

INTRODUCTION

The Meaning of the Anthropocene

‘What it lies in our power to do, it lies in our
power not to do.’

ARISTOTLE, *NICOMACHEAN ETHICS*, c. 350 BC

‘The conquest of the earth ... is not a pretty
thing when you look into it ...’

JOSEPH CONRAD, *HEART OF DARKNESS*, 1899

If you compressed the whole of Earth's unimaginably long history into a single day, the first humans that look like us would appear at less than four seconds to midnight. From our origins in Africa, we spread and settled on all the continents except Antarctica. Earth now supports 7.5 billion people living, on average, longer and physically healthier lives than at any time in our history. In this brief time we have created a globally integrated network of cultures of immense power.

On this journey we have also exterminated wildlife, cleared forests, planted crops, domesticated animals, released pollution, created new species, and even delayed the next ice age. Although geologically recent, our presence has had a profound impact on our home planet.

We humans are not just influencing the present. For the first time in Earth's 4.5 billion year history, a single species is increasingly dictating its future. In the past, meteorites, super-volcanoes and the slow tectonic movement of the continents radically altered the climate of Earth and the life-forms that populate it. Now there is a new force of nature changing Earth: *Homo sapiens*, the so-called 'wise' people.

The influence of human actions is more profound than

many of us realize. Globally, human activities move more soil, rock and sediment each year than is transported by all other natural processes combined. The total amount of concrete ever produced by humans is enough to cover the entire Earth's surface with a layer two millimetres thick. We have manufactured so much plastic that it has made its way as tiny fibres into almost all of the water we drink.

We are disrupting the global cycling of the elements necessary for life. Factories and farming remove as much nitrogen from the atmosphere as all Earth's natural processes do. Since the dawn of the Industrial Revolution we have released 2.2 trillion metric tonnes of carbon dioxide into the atmosphere, increasing levels by 44 per cent. This is acidifying the world's oceans and raising the Earth's temperature.

We are also directly changing life on Earth. Today, there are about 3 trillion trees on Earth, down from 6 trillion at the dawn of agriculture. This farmland annually produces 4.8 billion head of livestock and a further 4.8 billion tonnes of our top five crops: sugar cane, maize, rice, wheat and potatoes. We also extract 80 million tonnes of fish a year from the oceans, with another 80 million tonnes being farmed.

Almost every living creature is affected by human actions. Populations of fish, amphibians, reptiles, birds and mammals have declined by an average of 58 per cent over the last forty years. Extinctions are commonplace, running at 1,000 times the typical rate seen before humans walked the Earth. On land, if you weighed all the large mammals on the planet today, just 3 per cent of that mass is living in the wild. The rest is made up of human flesh, some 30 per cent of the total, with domesticated animals that feed us

contributing the remaining 67 per cent. In the oceans, low-oxygen dead zones have appeared across 245,000 square kilometres of coastal waters. We live on a human-dominated planet.¹

The implications of these statements are profound. The cumulative impacts of human activity rank alongside other planetary-scale geological events in Earth's history. And for us, the unusually stable environmental conditions that began about 10,000 years ago, when farming emerged and increasingly complex civilizations developed, are over. We have entered a time of greater variability and extremes, the repercussions of which are only now beginning to be understood. Can humans flourish on a rapidly changing planet, or is the future one of grim survival, or even our own extinction?

Combining the Greek words for 'humans' and 'recent time', scientists have named this new period of time the Anthropocene. It describes when *Homo sapiens* became a geological superpower, setting Earth on a new path in its long development. The Anthropocene is a turning point in the history of humanity, the history of life, and the history of the Earth itself. It is a new chapter in the chronicle of life and a new chapter of the human story.

The stakes could not be higher. Yet the idea of the Anthropocene is so immense it can be debilitating. It is hard to comprehend a geological epoch. Each successive epoch in Earth's history marks an important change to the Earth, usually encoded in the life-forms that live at that time. Epochs typically last for millions of years. It is doubly difficult to grasp the reality of a human epoch. Can we even conceive of

environmental changes driven by us that will last longer than our species has existed?

Although many people use the Anthropocene as a synonym for climate change or global environmental change, it is much more than these critical threats. People began to change the planet long ago, and these impacts run deeper than just our use of fossil fuels. And so our responses to living in this new epoch will have to be more far-reaching.

