INTRODUCTION: THE HUMAN PLANET

Four and a half billion years ago, out of the dirty halo of cosmic dust left over from the creation of our sun, a spinning clump of minerals coalesced. Earth was born, the third rock from the sun. Soon after, a big rock crashed into our planet, shaving a huge chunk off, forming the moon and knocking our world on to a tilted axis. The tilt gave us seasons and currents and the moon brought ocean tides. These helped provide the conditions for life, which first emerged some 4 billion years ago. Over the next 3.5 billion years, the planet swung in and out of extreme glaciations. When the last of these ended, there was an explosion of complex multicellular life forms.

The rest is history, tattooed into the planet's skin in three-dimensional fossil portraits of fantastical creatures, such as long-necked dinosaurs and lizard birds, huge insects and alien fish. The emergence of life on Earth fundamentally changed the physics of the planet.[1] *Plants sped up the slow*

breakdown of rocks with their roots, helping erode channels down which rainfall coursed, creating rivers. Photosynthesis transformed the chemistry of the atmosphere and oceans, imbued the Earth system with chemical energy, and altered the global climate. Animals ate the plants, modifying again the Earth's chemistry.

In return, the physical planet dictated the biology of Earth. Life evolves in response to geological, physical and chemical conditions. In the past 500 million years, there have been five mass extinctions triggered by supervolcanic eruptions, asteroid impacts and other enormous planetary events that dramatically altered the climate.[2] *After each of these, the survivors regrouped, proliferated and evolved. The diversity of plants, animals, fungi, bacteria and other life on Earth is richer now than at any point in time.*[3]

And us? Anatomically modern humans didn't arrive until nearly 200,000 years ago and it was touch and go whether we would survive. But something pulled us through, the something that differentiated us from the other species in this shared biosphere and made us so successful that we now rule our world: the human brain. We're more intelligent and use tools better than the other animals. And humans can make and control fire. Ever since the first human lit the first spark, our destiny as the most powerful species was assured. Having this external source of energy, which we could move wherever we chose, gave us power over the landscape, protection from other animals, allowed us to cook our food, keep warm and, ultimately, take over the world.

For thousands of years, humans shared the planet with Neanderthals and our other cousin species. A supervolcanic eruption at Toba in Indonesia 74,000 years ago nearly wiped us all out – the human population shrank to a few thousand. But, by 35,000 years ago, truly modern humans, indistinguishable from people alive today and littering caves and rocks with signs of their culture, had emerged and migrated out of Africa. Thus began the heroic ascent of man.

In the Stone Age, our impact as a species on the planet was limited to some extinctions – particularly of large mammals – and some local landscape

changes, such as the burning of forests. Technologies were primitive and minimal, and were fashioned entirely from renewable materials. Over the following centuries, our impact grew. Farming was invented around 10,000 years ago (about 300 generations ago; world population: 1 million), transforming some regional landscapes as human-bred plant varieties replaced wild flora. Around 5,500 years ago (world population: 5 million), cities were built and the first great civilisations emerged. The Industrial Revolution in Europe and North America, which replaced the labour of humans and beasts with machines, started having a measurably global impact about 150 years ago (world population: 1 billion), as large volumes of carbon dioxide from fossil fuels were released into the atmosphere.

Nothing, however, compares to the scale and speed of our planetary impact since World War Two, driven by population expansion, globalisation, mass production, technological and communications revolutions, improved farming methods and medical advances. Known as the Great Acceleration, this rapid increase in human activity can be seen across a vast range of things, from the number of cars to water use.[4] *It took 50,000 years for humans to reach a population of 1 billion, but just the last ten years to add the latest billion.*

This rapid transformation spurred social and economic development – a century ago, life expectancy in Europe was less than fifty years, now it's around eighty years. But the Great Acceleration has been a filthy undertaking. Pea-souper smogs shrouded cities like London killing thousands, acid rain poisoned rivers, lakes and soils, eroding buildings and monuments, refrigerant chemicals ate away at the protective ozone layer, and carbon dioxide emissions changed in the global climate and acidified the oceans. Our voracious plundering of the natural world has led to massive deforestation, a surge in extinctions and destroyed ecosystems. It has produced a deluge of waste that will take centuries to degrade. In a single lifetime we've become a phenomenal global force and there is no sign of a slowdown – in fact, our extraordinary impact on the planet is only increasing.

