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Bill McKibben

The End of Nature

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Bill McKibben is a writer and environmental activist. His *The End of Nature* (1989) is considered the first book for a general audience about climate change. He serves as the Schumann Distinguished Scholar in Environmental Studies at Middlebury College, as a fellow of the American Academy of Arts and Sciences, and he has won the Gandhi Peace Prize. He has campaigned on every continent, including Antarctica, for climate action. In recognition of his activism, a new species of woodland gnat – Megophthalmidia mckibbeni – was in 2014 named in his honour.

BILL McKIBBEN

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Penguin Random House UK

First published in Great Britain by Viking 1990
First published in Penguin Classics 2022
001

Set in 10.5/13 pt Dante MT Std
Typeset by Jouve (UK), Milton Keynes
Printed and bound in Great Britain by Clays Ltd, Elcograf S.p.A.

The authorized representative in the EEA is Penguin Random House Ireland, Morrison Chambers, 32 Nassau Street, Dublin D02 YH68

A CIP catalogue record for this book is available from the British Library

ISBN: 978–0–241–51442–9

www.greenpenguin.co.uk

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FSC www.fsc.org

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For Kathryn Jeanne Ostrow (1962–1977) and for Sue

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Acknowledgements

I owe a large debt – all of us owe a large debt – to the scientists who have brought to the world's attention the greenhouse effect and the other environmental cataclysms described in this book. The science of global climate change is young and still evolving, so there are few textbooks or standard references on which to draw. However, the investigators in this field have made many efforts to communicate their findings to the public, and much of the most important material has been collected in several American government reports, the most recent of which is *Policy Options for Stabilizing Global Climate*, a two-volume report to Congress from the Environmental Protection Agency. Other important summaries have been issued by the National Research Council, the National Academy of Sciences, and the United Nations.

I am indebted to a number of individual scientists and policy analysts, who helped me understand the implications of their work. This list includes, among many others, James Hansen, Roger Revelle, Stephen Schneider, George Woodwell, Pat Zimmerman, Michael McElroy, Irving Mintzer, and James Titus. Many of these researchers work at government agencies or universities, while others are employed by a constellation of non-profit environmental groups whose reports have helped me considerably. These groups include the Worldwatch Institute (which publishes a valuable planetary 'check-up' each year), the World Resources Institute (which conducts extensive independent policy analysis), the Environmental Policy Institute (which has done a particularly good job addressing the ozone question), the Natural Resources Defense Council, the

Environmental Defense Fund, and others. None of them, of course, are responsible for my characterizations of their work.

As much of this work deals with society's response to global change, I have made extensive use of the popular press – *The New York Times* in particular has kept me abreast of developments, and I have also relied on magazines as far afield as the *New Statesman* and *International Wildlife*. The Southern Adirondack Library System tracked down some of the more obscure naturalist writings that I have quoted, while others have recently become more easily available in America in a series of 'Penguin Nature Library' reprints edited by Edward Hoagland. Paul Brooks's fine summary of American nature writing helped order my thinking.

For additional help in gathering material, I am indebted to Robert Silvers, editor of *The New York Review of Books*, who also provided me with a forum to try out some of the material in the opening chapter. His assistants – Henning Gutmann, Neil Gordon, and Ann Kjellberg – were also of great aid.

The Lyndhurst Foundation helped support this work, and for their aid to both my finances and morale I am very thankful.

Gloria Loomis, my American agent, did a marvellous job of finding this book a home; I thank both her and Kendra Taylor, her assistant. I would also like to thank Abner Stein, Paul Marsh, and Susanna Nicklin, my foreign agents; and Peter Carson and Esther Sidwell of Penguin Books in London.

For their valuable early readings of my manuscript, I am indebted to David Edelstein, Scott Rosenberg, Sam and Lisa Verhovek, David Goldfarb, Shawn Leary, and Michael Considine. David Rosenthal, my editor at Random House, improved my original efforts immeasurably, chipping away at the blocks of verbal stone in which I had imprisoned my argument until its outlines became more visible. His colleagues at Random House – Joni Evans, Annik LaFarge, Sono Rosenberg, Mitchell Ivers, Mary Peters and many others – were also of great assistance, as was Tim Guzley who checked the facts contained herein.

Many at the *New Yorker* magazine aided my efforts – especially Sara Lippincott and the incomparable Eleanor Gould Packard, as well as the checking staff, led by Martin Baron.

