Chapter 1

The Age of Humanity: Trajectories of the Anthropocene

In *The Planet Remade*, Oliver Morton states that the conception that 'humans can, in lifetimes, make changes over which the Earth unaided would labour for millions of years is at the heart of the idea of the Anthropocene' (2016: 219), while Timothy Morton (2016) stresses that the concept of the Anthropocene brings together forces that are conventionally distinct: geology and humanity, forces whose interconnections have intensified, perhaps to globally disastrous levels, in recent centuries. From this perspective, humans have become a 'geological agent' (Zizek, 2011: 330). But while the designator of the Anthropocene is one that has gathered pace in the twenty first century, the charge that humans have changed the natural conditions and developmental trajectory of the planet, and so possess the ability to artificially transform the Earth's biosphere, has a long history. For instance, the Italian priest and geologist Antonio Stoppani used the concept of the 'Anthropozoic' in 1887 to designate a new geological era 'where humans represent 'a new element with a strength by no means known to ancient worlds'' (Luciano and Zanoni, 2023: 111). Such human-made transformations were also recognized by early ecologists such as George Perkins March, who, in 1884, wrote of the human 'modifications of the flora and fauna and of the destruction wrought on forests, waters, soils, and sands' (Kates, Turner II and Clark, 1990: 3). This perception would lead the geochemist Vladimir Ivanovich Vernadsky, writing in the 1920s and working with the geologist Pierre Teilhard de Chardin and mathematician and philosopher Edouard Le Roy that, to state that given humanity's presence over the whole face of the planet, the species had become 'a powerful geological force' whose actions had transformed the biosphere, the 'planet's face,' to create an entirely new mode of the biosphere, the noosphere. This was an entirely new epoch of 'geological evolutionary change' directly influenced by human actions (Vernadsky, 2007: 414-417). Furthermore, the first images of the Earth produced by NASA missions inspired the 1972 Club of Rome to publish a report calling attention to the needs of human to limit their growth on the planet, while Eugene F. Stoermer and Andrew C. Revkin used the terms Anthropocene and Anthrocene in the 1980s and early 1990s (Steffen, Grinevald, Crutzen, and McNeill, 2011), while the philosopher Michel Serres wrote of rising levels of atmospheric carbon dioxide via the burning of fossil fuels in an age of 'enormous and dense tectonic plates of humanity' (1995: 16).

However, the concept of the Anthropocene was famously popularized in February 2000 by the meteorologist and atmospheric chemist Paul Crutzen at the International Geosphere-Biosphere Programme Scientific Committee (IGBP-SC) in Cuernavaca, Mexico, leading to its increasing usage in the circles of Earth System Science and geology, and then beyond the sciences into fields such as philosophy, ecocriticism, and postcolonial theory (Luciano, 2023). The importance and legacy of Crutzen's insistence that a new epoch had was that:

> This seminal and now fabled moment has jumpstarted discussions about the meaning, scale, and, more damning, the viability of human existence – derailing strongly held assumptions about humanity's relationship to the earth (Marzec, 2018: 586).

Given the intensified (and destructive) impact of this force, Steffen, Paul Crutzen, and McNeill (2011) argued that the term Anthropocene is argued to more powerfully captures the extent to which the Earth has definitively left its previous epoch, the Holocene, which began some 11,700 years ago. Moreover, unlike the more optimistic vision of Verdansky's (1945) science-driven noösphere, the new epoch has been propelled towards a state that is, and will progressively be less biologically diverse, progressively warmer, and subject to increasingly volatile and unpredictable weather conditions and patterns. All these forces signaled that the relationship between humans and nature had changed, following trajectories that will result in adverse environmental consequences without action being undertaken to avert 'global scale damage and suffering' (Crutzen, 2021: 13). Principally, these impacts derive from the dramatic increase of carbon dioxide (CO_2) that has entered the atmosphere; the altering and intensifying of biogeochemical cycles such as nitrogen, phosphorous, and sulfur; the modification of river flows from the sea; and diminishing animal and plant species biodiversity. As Crutzen and Eugene F. Stoermer stated in their IGBP paper prophetically warned of the dangers of the Anthropocene:

> Without major catastrophes like an enormous volcanic eruption, an unexpected epidemic, a large-scale nuclear war, an asteroid impact, a new ice age…[humankind] will remain a major geological force for many millennia, maybe millions of years to come (2000: 18).