Meanwhile, our closest relative, the chimpanzee, is living much as he did

50,000 years ago. Humans are the only creatures to have cumulative culture, allowing us to build on the past rather than continually reinvent the wheel. But, as we fumble about on Earth's surface, hostage to the whims of our phenomenally powerful brains, humanity is undertaking a brave experiment in remodelling the physical and biological world. We have the power to dramatically shift the fortunes of every species, including our own. Great changes are already being wrought. The same ingenuity that allows us to live longer and more comfortably than ever before is transforming Earth beyond anything our species has experienced before. It's a thrilling but uncertain time to be alive. Welcome to the Anthropocene: the Age of Man.

We live in epoch-making times. Literally. The changes humans have made in recent decades have been on such a scale that they have altered our world beyond anything it has experienced in its 4.5 billion-year history. Our planet is crossing a geological boundary and we humans are the change-makers.

Millions of years from now, a stripe in the accumulated layers of rock on Earth's surface will reveal our human fingerprint just as we can see evidence of dinosaurs in rocks of the Jurassic, or the explosion of life that marks the Cambrian or the glacial retreat scars of the Holocene. Our influence will show up as a mass of species going extinct, changes in the chemistry of the oceans, the loss of forests and the growth of deserts, the damming of rivers, the retreat of glaciers and the sinking of islands. Geologists of the far future will note in the fossil records the extinctions of various animals and the abundance of domesticates, the chemical fingerprint of artificial materials, such as aluminium drinks cans and plastic carrier bags, and the footprint of projects like the Syncrude mine in the Athabasca oil sands of north-eastern Canada, which moves 30 billion tonnes of earth each year, twice the amount of sediment that flows down all the rivers in the world in that time.

Geologists are calling this new epoch the Anthropocene, recognising

that humanity has become a geophysical force on a par with the earth-shattering asteroids and planet-cloaking volcanoes that defined past eras.[5]

Earth is now a human planet. We decide whether a forest stands or is razed, whether pandas survive or go extinct, how and where a river flows, even the temperature of the atmosphere. We are now the most numerous big animal on Earth, and the next in line are the animals we have created through breeding to feed and serve us. Four-tenths of the planet's land surface is used to grow our food. Three-quarters of the world's fresh water is controlled by us. It is an extraordinary time. In the tropics, coral reefs are disappearing, ice is melting at the poles, and the oceans are emptying of fish because of us. Entire islands are vanishing under rising seas, just as naked new land appears in the Arctic.

During my career as a science journalist, it became my business to take special interest in reports on how the biosphere was changing. There was no shortage of research. Study after study came my way, describing changes in butterfly migrations, glacier melt rate, ocean nitrogen levels, wildfire frequency . . . all united by a common theme: the impact of humans. Scientists I spoke to described the many and varied ways humans were affecting the natural world, even when it came to seemingly impervious physical phenomena like weather and earthquakes and ocean currents. And their predictions were of bigger changes to come. Climate scientists tracking global warming told of deadly droughts, heatwaves and metres of sea-level rise. Conservation biologists were describing biodiversity collapse to the extent of a mass extinction, marine biologists were talking of 'islands of plastic garbage' in the oceans, space scientists were holding conferences on what to do about all the junk up there threatening our satellites, ecologists were describing deforestation of the last intact rainforests, agro-economists were warning about deserts spreading across the last fertile soils. Every new study seemed to hammer home how much our world was changing – it was becoming a different planet. Humanity was shaking up our world, and as I and others reported these stories,

people around the world were left in no doubt about the environmental crises we were responsible for.[6] It was profoundly worrying and often overwhelming.

As I followed the latest research, I heard plenty of dire predictions about our future on Earth. But at the same time I was also writing about our triumphs, the genius of humans, our inventions and discoveries, about how scientists were finding new ways to improve plants, stave off disease, transport electricity and make entirely new materials. We are an incredible force of nature. Humans have the power to heat the planet further or to cool it right down, to eliminate species and to engineer entirely new ones, to resculpt the terrestrial surface and to determine its biology. No part of this planet is untouched by human influence – we have transcended natural cycles, altered the physical, chemical and biological processes of the planet. We can create new life in a test tube, bring extinct species back from the dead, grow new body parts from cells or build mechanical replacements. We have invented robots to be our slaves, computers to extend our brains, and a new ecosystem of networks with which to communicate. We have shifted our own evolutionary pathway with medical advances that save those who would naturally die in infancy. We have surmounted the limitations that restrict other species by creating artificial environments and external sources of energy. A 72-year-old man now has the same chance of dying as a 30-year-old caveman. We are supernatural: we can fly without wings and dive without gills, we can survive killer diseases and be resuscitated after death. We are the only species to leave the planet and visit our moon.