As Naomi Klein said of rapid global climate change: this changes everything.² The Anthropocene embraces even more than this, encapsulating all the immense and far-reaching impacts of human actions on Earth. It says: this changes everything, for ever.

There is no single entity called ‘humanity’ that drives the changes to our home planet: specific groups of people cause each impact. Nevertheless, an analysis of these behaviours raises the question of whether humans, as a particular type of animal, are special. Other species consume resources until natural limits stop that growth – whether food supplies, nesting sites, or some other essential need. With access to vast new resources – think of the uncontrollable growth of bacteria in a Petri dish or an algal bloom in a lake – these communities grow exponentially and then collapse as resources are exhausted.

Although anatomically modern humans had emerged by about 200,000 years ago, it wasn’t until 1804 that our numbers reached one billion. It then took only a single century to pass two billion people. The sixth to seventh billion was added in just twelve years. Over the long run the

human population has grown faster than exponentially – the amount of time taken to double the population has been getting shorter – although rates have slowed since the 1960s. Of course, our impacts also relate to what, and how much, people produce and consume. In the past fifty years the global economy increased six-fold, whereas the human population only doubled. The resulting explosion in resource use and environmental impacts is out of all proportion to our numbers. So can the human enterprise, the economy included, continue to expand indefinitely given the vulnerabilities of the land, oceans and atmosphere that constitute our planetary life support system? Can we escape the exponential growth–collapse cycle of other species? Or is the Anthropocene the terminal phase of human development?

This is only one story that acknowledging the Anthropocene can tell. To some a new human epoch symbolizes a future of superlative control of our environment and our destiny. Perhaps we have become a ‘god species’, *Homo deus*, with the clever deployment of technologies solving our problems. To others a human-driven epoch is the height of hubris, the ultimate folly of the illusion of our mastery over nature. Perhaps we have prodded Earth one too many times and awoken a monster. Whatever our view, just beneath the surface of this odd-sounding scientific name, the Anthropocene, is a heady mix of science, politics, philosophy and religion linked to our deepest fears and utopian visions of what humanity, and the planet we live on, might become.

These are not abstract concerns: the story we choose to tell matters. At one extreme, if the Anthropocene began when people first began using fire or farming crops, environmental

change is merely part of the human condition. At the other extreme, if human activity transformed Earth only in recent decades, we need to question the role of technology and the development of consumer capitalism. More concretely, the changes we are making to the planet needs a response. This is because the release of carbon dioxide from fossil fuel use has already pushed Earth outside the 10,000 year period of relatively stable climate. The resulting increasing variability and extremes of weather will increasingly affect people's health, security and prosperity. What should our response be?

One answer is to stop using fossil fuels. Another could be to use geoengineering – deliberate major interventions in how our planet functions – to stabilize Earth's climate. But might such intentional large-scale interference with Earth's natural processes, such as reflecting some of the energy coming from the sun back into space, have severe unintended consequences? Could other solutions that stabilize Earth's climate, with differing planetary impacts, be better? There are no easy answers, but increasingly society will be confronted with questions like these. Once we recognize ourselves as a force of nature, we will need to address who directs this immense power, and to what ends.

Our home planet functions as a single integrated system: the oceans, atmosphere and land-surface are all interlinked. This 'Earth system' can be thought of as consisting of physical, chemical and biological components. The biological component, beginning some 4 billion years ago when life first emerged, has had planet-changing impacts which continue

today. First micro-organisms, and later plants have radically altered Earth's development, with *Homo sapiens* being a recent biological addition. This book charts the rising environmental impact of this large-brained animal, from our pre-human ancestors to the present day. The chapters proceed chronologically, beginning with the birth of Earth and ending with a look into the future.

The book is based around four main themes integral to the Anthropocene. Firstly, that the environmental changes caused by human activity have increased to a point that today human actions constitute a new force of nature, increasingly determining the future of the only planet known to harbour life. And as in past episodes in Earth's long history, this new human epoch is captured in Earth's natural data storage devices, geological sediments, that will become the rocks of the future. These changes and the resulting indelible markings, when carefully compared to past changes in Earth's history, show that the Anthropocene is a genuinely new and important phase. This is the usual focus for scientific investigations of the Anthropocene.

Yet understanding this new chapter in Earth's history requires a deeper investigation than merely comparing today's planetary changes to those of the distant past. The Anthropocene is the interlacing of human history and Earth's history. To understand the creation of the human-dominated planet we live on, we also need to take a fresh look at our history of changing the environment around us, and the legacy of these changes. As scientists, we re-interpret human history in a new way, looking through the lens of Earth system science.