My neighbours, especially the men and women of the local United Methodist Church and our pastor, the Revd Lucy B. Hathaway, were a great support and resource. My parents, Peggy and Gordon McKibben, besides their obvious crucial role in any effort of mine, also shuttled much information back to me from their London home. My brother, Tom, provided a good deal of spirited criticism and argument which forced me to think more deeply.

Most of all, I owe an unpayably large debt to my wife, Sue. She served as an exceptionally able critic; more, she is my unshakeable friend and companion.

PART ONE

The Present

I

A New Atmosphere

Nature, we believe, takes for ever. It moves with infinite slowness through the many periods of its history whose names we can dimly recall from school – the Devonian, the Triassic, the Cretaceous, the Pleistocene. Ever since Darwin, nature writers have taken pains to stress the incomprehensible length of this path. 'So slowly, oh, so slowly have the great changes been brought about,' wrote John Burroughs at the turn of the century. 'The Orientals try to get a hint of eternity by saying that when the Himalayas have been ground to powder by allowing a gauze veil to float against them once in a thousand years, eternity will only just have begun. Our mountains have been pulverized by a process almost as slow.' We have been told that man's tenure is as a minute to the earth's day; but it is that vast day which has lodged in our minds. The age of the trilobites began some 600 million years ago. The dinosaurs lived for nearly 140 million years. Since even a million years is utterly unfathomable, the message is: Nothing happens quickly. Change takes unimaginable – 'geological' – time.

This idea about time is essentially mistaken. Muddled though they are scientifically, the creationists, believing in the sudden appearance of the earth some seven thousand years ago, may intuitively understand more about the progress of time than the rest of us. For the world as we know it – that is, the world with human beings formed into some sort of civilization, the world in which North America and Europe are warm enough to support much in the way of human life – is of quite comprehensible duration. People began to collect in a rudimentary society in the north of Mesopotamia some twelve thousand years ago. Using thirty-three years as a generation, that is 363 generations ago. Sitting here at my desk I can think back five generations – I have photos of four. That is, I can think back nearly one seventieth of the way to the start of civilization. A skilled genealogist could easily get me one fortieth of the distance back. And I can conceive of *how* most of those forebears lived. From the work of archaeologists and from accounts like those in the Bible I have some sense of daily life at least as far back as the time of the pharaohs, which is more than a quarter of the way. Three hundred and three generations ago, Jericho was a walled city of three thousand souls. Three hundred and three is a large number, but not in the way that 600 million is a large number – not inscrutably large.

Or look at it this way: there are plants on this earth as old as civilization. Not species – individual plants. The General Sherman tree in California's Sequoia National Park may be a third as old, about four thousand years. Certain Antarctic lichens date back ten thousand years. A specific creosote plant in the Southwestern Desert was estimated recently to be 11,700 years of age.

And within that ten thousand years of civilization, of course, time is not uniform. The world as we really know it dates back perhaps to the Renaissance. The world as we really *really* know it dates back to the Industrial Revolution. The world as we actually feel comfortable in it dates back to perhaps 1945. It was not until after the Second World War, for instance, that plastics came into widespread use.

In other words, our reassuring sense of a timeless future, which is drawn from that apparently bottomless well of the past, is a delusion. True, evolution, grinding on ever so slowly, has taken billions of years to create us from slime, but that does not mean that time always moves so ponderously. Events, enormous events, can happen quickly. We've known this to be true since Hiroshima, of course, but I don't mean *that* quickly. I mean that over a year or a decade or a lifetime, big and impersonal and dramatic changes can take place. We're now comfortable with such bizarre ideas as that continents can drift over aeons, or that continents can die in an atomic second. But normal time seems to us immune from such huge changes. It isn't, though. Since I was born less than three decades ago, for example, the amount of carbon dioxide in the atmosphere has increased by more than 10 per cent, from about 315 to more than 350 parts per million. In the last decade, an immense 'hole' in the ozone layer has opened above the South Pole each fall. In the last half-decade, the number of West Germany's forests damaged by acid rain has risen from less than 10 per cent to more than 50 per cent. According to the Worldwatch Institute, in 1988 – for perhaps the first time since the Pilgrim Fathers' first lean winter in New England – America ate more grain than it grew. Burroughs again:

> One summer day, while I was walking along the country road on the farm where I was born, a section of the stone wall opposite me, and not more than three or four yards distant, suddenly fell down. Amid the general stillness and immobility about me the effect was quite startling . . . It was the sudden summing up of a half a century or more of atomic changes in the material of the wall. A grain or two of sand yielded to the pressure of long years, and gravity did the rest.