In Amos Nascimento's (2018) view, the Anthropocene represents the latest stage in the Earth's 4.5-billion-year history that has been divided into eons, eras, periods, and epochs. For geologists, the last period in the Earth's development was the Quaternary, which began 2.6 million years ago and has consisted of two distinct epochs, the Pleistocene and the Holocene, with the beginnings of human influence on the Earth beginning toward the close of the Pleistocene epoch, with the major changes that have formed the environmental conditions of the current Earth configurations occurring during the Holocene, the epoch it is argued has now ended with the advent of the Anthropocene. Yet, while the provocative concept of the Anthropocene has become notable and widely disseminated in both scientific and cultural discourses, it nevertheless remains an unauthorized designator of the current epoch that must be confirmed as part of the Anthropocene Working Group of the Subcommission on Quaternary Stratigraphy (Steffen, Grinevald, Crutzen, and McNeill, 2011). Consequently, the confirmation of the Anthropocene is in the hands of geologists to be formally recognized, and the end of the Holocene formally confirmed. But, as Simon L Lewis and Mark A. Maslin stress, it is an onerous process to ultimately sanction that the Holocene has now given way to the Anthropocene and so add the current age into the Geologic Time Scale, the now standardized 'geochronology of Earth history' (Ellis, 2018: 38).

The process to officially define the Anthropocene begins with the reviewing of evidence of the human impact on the planet and that the evolutionary course of nature is being altered to the point that it will be detectable in the future fossil record. The second stage is the discovery of a human-influenced geological stratum, such as landfill and plastic pollution, which will ultimately 'be crushed in the usual process of forming sedimentary rocks [and] will form a thin but clear marker within future rocks, at least a millimetre thick, just from changes so far' (Lewis and Maslin, 2018: 301-302). Thirdly, there is the need to decide when the Anthropocene began, a factor that will be determined when the 'golden spike,' a Global Stratotype Section and Point (GSSP) is made to determine evidence of human-created change, deposits (numbering six) that establish changes to the Earth system which are found across the world. This should be 'isochronous,' that is, the unit of evidence that can be identified at numerous positions throughout the world at the same time (Erle, 2018). Once selected, this will be the point that is most precisely connected to the human activity that is confirmed to be altering the Earth system and the golden spike marks the beginning of the Anthropocene (Lewis and Maslin, 2018). Hence:

> The Anthropocene…invites us to imagine a world in which an alien geologist from the future detects in the strata of the ground evidence of the presence of humans long after we have gone extinct. This science fiction-like character of the concept of

> Anthropocene opens up to a retrospective reading of the current moment, a "paleontology of the present" in which humans themselves have become geological sediments (Tsing, Swanson, Gan, and Bubandt, 2017: G135-G136).

Yet, the Subcommission on Quaternary Stratigraphy has so far rejected formally recognizing the Anthropocene as a geological Epoch, yet it remains a potent means by which to understand changes to the Earth's climate, and the concept of the Anthropocene has progressively become a subject of interdisciplinary concern as it has 'evolved from its original meaning…to encompass a global and diverse range of expertises, fields, and backgrounds' (Henderson and Vachula, 2024: 2). For instance, Christophe Bonneuil and Jean-Baptiste Fressoz (2017) argue that the units that are sought in this regard are related to increased levels of atmospheric carbon dioxide and its effects on current and future global warming, leading to the increase of species extinction that will leave traces in the new fossil record. Furthermore, human changes to the nitrogen and phosphorus cycles have left traces in addition to the impact of population growth, urbanization, industrial production, mining, and agriculture, as are the artificial materials that are now part of the Earth's ecosystems, such as plastics, pesticides, and radionuclides. Therefore, there are abundant sources of human traces that are finding their way into rock strata and ice cores. Still, in lieu of its formal geological designation, the concept of the Anthropocene has significant value in capturing the scale of environmental changes that are underway, and which if not mitigated, will result in fundamental environmental challenges in the future. In this sense, Bonneuil and Fressoz argue that the:

> Anthropocene is political inasmuch as it requires arbitrating between various conflicting human forcings on the planet, between the footprints of different human groups (classes, nations), between different technological and industrial options, or between different ways of life and consumption (2017: 26).

Clive Hamilton, Christophe Bonneuil, and François Gemenne stress that an alternative approach to defining and explaining the Anthropocene comes from the disciplines that comprise Earth system science (such as climatology, global ecology, geochemistry, atmospheric chemistry, oceanography, and geology) to reveal a broad view of a myriad of changes occurring in the differing levels of the Earth system, such as the lithosphere (the outer layer of the Earth), hydrosphere (the waters of the planet), cryosphere (the frozen water zones), biosphere (the Earth regions populated by living organisms), and the atmosphere (the covering of gases surrounding the planet) that includes geological markers, but goes beyond them as indicators of the Anthropocene and is not limited to traces only evident in rock strata. Therefore:

> With this wider lens, the Earth system science claims that the Earth as a system is experiencing a shift, leaving behind its Holocene state, characterized by several millennia of exceptionally stable temperatures and sea levels, to enter a new Anthropocene state with far-reaching impacts (2015: 2).