This brings us to our second theme in the book. As we trace human societies from our march out of East Africa through to today's globally connected network of cultures, there are four major transitions – a pair relating to patterns of energy use and a pair relating to the scale of human social organization – that fundamentally altered both human societies and our environmental impacts on the Earth system. We call this the 'human development double two-step', with each transition leading to ever larger impacts on the Earth system.

Human societies spread worldwide as hunter-gatherers. The first transition, beginning roughly 10,500 years ago, resulted from learning to farm. By domesticating other species to serve human ends people captured more of the sun's energy. Within a few thousand years foraging had been replaced by agriculture almost everywhere. These farmers transformed landscapes, and over time changed the chemistry of the atmosphere so much that they stabilized Earth's climate. Serendipitously, farming created environmental conditions across our home planet that were unusually stable. This gave time for large-scale civilizations to develop.

The second of the four transitions was organizational: in the early sixteenth century Western Europeans began colonizing large areas of the rest of the world, creating the first globalized economy. A new world order driven by the search for private profit was born. These new trade routes linked the world as never before. Crops, livestock, and many species just hitching a ride, were moved to new continents and new oceans. Called the Columbian Exchange, this cross-ocean

exchange of species began an ongoing global re-ordering of life on Earth. This reconnecting of the continents, for the first time in 200 million years, has set the Earth system on a new developmental trajectory. Beginning in 1492, the collision of Europe and the Americas was a watershed event resulting to a new global economy and a new global ecology. Like the original agricultural revolution, this newly emerging capitalist mode of living would spread and eventually encompass almost all of humanity.

The third transition was driven by another leap in the energy available: people learned to mine and use large quantities of old concentrated stores of the sun's energy. These fossil fuels were a key component of the late eighteenth-century Industrial Revolution. Large-scale production could be centralized around factories, and humans became an increasingly urban species. One critical planetary change was the rise in emissions of carbon dioxide from fossil fuels. For 2.6 million years Earth has cycled through cool glacial and warm interglacial phases, but over time human actions have done something remarkable: delayed the next scheduled ice age and created a new planetary state, a state warmer than an interglacial – a super-interglacial. Fossil fuel use has pushed Earth outside the environmental conditions that every human culture evolved within.

The fourth, and so far final, transition was driven by a further globe-spanning organizational change. After the Second World War a suite of new global institutions was created, resulting in major increases in the productivity of the global economy alongside improvements in human health and material prosperity. Environmental historians describe these

changes and the resulting step-change in the size and variety of environmental impacts as the Great Acceleration. Since 1945 changes to the global cycling of elements and the energy balance of Earth have departed from the range of conditions of the past 10,000 years, with major consequences for societies globally. A dangerous experiment with the future of human civilization has begun.

Arriving at the present day, we turn to the third theme in the book: which of the four critical transitions constitutes the beginning of the Anthropocene? The chosen date matters because it will be used to shape political responses to living in the Anthropocene. For example, a very early date could be used to normalize and downplay today's global environmental change, while dating it to the Industrial Revolution might be used to assign historical responsibility for the impacts of today's environmental problems. Given the high stakes, who will make the monumental decision of arbitrating on when humans actions constitute a force of nature? The answer is a little-known network of committees, who will decide whether the Anthropocene will become part of the official geological history of Earth, known as the Geologic Time Scale. So far, their deliberations have been fraught and without consensus, with an official decision not expected for many more years.

In response, we present a simple method to arrive at a start date for the Anthropocene. Having established that Earth is moving towards a new state, we look to geological sediments to define an epoch, just as past epochs in Earth's history have been defined. A specific chemical or biological change in a geological sediment needs to be chosen to signal

the beginning of a new human-influenced layer of sediment. This marker must also be correlated with changes in other sediments worldwide. Called a ‘golden spike’, the marker says: *after this point Earth is moving towards a new state.*

We sift through the various golden spikes that have been proposed. Our analysis concludes that the earliest date when these geological criteria are met is the year 1610, marked by a short-lived but pronounced dip in atmospheric carbon dioxide captured in an Antarctic ice-core, reaching its lowest level in this year. Called the Orbis Spike, from the Latin for ‘world’, it marks when the Columbian Exchange can be seen in geological sediments. Much of the drop occurred because Europeans carried smallpox and other diseases to the Americas for the first time, leading to the deaths of more than 50 million people over a few decades. The collapse of these societies led to farmland returning to forest over such an extensive area that the growing trees sucked enough carbon dioxide out of the atmosphere to temporarily cool the planet – the last globally cool moment before the onset of the long-term warmth of the Anthropocene.