The realisation that we wield such planetary power requires a quite extraordinary shift in perception, fundamentally toppling the scientific, cultural and religious philosophies that define our place in the world, in time and in relation to all other known life. Up until the Middle Ages, man was believed to be at the centre of the universe. Then came Nicolaus Copernicus in the sixteenth century, who put Earth in its place as just

another planet revolving around the sun. By the nineteenth century, Charles Darwin had reduced man to just another species – a twig on the grand tree of life. But now, the paradigm has shifted again: man is no longer just another species. We are the first to knowingly reshape the living earth's biology and chemistry. We have become the masters of our planet and integral to the destiny of life on Earth.

The last time our planet entered a new geological age was around 10,000 years ago and it had a profound effect on the survival and success of our species. As the last ice age ended, a new epoch of global warming called the Holocene began. Ice sheets retreated to the poles and the tropics became wetter. People came out of their caves and began taking advantage of the new conditions: grasses proliferated and those with nutritious seeds, like wheat and barley, could be farmed. Around the world, people began settling in larger communities and processing food rather than simply hunting and gathering. This stability led to the development of culture and civilisations – our species became more populous and so successful we spread across six continents. The impacts of the Anthropocene will be just as profound.

It was Nobel laureate Paul Crutzen who came up with the term Anthropocene. The Dutch chemist was sitting in a scientific conference, he told me, when it occurred to him that all the biophysical changes that researchers were discussing 'meant we weren't in the Holocene any more. The planet had changed too much from what would be considered normal for the Holocene.' Crutzen made a case for the Anthropocene in an article in *Nature* in 2002, and over the past decade the term has gained use in the scientific community.[7] Now, the British Geological Society is beginning the slow process of formally deciding and listing this new epoch, based on the changes humans are making to the biosphere that will be preserved in the geology, chemistry and biology of our planet for thousands or millions of years.[8] These include land-use changes, such as the conversion of forest to farmland, and radioactive fallout particles. Boundaries between

geological times are fuzzy and often span thousands of years, as scientists try to calculate them from stripes in rocks around the world. The geologists will have to decide when the epoch started – was it thousands of years ago with the advent of farming, a few generations ago with the industrial revolution, or the 1950s with the Great Acceleration? That decision will depend on which marker the geologists use to define the Anthropocene: the atomic tests of 1949, say, or the rise in atmospheric carbon dioxide concentration around 150 years ago.

But while the geologists battle the conceptual difficulty of palaeontological dating for an era whose palaeontology and geology are still being created, the Anthropocene has escaped the confines of academia and been embraced by a far broader section of society. The idea that humanity is having a truly planetary effect has aroused the interest of artists and poets, sociologists and conservationists, politicians and lawyers. Scientists are using the term to describe multifaceted changes to our planet and its life. And it is in the spirit of this broader definition – and the growing consensus that we are now crossing the boundary into the Anthropocene epoch – that I write this book.

So how can we recognise the Anthropocene – what are the signs that we're entering a new geological age? In the atmosphere, carbon dioxide levels are almost 50% higher than the Holocene mean – our industrial and domestic emissions of greenhouse gases are warming the atmosphere, changing the climate and disrupting weather patterns across the globe.[9] The impacts of climate change are planetary and affect all life on Earth to some degree. The atmosphere has also newly become a repository for a range of other chemicals. Mountains are losing glaciers that have covered them for many thousands of years, causing them to crumble faster – and they are also being hacked at by miners. Rivers are rerouted, dammed, drained and exhibiting a dramatic reduction in sediment flow. Farmlands have appeared out of the natural landscape and there has been an explosion in the amount of available nitrogen on the planet because of the fertilisers

we're adding. This nitrogen has increased crop yields, which has allowed human populations to soar, doubling in the last fifty years, with far-reaching consequences for the entire planet. The oceans are becoming more acidic as they dissolve our carbon dioxide emissions from the atmosphere, and they are becoming less biodiverse as coral dies and we lose fish through overfishing, pollution and warming waters. The Arctic is melting and coastlines are eroding as storms increase in frequency and violence, the sea level rises and protective sediments, mangroves and wetlands vanish.