These impacts are fundamentally affecting the environment in terms of pervasive human land use, increased retention of carbon in the world's oceans that is increasing temperatures causing sea level rises due to water expansion and melting ice shelves and glaciers, and a transforming atmosphere in the wake of fuel burning that 'have been releasing CO_2 at a rate faster than physical, chemical, and biological processes can remove it' (Hamilton, 2016: 4). Sverre Raffnsøe describes this epoch as the point in which humans have a power that differentiates them from all other forms of life on Earth, to the extent that the 'world seems to have turned towards the human, insofar as the human being is perceived as having a decisive impact on even very fundamental conditions in the world' (2016: xiii). Consequently, humans are no longer dependent on a mode of survival fixed by the Earth as more of the space of the planet has been absorbed into the domain of human activity and with the radical growth of the human population, 'a very significant part of the planet's dry biomass is now allocated to human bodies' (2016: 11). The result of this impact is that the trajectory of this human-dominated future is uncertain and unknown, and, given the scale and overwhelming force of human action, it can be considered as 'monstrous' and so 'overwhelming that one must fear it' (2016: 12). There are, as Julia Thomas, Mark Williams, and Jan Zalasiewicz (2020), argue, many reasons why the development of the Anthropocene can have an enormous (and potentially monstrous) impact and quality for the future of the planet and for the future of human and non-human life as the Anthropocene does not have the environmental stability of the Holocene Epoch. This is because the period of interglacial environmental conditions that provided the ideal conditions for human settlement and agricultural development have changed and will result in global conditions that will not be conducive to human welfare and safety. Therefore, while the Anthropocene is, in geological terms an 'eyeblink of time' (2020: 58), its traces and marks on the planet are significant and there are numerous chemical signs of its impact on the planet.

For instance, carbon has habitually been released from inside the Earth through volcanic eruptions into the atmosphere as carbon dioxide, part of which is extracted via photosynthesis in plants, which use it to grow their tissues, and in the cycle of their decaying, it is re-released back into the atmosphere. Furthermore, carbon is fossilized in rocks, coal, oil, and gas and can stay underground for millions of years until re-released by volcanic activity. Nonetheless, while carbon is a vital part of the maintenance of life on Earth, carbon release has been radically accelerated by industrial fossil-fuel burning and 'is set to disrupt a long-established climate pattern' (2020: 60). Nitrogen also comprises the bulk of the atmosphere and its value as a fertilizer to meet the food demands of growing populations grew in the early twentieth century. While nitrogen was initially obtained using saltpeter deposits, guano (seabird excreta) and the recycling of human excrement (dubbed "night soil") the Haber-Bosch process was able to artificially produce greater amounts of nitrogen for agricultural use. It was non-toxic gas rising from soil bacteria into the atmosphere that would react with the radiation of the stratosphere that Paul Crutzen (in 1970) argued was damaging the ozone layer, with nitrogen-rich fertilizers potentially increasing these emissions and the damage they were causing, with Frank Sherwood Rowland and Mario Molina later stressing that the human-made and artificial gases, the chlorofluorocarbons (CFCs), central to refrigerators and aerosols, were further damaging the ozone layer and creating a hole in the protective stratum (Ellis, 2018).

Similarly, phosphorus was also employed as a fertilizer and (in terms of calcium phosphate) meant that agricultural phosphates were once obtained from bones from slaughterhouses, the bones of fallen soldiers, dinosaur bones, fossilized excreta, and even mummified cats obtained from ancient Egyptian tombs, although the material would later be obtained via the mining of phosphate-rich rocks. In terms of environmental impact:

> Together with nitrogen, phosphorus affects wider biological productivity as it escapes from farmland into the wider environment. Fertilizer overspill into rivers and then the sea has led, since the 1960s, to hundreds of "dead zones" in shallow seas, covering hundreds of thousands of square kilometers in total…These develop in summer as plankton blooms grow, die and then sink and decay on the sea floor, using up oxygen and causing mass deaths of sea floor organisms. The resulting biological changes can be preserved into the fossil record (2020: 62).

One can also flag the impacts of insecticides in the service of enhanced agriculture, or as Rachel Carson called them, "biocides" as the result of the post-World War II industrial production of chemicals that have affected human and non-human life and have saturated 'the animate and inanimate world' ([1962] 2002: 15). Such processes will, Gaia Vance argues, only intensify as, in the wake of human population growth, farmlands will have to produce more food, creating new and evermore intensive agricultural production (and the chemical processes it depends on). But these are not the only physical transformations, as deserts replace forests (while others are razed by road building), reefs are destroyed, and Artic regions radically change from their Holocene conditions, forces that comprise an Anthropocene in which, as Vance pithily describes it, humans have 'started to push global processes out of whack' (2016: 10). Therefore, irrespective of its formal geological ratification, the concept of the Anthropocene has been extensively used to understand increased climate change and a myriad of other fundamental planetary fluctuations, such as rising mercury levels in sea life, industrial fishing, nuclear traces from bomb testing and reactor meltdowns in oceans (McCauley, 2017), ecosystem degradation or simplification to service 'a few harvestable species' (Folkes, 2021: 843). It has also involved drilling, farming, and deforestation, the latter of which has increased methane and other greenhouse gases to rise far higher than that of pre-industrial periods (Oppenheimer, 2022), although there has been, and remains, considerable debate concerning the commencement of the Anthropocene.