The 1610 Orbis Spike marks the beginning of today’s globally interconnected economy and ecology, which set Earth on a new evolutionary trajectory. It also points to the second transition we identify – from an agricultural to a profit-driven mode of living – being the decisive change in *Homo sapiens*’ relationship with the environment. In narrative terms, the Anthropocene began with widespread colonialism and slavery: it is a story of how people treat the environment and how people treat each other.

This brings us to the final theme in the book, the future

of humanity in the Anthropocene. Will there be a fifth transition to a new form of human society, perhaps one that lessens our environmental impacts and improves people's lives? Or are we akin to bacteria in a petri dish – which multiply until they have consumed the available resources and then nearly all die – are we heading for a collapse of human society? Again, the lens of Earth system science allows us to approach the question in a new way.

We view human societies as complex adaptive systems, noting that such systems change from one state to another when they are gripped by feedback loops where change reinforces further change. Analysing each of the four transitions we see these self-reinforcing loops and the emergence of new states, to agricultural, mercantile capitalist, industrial capitalist and consumer capitalist modes of living. The new form of human society that emerges is always reliant on greater energy use, greater information availability and an increase in collective human agency, and has greater environmental impacts. Understanding the non-linear history of human societies and the dynamics of additional energy and information availability begins to explain how *Homo sapiens* has become a force of nature like no other.

We make the case that since the early modern world of the sixteenth century two interlinked self-reinforcing feedback loops – the investment of profits to generate more profits, and the production of ever-greater knowledge from the scientific method – have increasingly dominated the world's cultures. These forces have unleashed ever-increasing rates of change, including environmental change. At its root, this is an outcome of the exponential growth of the global

economy, which, growing at 3 per cent per year, is expected to more than double in size every twenty-five years. When the economy was small, doubling its size had little impact – the change experienced over a human lifespan was typically modest. But as a very large economy doubles in size, and soon doubles again, ever-more dramatic changes to society and the Earth system become the norm. These rising social and environmental changes point towards either a new configuration of human society or its collapse.

A fifth transition to a new mode of living is a daunting prospect. Yet just as the post-war settlement improved lives, a new transition to a higher-energy, greater-information state could radically increase human freedoms and even undo much environmental damage. What a looming transition does mean is that the political choices made over the coming few decades may well set the course for much of humanity over a far longer time period. Our hope is to illuminate what is at stake in order to allow the crafting of humane and intelligent responses to living on our human-dominated planet.

The Anthropocene is one of the most arresting ideas to emerge from science in recent years. It could radically change the world. To do so, it must withstand intellectual scrutiny and have the capacity to alter our collective behaviour in a sustained way. Given the increasing recognition of the global environmental crisis humanity faces, the Anthropocene may have that kind of rare power. Acknowledging the Anthropocene forces us to think about the long-term impacts of the globally interconnected mega-civilization we have created, and what kind of world we will bequeath to future

generations. Perhaps it can also help us change that future to one more aligned with the name we give ourselves: *Homo sapiens*, the wise humans. This might be possible, since the Anthropocene may become one of the few scientific discoveries that fundamentally alters our perception of ourselves.

Past scientific discoveries have tended to reduce the importance of humans. In 1543 Nicolaus Copernicus set out the proof that the Earth revolved around the Sun: we are not at the centre of our solar system. Later, Charles Darwin's 1859 book *On the Origin of Species* revealed that *Homo sapiens* are descended from ape-like ancestors: we have no special origin, and are simply part of the tree of life. More recently still, the Kepler satellite and telescope has shown us that we live on just one of many trillions of planets in one of billions of galaxies in the universe. Acknowledging the Anthropocene reverses this trend. The future of the only place in the universe where life is known to exist is increasingly being determined by human actions. After almost 500 years of ever-increasing cosmic insignificance, people are back at the centre of the universe.³ One key scientific challenge of our time is to understand the power we have. Only then will we be able to answer the political question of our age more wisely: what should we do with this immense power?