In much the same comforting way that we think of time as imponderably long, we consider the earth to be inconceivably large. Although, with the advent of space flight, it became fashionable to picture the planet as a small orb of life and light in a dark, cold vastness, that image has never really sunk in. To any one of us, the earth *is* enormous, 'infinite to our senses'. Or at least it is if we think about it in the usual horizontal dimensions – even the frequent flier with many bonus miles has seen only a tiny fraction of the earth's terrain; even the most intrepid mariner cuts a single furrow across the ocean field. There are vast spaces between Manhattan and my house in the Adirondack mountains of upstate New York – it's a five-hour drive through one state in one country of one continent. But from my house to the post office at the end of the road is a trip of six and a half miles. On a bicycle it takes about twenty-five minutes, in a car eight or nine. I've walked it in an hour and a half. If you turned that trip on its end, the twenty-five-minute pedal past Bateman's sandpit and the graveyard and the waterfall and Allen Hill would take me a mile beyond the height of Mt Everest, past the point where the air is too thin to breathe without artificial assistance. Into that tight space, and the layer of ozone above it, is crammed all that is life and all that maintains life.

This, I realize, is a far from novel observation. I repeat it only to make the same case I made with regard to time. The world is not so large as we intuitively believe – space can be as short as time. For instance, the average American car driven the average American distance – ten thousand miles – in an average American year releases its own weight of carbon into the atmosphere. Imagine each car on a busy freeway pumping a ton of carbon into the atmosphere, and the sky seems less infinitely blue.

Our optimistic perceptions of time and space, then, distort our sense of the world. But so do some other, comparatively minor, misunderstandings. Consider, for instance, an ephemeral accident of the calendar: we live too close to the year 2000. Forever we have read about the year 2000. It has become a symbol of the bright and distant future, when we will ride in air cars and talk on video phones. The year 2010 still sounds far off, almost unreachably far off, as though it were on the other side of a great body of water. If someone says to me that a very bad thing will happen in 2010, I may feign concern, but subconsciously I file the fear away for future consideration. So it always shocks me when I realize that 2010 is now as close as 1970 – closer than the break-up of the Beatles – and that the turn of the century is no further in front of us than 1980 is behind. We live in the shadow of a number, and this makes it hard for us to see the future.

Our comforting sense, then, of the permanence of our natural world, and our confidence that it will change gradually and imperceptibly, if at all, is the result of a subtly warped perspective. Changes in our world can happen in our lifetime – not just changes like wars, but bigger and more total events. I believe that, without recognizing it, we have already stepped over the threshold of such a change: that we are at the end of nature.

By this I do not mean the end of the world. Though they may change dramatically, the rain will still fall, and the sun shine. When I say 'nature', I mean a certain set of human ideas about the world and our place in it. But the death of these ideas begins with definite changes in the reality around us – changes that scientists can measure and enumerate. More and more frequently these changes will clash with our perceptions, until, finally, our mistaken sense of nature as eternal and separate will be washed away and we will see all too clearly what we have done.

Svante Arrhenius took his doctorate in physics from the University of Uppsala in 1884. His thesis earned him the lowest possible grade short of outright refusal. Nineteen years later that thesis, which was on the conductivity of solutions, earned him the Nobel Prize. He subsequently accounted for the initial poor reception thus:

> I came to my professor, Cleve, whom I admired very much, and I said, 'I have a new theory of electrical conductivity as a cause of chemical reactions.' He said, 'This is very interesting,' and then he said, 'Goodbye.' He explained to me later that he knew very well that there are so many different theories formed, and that they are almost certain to be wrong, for after a short time they disappeared; and therefore, by using the statistical manner of forming his ideas, he concluded that my theory also would not exist long.