The Beginning of the Anthropocene: A Long Story

For an Earth-altering process that is driven by human actions, the Anthropocene has many foundational stories. Given that it is inextricably connected to human planetary activities, it is argued that the Anthropocene began as soon as humans had the ability to directly affect their environment. For example, prior to the establishment of agriculture, humans lived in hunter-gatherer groups that were able to impose their influence on the environment through the modification of land, principally using fire. It is believed that early humans (*Homo erectus*) began using fire some 1.6 million years ago for warmth and light (Clark, 2012), a force that gave later humans a unique species distinction and enabled early humans to repel predators, changed the diet from mainly vegetation-based food to an omnivorous state, and resulted in landscape fires that cleared areas of forests, woodlands, savannahs, and grasslands. Therefore, the use of fire was a unique anthropogenic practice (Bird, Bliege Bird, and Codding, 2016). This was the learning of a 'new trick,' the 'use of fire to derive energy from the controlled combustion of detrital biotic carbon such as wood and peat' (Raupach and Canadell, 2010: 211) that set humanity 'on the long path towards the Anthropocene' (Steffen, Crutzen, and McNeill, 2007: 614). Furthermore, the expansion of humans in the interglacial Holocene Epoch is argued to have increased levels of the anthropic extinctions of many megafauna species, introducing a 'novel predator' that began to rapidly damage biodiversity and drive many species to extinction (Lemoine, Buitenwerf, and Svenning, 2023). The loss of entire species in the late-Quaternary period impacted on vegetation structures and the ecosystem through 'faunal downsizing' (Ostergaard, Faurby, and Svenning, 2023: 29), such as the extinction of animals such as the mammoth, for which a combination of climate and human hunting lead to an increase in previously consumed flora that had a global warming effect. From this perspective, the onset of the Anthropocene began thousands of years (Doughty, Wolf, and Field, 2010). From these early human settlements, agriculture systems were developed that replaced natural ecosystems and established larger fixed human settlements for rapidly growing human populations (progressively by the billions), such as the establishment of towns some 11,000 years ago and then in the later cities, all of which impacted and transformed the biosphere (Norra, 2014).

While these archaic human developments and environmental impacts are profound, Lewis and Maslin (2015) argue that neither provide the necessary 'golden spike' needed to geologically confirm the Anthropocene, and nor does early agriculture, which although it did have extensive environmental impacts, its traces are too localized to form the critical GSSP indicator. Therefore, the beginnings of the Anthropocene are not to be found thousands of years ago, but rather to a specific later date in history: 1492. This date marked the arrival of Europeans in the Caribbean and soon into further territories in the Americas (marked by the voyages of Christopher Columbus and later (in 1503) of Amerigo Vespucci), resulting in a fundamental process of human population replacement. In what would become known as the Colombian Exchange, an extraordinary mixing of flora and fauna occurred, resulting in the exportation of 'New World' foodstuffs such as maize that were subsequently grown in Europe (and Asia and Africa) and sugarcane and wheat that was exported to the Americas. Additionally, a host of European animals were shipped to the new lands, such as cows, goats, and pigs (and animals that had travelled aboard the ships, such as black rats), all of which 'contributed to a swift, ongoing, radical reorganization of life on Earth without geological precedent' (2015: 174). Indeed, the 'first horses to exist in America since the Pleistocene arrived with Columbus in 1493' (Crosby Jr, 1972: 80). Furthermore, Lewis and Maslin (2018) argue that the introduction of such animals also brought diseases to the indigenous populations, with disastrous consequences, such as the pigs Columbus released in 1493, which passed on disease that caused immediate Indigenous peoples' deaths, with smallpox arriving from ships by 1519, compounded by other infections (such as influenza), for which the Indigenous populations had no immunity. Diseases (in addition to acts of military action) also played a decisive role in the Spanish conquests of the Mexican Triple Alliance, or the Aztec empire, followed by the Spanish conquistador Francisco Pizarro's conquest of the Incas in 1526. As such:

> By the 1580s, disease, ably assisted by Spanish brutality, had killed off or driven away most of the peoples of the Antilles and the lowlands of New Spain [Mexico], Peru, and the Caribbean littoral (Crosby Jr, 1972: 38).

What became Colombian Exchange, represented a global mingling of humans, pathogens, plants, and animal species that inaugurated the creation of a global economic system that connected Europe and South America and would, in the sixteenth century, see the beginning of the transatlantic slave trade in which humans were transferred to the Americas to forcibly produce cotton, sugar, and tobacco, establishing a new mode of world-economy based on a capitalist method of production and new world-system (Wallerstein, 1974). Therefore, the world witnessed a new global economic organization that represented both economic and biological homogeneity. As such:

> The impacts of the Colombian Exchange set Earth on a new evolutionary trajectory. The physical impacts are easy to see. Fields of the same crops across the world: wheat in Europe and North America, maize in Mexico and East Africa. The same animals across the world: pig farms in China and Brazil, cows in fields in England, Mexico and New Zealand (Lewis and Maslin, 2018: 164).

