to speculate that we may be on the verge of finding signs of intelligent, organic alien life. But I suspect these people are being too anthropocentric. For one thing, it is important for alien-hunters to distinguish planets regulated by organic life forms from those regulated by electronic life.

That the latter will evolve from the former is the subject of this book. Any more advanced civilization than ours is likely to be electronic so there is little point in looking for small creatures with big heads and large, slanting eyes.

Then there is the matter of the temperature of these exoplanets. Particularly exciting has been the discovery that some lay within the 'zone of habitability'. This is sometimes called the Goldilocks Zone: like Goldilocks's porridge, it is just right – not too hot and not too cold. A Goldilocks planet would be just far enough from a star to support life – not so far as to become an ice world and not so near as to be sterilized by heat.

As I say, I don't think there are intelligent beings out there, but let's pretend for a moment that there are and they are doing exactly what we are doing – seeking planets in this habitable zone. These alien astronomers would reject Mercury and Venus, which are obviously too close to the Sun. But they would also reject Earth, which is also too close. Mars, they will conclude, is the only contender.

Earth absorbs and radiates such a prodigious amount of heat that it cannot possibly be classified as lying within the habitable zone. An alien astronomer viewing the solar system would be obliged to wonder about the anomalous surface temperature of our planet compared with that of Venus. The effective temperature of the Earth when seen from outer space is hotter, not cooler, than Venus. Yet the Earth is 30 per cent further from the Sun than Venus. The Earth's effective temperature is high because our atmosphere contains only a trace amount of carbon dioxide when compared with Venus. To stay in thermal equilibrium with the Sun, the Earth must radiate more thermal energy, and it does so at the long wavelengths of infrared. This makes the upper atmosphere at the edge of space hot, but, by the same measure, keeps the Earth's surface cool.

I think the zone of habitability idea is flawed because it ignores the possibility that a planet bearing life will tend to modify its environment and climate in a way that favours the life upon it, as ours does. A great deal of time may have been wasted during the search for life elsewhere because of the false assumption that the current environment of the Earth is simply a matter of geological happenstance. The truth is that the Earth's environment has been massively adapted to sustain habitability. It is *life* that has controlled the heat from the Sun. If you wiped out life entirely from the Earth, it would be impossible to inhabit because it would become far too hot.

So we are made by our star, which provides the energy for life, but we are also threatened by it. This star is a perfectly ordinary, somewhat small, middle-aged cosmic entity – a 5 billion-year-old main sequence star. Models of the Sun explain how it stays hot by fusing its hydrogen into helium in the ultra-incandescent regions of its interior. But just as burning coal in oxygen produces carbon dioxide, so fusing hydrogen produces helium. Both carbon dioxide and helium are greenhouse gases: the first warms the Earth, the second warms the Sun. This makes the inner regions of the Sun hotter and so increases the rate of fusion; the extra heat makes the Sun expand and from its greater surface area more heat escapes and warms the Earth. It will continue to increase its output of heat until, in 5 billion years' time, it becomes a red giant star and slowly absorbs the Earth and the inner planets of the solar system.

So far, the heating of the Sun has been slow enough to allow life to evolve, a process which takes millions of years. Unfortunately, the Sun is now too hot for the further development of organic life on Earth. The output of heat from our star is too great for life to start again as it did from the simple chemicals of the Archean Period between 4 billion and 2.5 billion years ago. If life on Earth is wiped out, it will not start again.

But that is not the immediate problem. The real threat is that, even though for the moment it is stable, the Sun is gradually emitting ever more heat. In fact, over the last 3.5 billion years its output has increased by 20 per cent. This 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 sterilized the planet. But it didn't happen. To be sure, there have been what we feel to be hot periods and ice ages, but the average temperature of the whole planetary surface does not seem to have varied by more than about 5°C from its current temperature: 15°C.

Gaia does this. In Greek mythology, Gaia is the Greek goddess of Earth and, at the suggestion of the novelist William Golding, I gave her name to the theory I developed fifty years ago. The theory is that, since it began, life has worked to modify its environment. This is not easily explained in full because it is a complex, multidimensional process. I can, however, illustrate how it the proximity to a star and the heat radiating from Earth indicated that life could not happen here. That radiation is the work of Gaia. It is she who pumps excess heat out into space to preserve life and it is for her sake that we must change our ways of thinking.

As a much younger man I accepted the conventional scientific view that the cosmos was a straightforward system of cause and effect. B is caused by A and then causes C. I had perhaps not paid close enough attention to Gaia. The 'A causes B' way of thinking is one-dimensional and linear whereas reality is multi-dimensional and non-linear. One has only to think of one's own life to see how absurd it is to think everything can be explained as a simple linear process of cause and effect.

There are also examples from basic engineering. Take the steam engine governor invented by James Watt in the nineteenth century. This was a solution to controlling the speed of a locomotive. The governor consists of a vertical steel shaft rotated by a tiny proportion of the main drive power and it simply spins out a pair of brass balls. The faster the rotation, the more they spread out. The movement of the spinning was arranged so that fast spinning closes the valve that sets the quantity of steam passing to the engine. For any given setting, this simple system would stabilize and maintain a constant speed regardless of whether the engine was going uphill or downhill. Using it, the driver could set a constant speed and leave the governor to maintain it.

You might think that this is simple and obvious; clever, but no more than that. Think again. Trying to explain