Deserts are spreading across savannahs, forests are drying and being logged. Wildlife is being hunted and dying because of habitat loss, climate change and species invasions, pushing the planet towards the sixth mass extinction in its history. Meanwhile, we are causing the proliferation of our domesticated species and indiscriminately scattering others around the globe. We are disembowelling the Earth through mining, drilling and other extractions, littering the planet with novel compounds and materials, devices and objects, that could never have occurred naturally. And we are building enormous steel, concrete and glass cities that light up the night sky and are visible from space.

And what about the impacts of our changed planet on us? After all, we've evolved and adapted to a life in the Holocene, and the new changes have occurred very rapidly. The transformations we have made to our planet have been key in enabling us to become this superspecies – and they have also been a consequence of our extraordinary ascent. In changing the Earth we have been able to thrive, to live longer and healthier, in better comfort even in greater numbers than ever before. However, for now, at least, humans are still of nature – we evolved on this living planet, we are made of cells, we breathe air, drink water and eat protein. We rely on the biological, chemical and physical parts of our planet to provide everything, including all our materials, fuels, food, clothes, and to clean our air, recycle our water and manage our waste. Our growing population and the way we live in this new human world are making us more demanding than ever of our

planet's resources and processes. But, as we continue to change Earth, we reduce its ability to meet these needs and, as a result, we are facing crises in fresh-water availability, food production, climate change and 'ecosystem services', the immeasurable functions that the biosphere performs to enable our survival.

In the Anthropocene, we have already started to push global processes out of whack. In some cases, just tiny further changes could spell disaster for humans; for others, we have quite a bit of leeway before we face the consequences. Most of them have some sort of tipping point beyond which it will be almost impossible to return to Holocene-like conditions. For example, glacier melt at the poles could reach a tipping point at which sudden runaway melting occurs and sea level rises by metres. Fears of big changes like these have led some scientists to describe 'planetary boundaries' – biophysical limits for human safety, such as the extent of land-use change and biodiversity loss – some of which they say we've already exceeded.[10] In leaving the relative safety of stable Holocene conditions, it is clear that humans face unprecedented challenges.

The key here is how we will deal with the consequences. It may have been desirable to keep within the internationally agreed 'safe' global-warming limit of 2°C (above pre-industrial levels), for example, but we will almost certainly exceed that by the end of this century, and so the question becomes how we can live in the warmer Anthropocene environment.[11] We have always altered ecosystems to serve our needs and presumably will continue to do so. Our habitable range, for example, is not limited to the tropics, because we invented clothes and other ways to keep warm, just as air-conditioning technology keeps us cool. We have improved the planet for our survival in a number of ways, including by staving off the next ice age, but we have also made it worse. Some of those negative consequences we can overcome through technological advances or migration or other adaptations. Others we will need to reverse; some others we will need to learn to live with.

The good news is that some problems are already being brought under control. Pollution is being curbed in many countries through laws and technological improvements; radioactive pollution has been limited through the international nuclear test ban treaty. The growth in the ozone hole has also started to slow because of the Montreal treaty banning ozone-destroying chemicals. Crucially, the rate of population growth is also slowing, with many countries now in negative growth.[12] Other problems, however, remain increasing and significant threats. And, while science may be able to identify biophysical issues, it cannot tell us how to react – that is for society to decide. Humans are no longer just another animal, we have specifically *human* rights that are expected to be achieved through development, including access to sanitation and electricity – even the Internet.[13] Delivering social justice and protecting the environment are closely linked; how poor people get richer will strongly shape the Anthropocene.