In terms of human cost and the environment, the Colombian Exchange resulted in a substantial decline in Indigenous human numbers in the tens of millions due to the introduction of European diseases, acts of war, slavery, and famine, which collectively resulted in a radical reduction in farming and fire use, causing widespread regeneration of millions of hectares of forests and grasslands that contributed to a decline in atmospheric CO_2 and representing an "Orbis spike" – a designator of human-driven environmental change. In consequence, for Lewis and Maslin, the 'impacts of the meeting of Old and New World populations – including the geologically unprecedented homogenization of Earth's biota – can be argued to mark the beginning of the Anthropocene' (2015: 175) and transported pollens from the New World can be found preserved in marine sediments, and so are evident in stratigraphy. However, while there is evidence to support this contention (although it is contested), as Sunil Amrith states:

> [It] is difficult to disaggregate the climatic effects of ruin and destruction in the Americas from the countervailing impact of the continued growth of cultivation, and loss of forests, across many parts of Eurasia and Africa (2024: 43-44).

While the period of the Columbian Exchange makes for a powerful evidence point for the foundation of the Anthropocene, Paul Crutzen and Eugene F. Stoemer (2000) make the case that the basis of the Anthropocene needs to be moved forward some three hundred years to the beginnings of the Industrial Revolution in England in the 1700s, a period that inaugured rapid social change, mechanization, accelerated consumption and, most potently, the expansion of fossil fuel burning. A significant aspect of the Anthropocene being traced to the Industrial Revolution is that it was not an anonymous force, but rather, has a distinctive cast of historical personages. For instance, Bill McGuire identifies these industrial practices beginning in Cromford, England, in 1771, because of the technological innovation of Richard Arkwright. Having made a substantial profit from his invention of waterproof dye for wigs, Arkwright turned his entrepreneurial interests towards improving the production of yarn from the inefficient Spinning Jenny device to Arkwright's patented mechanized spinning machine, the water frame, which could keep pace with increasing demand for yarn from the cotton industry. As the name suggests, Arkwright's innovation was driven by water wheels in newly constructed factories, in which machines replaced human muscle and handcraft skills, a process soon followed by other machine-driven producers across a range of proliferating industries, and which would be globally transformative:

> Arkwright's revolution, born on that sunny Derbyshire day in 1771, was nothing less than the Industrial Revolution. In the century that followed, a tsunami of mechanization and mass production swept across Europe and North America, destroying one way of life and replacing it with another; a seemingly unstoppable wave of change that continues to roar across the face of our planet today (2022: 3).

However, Arkwright was not the only agent transforming technology, and ultimately driving the Industrial Revolution. For example, innovations in the development of steam power were impelled by the increasing importance of coal as a primary energy source, and the pressing challenge of establishing an efficient drainage system to remove water from coal mines. An early patented machine was developed by Thomas Savery in 1698, that used the power of atmospheric pressure to bring up mine water, a steam-driven technological approach that was subsequently further developed and improved by Thomas Newcomen and used in coal mines in 1712, to the point that the Newcomen engine, 'made possible the raising of water in quantities and from depths quite unthinkable by the technologies it began to replace' (Flinn, 1984: 116). The engine enhanced the scope and scale of coal mining, enabling miners to reach seams that were previously inaccessible. This technology, argues James Lovelock, based on a machine that burned coal and used the generated heat to boil water into steam that entered a cylinder with a moveable piston, 'should be heralded not just as the start of the Industrial Revolution but also as the beginning of the Anthropocene – the age of fire, the age in which humans acquired the power to transform the physical world on a massive scale' (2019: 34-35). Yet, Newcomen's engine would itself be rendered obsolete and enhanced by James Watt, who, working with a Newcomen engine, added an additional unit to the machine that enhanced fuel efficiency, the design of which he patented in 1784 and was used in coal mines and steam driven textile mills, but later employed to power steamboats and steam trains (Merchant, 2020). The relevance and addition of Watt to the industrialization story is crucial because, as Crutzen states:

> The Anthropocene could be said to have started in the latter part of the eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane. This date also happens to coincide with James Watt's design of the steam engine in 1784 (2002: 23).

The crucial element regarding these innovations as playing a role in identifying the origin of the Anthropocene is that they ushered in a new era of industrial production: fossil capital. As Andreas Malm (2016) argues, it was coal (unlike wood) that was the most feasible fuel choice for the new steam age, and its direct effect on the atmosphere with rising levels of CO_2. This was because, Anthony N. Penna explains, because steam power initiated further industrial mechanization, which in turn required greater levels of power. While mining for coal predated the Industrial Revolution, it became a dominant energy source, and one that physically transformed the environment:

> Mining coal, the product of compressed plant and animal biomass and buried for as long as 550 million years, changed the landscape of the countryside. The impact on air quality would become transformative. Residential and industrial burning blackened the skies, killed vegetation of all kinds from trees to weedy plants, and stained the built environment with tar and soot (2010: 187).