Arrhenius's understanding of electrolytic conduction was not his only shrug-provoking new idea. As he surveyed the first few decades of the Industrial Revolution, he realized that man was burning coal at an unprecedented rate, 'evaporating our coal-mines into the air'. Scientists knew by then that carbon dioxide, a by-product of fossil-fuel combustion, trapped infra-red radiation that would otherwise have reflected back out to space. Jean-Baptiste Joseph Fourier (who developed the theory of heat conduction and who was also one of the earliest students of Egyptian archaeology) had speculated about the effect nearly a century before, and had even used the 'hothouse' as a metaphor. But it was Arrhenius, employing measurements of infra-red radiation from the full moon, who did the first calculations of the possible effects of man's stepped-up production of carbon dioxide. The average global temperature, he concluded, would rise by as much as 5°C (9°F) if the amount of carbon dioxide in the air doubled from its pre-industrial level. That is, heat waves in the middle latitudes would reach 40–50°C or more; the seas would rise many metres; crops would wither in the fields.

This idea floated in obscurity for a very long time. Now and then a few scientists took it up – the British physicist G. S. Callendar speculated in the 1930s, for instance, that increasing carbon dioxide levels could account for the warming of North America and northern Europe that meteorologists had begun to observe in the 1880s. But that warming seemed to be replaced by a temperature decline around 1940; anyway, most scientists were too busy creating better living through petroleum to be bothered with such long-term speculation. And those few who did consider the problem concluded that the oceans, which hold much more carbon dioxide than the atmosphere, would soak up any excess that man churned out – that the oceans were an infinite sink down which to pour the problem.

Then, in 1957, two scientists at the Scripps Institute of Oceanography in California, Roger Revelle and Hans Suess, published a paper in the journal *Tellus* on this question of the oceans. What they found was dismaying – no, more than dismaying. What they found may turn out to be the single most important limit in an age of limits, the central awkward fact of a hot and constrained planet.

What they found was that the conventional wisdom was wrong – the upper layer of the oceans, where the air and sea meet to transact their business, would absorb less than half of the excess carbon dioxide produced by man. To be precise, what they demonstrated was that 'a rather small change in the amount of free carbon dioxide dissolved in seawater corresponds to a relatively large change in the pressure of carbon dioxide at which the oceans and the atmosphere are at equilibrium'. To be dramatic, what they showed was that most of the carbon dioxide being pumped into the air by millions of smoke-stacks, furnaces, and car exhausts would stay in the air, where, presumably, it would gradually warm the planet. 'Human beings are now carrying out a large-scale geophysical experiment of a kind that could not have happened in the past, nor be repeated in the future,' they wrote. This experiment, they added with the morbid understatement of true scientists, 'if adequately documented, may yield a far-reaching insight into the processes determining weather and climate.'

While there are other parts to this story – the depletion of the ozone layer, acid rain, genetic engineering – the story of the end of nature really begins with this greenhouse experiment, with what will happen to the weather.

Over the earth's history, great amounts of carbon dioxide have been vented from volcanoes. Almost all of it has been chemically transformed into calcium carbonate, magnesium carbonate, and organic matter. And almost all of this has been buried in sediments deep beneath the sea – there is about one hundred thousand times as much carbon dioxide buried beneath the ocean as in the atmosphere. When we drill into an oil field, we tap into a vast reservoir of this former organic matter. We unbury it. When we burn that oil (or coal or natural gas), we release its carbon into the atmosphere in the form of carbon dioxide. This is not pollution in the normal sense of the word. Carbon *monoxide* is 'pollution', an unnecessary by-product. A clean-burning engine releases less of it. But when it comes to carbon dioxide, a clean-burning engine is no better than the motor on a Model T Ford. It will emit about 2.5 kg (5.6 lb) of carbon in the form of carbon dioxide for every gallon of petrol it consumes. Over the course of about a hundred years, our engines and fires have released a substantial amount of the carbon that has been buried over time. It is as if someone had scrimped and saved for his entire life, and then spent every cent on one fantastic week's debauch. In this, if in nothing else, wrote the great biologist A. J. Lotka, 'the present is an eminently atypical epoch'. We are living on our capital, as we began to realize during the oil crises of the 1970s. But it is more than waste, more than a binge. We are spending that capital in such a way as to alter the atmosphere. It is like taking that week's fling and, in the process, contracting a horrid disease.

There has always been, at least since the start of life, a certain amount of carbon dioxide in the atmosphere, and it has always trapped a certain amount of sunlight to warm the earth. If there were no carbon dioxide, our world might resemble Mars – it would