The enormous impacts we're having on our living planet in the Anthropocene are a direct consequence of the immense social changes we're undergoing – changes to how we live as a species. We now support a massive global population, but we have not simply multiplied the number of small hunter-gatherer communities. More than half of the world's people now live in cities – artificial constructs of densely packed, purpose-built living spaces, which act as giant factories consuming the planet's plants, animals, water, rocks and mineral resources. Humanity operates on an industrial scale, and has needs – currently, eighteen terawatts of the energy at any time, 9 trillion cubic metres of fresh water per year and 40% of the global land area for food. It has become a super-organism, a creature of the Anthropocene, a product of industrialisation, population expansion, globalisation and the revolution in communications technology. The intelligence, creativity and sociability of this humanity super-organism is compiled from the linked-up accumulation of all the human brains, including those from the past who have left a cultural and intellectual legacy, and also

the artificial minds of our technological inventions, such as computer programs and information libraries like Wikipedia. Humanity is a global network of civilisations with a stream of knowledge already being channelled for human protection. And, just as a cloud of starlings suddenly flips direction en masse, it is difficult to predict humanity's behaviour. Although humanity is an enormous planetary force, our super-organism can be steered by individuals and its behaviour can be shaped by the societies within it – and the solutions are often to be found at the local level. We are essentially a conglomeration of chemicals that recycle other chemicals and the biosphere is capable of supporting 10 billion of us. The difficulty is doing so within social and environmental constraints.

The self-awareness that comes with recognising our power as a planetary force also demands we question our new role. Are we just another part of nature, doing what nature does: reproducing to the limits of environmental capacity, after which we will suffer a population crash? Or are we the first species capable of self-determination, able to modulate our natural urges, our impacts and our environment, such that we can maintain habitability on this planet into the future? And what of our relationship to the rest of the biosphere? Should we treat it – as every other species does – as an exploitable resource to be plundered mercilessly for our pleasures and needs, or does our new global power imbue us with a sense of responsibility over the rest of the natural world? Our future will be defined by how we reconcile these two opposing, interwoven forces.

There comes a time in a child's life when they first realise that the food they enjoy – the meat they eat – comes from an animal. That the lovely fluffy mammal they pet is also food. Some children become vegetarian and refuse to eat meat again. Most do not. At this moment in our history, we are like children, realising that the things we enjoy in life, that we depend upon, from energy to water to consumables, all come with environmental and social consequences that affect us. How we struggle to resolve this issue will determine the trajectory of the Anthropocene for years to come.

We are pioneers in this era, but we have a superior understanding of science, excellent communication and connectivity that breeds collaborative thinking. In the post-natural era of the Anthropocene, we will have to either preserve nature or master its tricks artificially. I wanted to find out how, and that would mean leaving my desk in London.

Just as latitude and longitude tell you all and yet nothing about a place, so the abstract numbers and graphs produced by scientists seemed to be telling me nothing about the new world we are living in. What's more, there is no other field of science in which the academic findings are so contested by society. People often hold extreme views on solutions to the problems of the Anthropocene – many even question established scientific fact. I was intrigued and I knew that I wanted to explore our planet at such a significant time in its history. It seemed to me that the most important people I hadn't heard from were the human guinea pigs of this new epoch – those who are already experiencing this changed world – and I wanted to see how they were coping. I wanted to delve behind the headlines, the barrage of statistics, computer models, the tit-for-tat arguments between green campaigners and corporations, the shock-doctrines and tired slogans. I wanted to investigate the truth for myself by looking at the situation on the ground, talking in person to the human players of this epoch, seeing with my own eyes the reality of our Anthropocene.

I decided to leave my job in London and set off on a quest: to explore the globe at a crucial moment in its living history, at the beginning of this extraordinary new human age. I looked at how people are learning to undertake nature's tasks. I found people creating artificial glaciers to irrigate their crops, building artificial coral reefs to shore up their islands, and artificial trees to clean the air. I met people who are trying to preserve important remnants of the natural world in the Anthropocene, and those trying to recreate the old world in new places. And I met people who are looking at ways to resolve the conundrum: to find a way for 10 billion people to live in greater comfort, with enough food, water and energy; and

yet at the same time, reduce our impact on the natural world and its ability to carry out the processes we rely on.

As I travelled through our changing planet, I looked at the world we are creating and wondered what sort of Anthropocene we want. Will we learn to love the new nature we make, or mourn the old? Will we embrace living efficiently or will we spread out over newly ice-free lands? Will we eat new foods, plant new crops, raise new animals? Will we make space for wildlife in this human world? I experienced the Anthropocene from different perspectives and met the pioneers who are negotiating a development path through the complexity of our shared biosphere. This book is a journey around our new world, a series of stories about remarkable people living in extraordinary times. It's the story of ingenious inventions, incredible landscapes and about how we have come to own Gaia for better or for worse.

As humanity faces its biggest challenge in 10,000 years, I set out to discover whether our species will survive, and how.