Coal also played a decisive role as an engine of expanding urbanization in terms of the rapid spread of cities and towns, and, in the nineteenth century, Britain was a leading coal exporter, facilitating the expansion and acceleration of international industrialization (Hatcher, 1993). However, in the early twentieth century this supremacy would be threatened by competition from American, first in the face of its coal industry, but more substantially from the proliferation of a new fossil fuel: oil (Church, 1986). As Paul Roberts argues, the beginning of the end of the 'coal age' was set in train on the 10th of January, 1901, when, in Texas on the Spindletop hill, a huge well of oil was stuck, an action that would transform oil from a small component of the energy industry into the prime fossil energy source. Formed fifty million years previously from the fossilized bodies of ancient plankton which were 'pressure-cooked' by layers of sandstone into 'a complex hydrocarbon brew known as petroleum' (2005: 33). Spindletop, and later large oilfields in North and South America, would produce tens of millions of barrels of oil, and as its price fell, it rapidly overtook the use of coal as the key source of energy production. Consequently, shipping companies converted their vessels to be powered by oil, and it was gasoline, previously an unused by-product of oil production, which enabled the proliferation of internal-combustion engine driven automobiles, replacing early innovations with steam and electric-powered vehicles. Hence, the release of 'the Sun's energy sequestered in fossil coal and oil by increasingly mechanized mining and drilling operations would provide the fuel for the age of industrialization' (Penna, 2010: 303). Furthermore, fossil fuels would radically change human relations with the ecosystem in comparison to constraints other species live within, effectively changing fossil fuels into food through mechanized production processes and food transportation (Lynas, 2007), but with a severe environmental cost. As Roberts states:

> Climate change is the latest and possibly greatest confirmation that our great mastery of energy may be more accurately described as a series of accounting errors. Though cheap, plentiful fossil fuels have clearly been key to our industrial success and continued economic vitality, we are discovering that our rosy picture of energy as the key to Prosperity has omitted a number of serious costs, from geopolitical instability and oil price volatility to…rising global temperatures due to centuries of carbon dioxide emissions (2005: 118).

From this perspective, the major impacts of industrial processes that drive the Anthropocene have been experienced and dramatically exacerbated from 1945 rather than the early 1800s, leading to yet another moving forward of the start date of the Anthropocene to what has been dubbed the 'Great Acceleration.' While Eunice Foote in 1856, John Tyndall in the 1860s, and Svante Arrhenius in the early twentieth century conducted experiments to determine rising levels of carbon dioxide in the atmosphere and made predictions of future increases of atmospheric carbon dioxide and warming, its impact (in addition to other greenhouse gases) would become a factor in the twentieth century, leading to the establishment of the Intergovernmental Panel on Climate Change in 1988 (Darwell, 2013; McGuire, 2022). Furthermore, there were other determining factors identified as representing the crucial 'golden spike' needed to determine the signature of the new epoch of the Anthropocene, most significantly radiation.

A major factor in the Great Acceleration argument are the traces in the Earth left by nuclear tests. From this perspective, the beginning of the Anthropocene could be dated precisely at 5:30 a.m. on July 16, 1945, the moment in which the world's first nuclear device was detonated at the Trinity site in Los Alamos. Its era-transforming impact was described by the New York Times journalist and test witness William L. Laurence in the following way: 'The big boom came about 100 seconds after the Great Flash – the first cry of a new-born world' (Bird and Sherwin, 2023: 309). Yet, it would be the legacy of the Trinty test that would identify nuclear testing as a prime indicator of the Anthropocene. As Waters et al. stress, the single atomic explosion, although momentous in terms of human impact on the world, was too localized to make a durable stratigraphic mark:

> In contrast, the fallout from numerous thermonuclear weapons tests that began in 1952 deposited large amounts of radionuclides in the environment and left a well-defined radiogenic signature. That level would provide an effective global signal that marks the beginning of the Anthropocene, in comparison to using the Trinity Test as a marker (2015: 49).

Given that there would be 2,053 nuclear weapons tests between 1945 to 1998, Waters et al. argue that the fallout signals such tests as a strong marker for the onset of the Anthropocene as strontium 90, cesium 137 and especially plutonium 239 dispersal have left 'a clear radiogenic signature in the global geological record (2015: 55) and this fallout 'has so saturated daily existence that humans have had a hard time seeing it, even though it reconfigures ecologies and bodies' (Brown, 2022: 195).

First used by a group at the 2005 Dahlem Conference exploring historical understandings of human-environment relationships, the 'Great Acceleration' was derived from Karl Polanyi's (1945) concept of 'The Great Transformation,' that explained the myriad changing dynamics of contemporary societies, such as revolutionary developments in the industrial 'tools of production,' the advancement of the market economy, and capitalist organization. From this perspective:

> [The] term 'Great Acceleration' aims to capture the holistic, comprehensive and interlinked nature of the post-1950 changes simultaneously sweeping across the socio-economic and biophysical spheres of the Earth System, encompassing far more than climate change (Steffen et al. 2015: 82)

The Great Acceleration, therefore, places climate change as a major factor in terms of human impact from the mid-twentieth century, but the scope of environmental factors and impacts is far more extensive and cumulatively intensifies the destructive marks that humanity is making on the Earth, traces that can be geologically read. As J.R. McNeill and Peter Engelke (2014) argue, the factors that have radically increased since 1945 include a huge increase in the numbers of automobiles on the planet and their pollutant effects, dramatic population growth, and the proliferation by millions of tons of plastics use and plastic waste, much of which finds its way into oceans where it effects marine life. On the one hand, fossil fuel industries have contributed to increased atmospheric carbon dioxide emissions, with a pre-industrial level of 280 ppm reaching over 400pm, and this resultant warming leads to effects on the world's oceans, most immediately, the melting of sea ice and resultant sea level rises. But on the other hand, fossil fuel extraction has transformed the physical landscape, such as mines creating 'honeycombs' in the Earth that can cause subsidence, slag heaps of mine waste that deface and damage the surrounding landscape and which can also contaminate waterways, which strip mining destroys mountains, the debris of which fills streams and buries forests. Furthermore, there is the human cost for those who have worked in the mines in terms of industrial deaths and post-work fatal diseases and health conditions. Meanwhile, oil drilling and exploration affects the natural landscapes as accidents with sea-borne tankers have created disasters for the natural environment, and air 'pollution, mainly from coal and oil burning [has] killed tens of millions of people' (2014: 21). Further signs of the Great Acceleration are also left in sites such as the Chernobyl Exclusion Zone, in which the reactor explosion that occurred in 1986 in the Ukraine left the zone unsafe for human habitation for some two hundred years. Moreover, acts of environmental warfare, such as the American use of defoliants in Vietnam, have left effects that have endured decades after the end of the conflict in 1975. Of the validity of the concept of the Great Acceleration, McNeill and Engelke stress:

> As we see it, the Anthropocene began when human actions became the main driving forces behind some basic Earth systems, such as the carbon cycle and the nitrogen cycle, and the general human impact on the Earth and its biosphere lurched upward to new levels. While it is futile to try to pinpoint this moment precisely, the weight of the evidence points toward a date in the middle of the twentieth century, something like 1945 or 1950 (2014: 211).

The continual growth of cities, with urban populations being more densely concentrated are major contributors to climate change in this regard, in which these the artificial building materials are creating 'urban heat islands' whereby anthropogenic 'activity contributes to increase the concentrations of air pollutants, which are considerably higher in urbanized areas.' (Cichowicz and Bochenek, 2024: 2). Furthermore, it is argued that further human-driven impacts on the planet because of climate change are the increase in large-scale wildfires, a factor exacerbated as humans increasingly inhabit fire-prone areas of the world, which is escalating the risks of such fires starting and their scale. These wildfires also release massive stores of carbon, and climate change is drying peatlands and rendering them more flammable and a rising cause of pyroclimatic change (Kinoshita et al, 2016; Folke et al, 2021; Clark and Richards, 2022), to the point that the modern era can be dubbed the Fire Age, or the Pyrocene (Pyne, 2021). Additionally, anthropogenic climate change is thawing permafrost that is exposing matter that rapidly decomposes and releases further carbon dioxide and methane into the atmosphere, but which also has the potential to revive prehistoric viruses which can remain infectious to the point that permafrost can represent 'reservoirs' for dangerous pathogens and microbes (Alempic et al., 2023; Wu, Trubi, Tas, and Jansson, 2022). Alternatively, medical scientific activities in the Anthropocene have affected non-human and human biota and have transformed the bacterial world, with the widespread use of antimicrobial agents resulting in the evolution of harmful bacterial lines that have 'negative effects on human health, agriculture, and aquaculture' (Gillings, 2017: 30). However, genetics are serving as ways in which the effects of the Anthropocene in terms of accelerated levels of species extinction are (or will be in the near-future) being mitigated in terms of conservation through de-extinction, regarding animals such as the passenger pigeon, the thylacine, and even the mammoth to the extent that de-extinction 'aims to recapture something lost – in many cases, long lost' (Sandler, 2017: S45).

The technological drivers of the Great Acceleration have evolved into the twenty-first century as technological changes such as artificial intelligence (AI) have initiated a new wave of economic, cultural, and social transformations. The use of artificial intelligence in countering climate change is a crucial factor given its data-informed predictive scope and applications in environmental awareness, resource conservation, and the development of new and greener forms of urban planning and building (Folke et al., 2021). Yet, as Kate Crawford argues, artificial intelligence is 'an extractive industry and the creation of contemporary AI systems depends on exploiting energy and mineral resources from the planet' (2021: 15). While artificial intelligence may appear as an immaterial technology, it is profoundly dependent on natural resources and has a significant (and accelerating) environmental impact. As such, computational representations such as the 'cloud' conceal the fossil-fuel and natural-resource dependent reality of AI, from the data centers that house servers that are now among the world's largest consumers of electricity, to the lithium batteries that power the computers that AI is accessed and utilized on. Therefore, AI and computer technologies need lithium mines in locations such as Nevada, Bolivia, Central Congo, Mongolia, Indonesia, and the Western Australian deserts, and so:

> The effects of large-scale computation can be found in the atmosphere, the oceans, the earth's crust, the deep-time of the planet, and the brutal impacts on disadvantaged populations around the world (2021: 28).

Therefore, AI and computers are finding their ways into the strata of the Earth to represent core technological signs of human impact and are part of future Anthropocene signatures. Yet, alternative examples of the Great Acceleration and technology are not leaving distinctive traces on, and in, the planet, but rather, above it. As Ruth Lisa Rand explains, since the 1957 launch of the Sputnik satellite, the number of 'spacefaring nations' (and billionaire-owned private companies, such as Space X and Blue Origin) and their space travel activities have proliferated, producing both numerous satellites circumnavigating the planet, and a mass of 'uncontrolled orbiting waste, colloquially known as space junk' (2017: 66). At one level, this is creating an ever-increasing belt of space debris, but some of these artificial objects can, and do, fall back to Earth, some of which bring with them the risks of chemical and radioactive pollutants. Consequently, the scope and scale of the Great Acceleration and its ongoing results have seen the biosphere and the immediate space beyond the atmosphere bear the marks, signs, and objects of humans, with the result that:

> The Earth of the Anthropocene is a much larger world than can be bounded by biology, geology, or atmosphere. Through the production, use, and discarding of spacecraft and space junk, humanity has broadened the boundaries of anthropogenic geophysical change into the universe (2017: 69).

However, regarding space debris and jettisoned rocket parts in orbit around the planet, SpaceX has perfected the capture, using huge mechanical arms on the launchpad, of descending rocket boosters so that they can be refurbished and subsequently relaunched (Harwood, 2024) and so not discarded in space. While Crutzen emerged as a leading proponent of the Anthropocene, cataloguing the negative impacts (and potentially bleak future) of the human-impacted epoch, his solution and hope for an optimistic outlook for both humans and the planet lie in technological innovation. From this perspective, the Anthropocene may be balanced between the plundering of natural resources and the inclusion of artificial waste into the environment with the wiser use of improved technology and planetary management. As such, the legacy of the Great Acceleration holds the promise of mitigating the worst excesses of the Anthropocene in the form of geoengineering projects that have the potential to repair human-caused damage and counter high levels of atmospheric carbon dioxide as the result of fossil fuel-driven societies. Therefore, Crutzen is hopeful for the future in this regard:

> There is little doubt in my mind that as one of the characteristic features of the "anthropocene," distant future generations of "homo sapiens" will do all they can to prevent a new ice-age from developing by adding powerful artificial greenhouse gases to the atmosphere. Similarly, any drop in CO_2 levels to excessively low concentrations, leading to reductions in photosynthesis and agricultural productivity would be combated by artificial releases of CO_2 (2006: 17).

However, Crutzen's faith in a future technological/geoengineering solution is regarded as a weakness in his approach to the Anthropocene and is a strategy that is just as likely to worsen planetary environmental conditions and represent a further tranche of human-initiated influences and effects on the Earth system. Consequently, Naomi Klein argues that geoengineering will 'monsterize' the planet. This is because:

> We very likely would not be dealing with a single geoengineering effort but some noxious brew of mixed-up techno-fixes – sulphur in space to cool the temperature, cloud seeding to fix the droughts it causes, ocean fertilization in a desperate gambit to cope with acidification, and carbon-sucking machines to help us get off the geo-junk once and for all. This makes geoengineering the very antithesis of good medicine, whose goal is to achieve a state of health and equilibrium that requires no further

> intervention. These technologies, by contrast, respond to the lack of balance our pollution has created by taking our ecosystems even further away from self-regulation (2014: 279).

Geoengineering, therefore, can be read as a further stage in the human drive to control nature and the environment and is a set of scientific and technological processes that further serve to challenge an ethical sense of human 'humility in the Anthropocene epoch' (Minteer, 2012: 858). Indeed, the issue of the human, and human suffering, in the various accounts of the inception of the Anthropocene are a crucial factor. As Kathryn Yusoff argues in *A Billion Black Anthropocenes or None*, the geological search for the 'golden spike' in each of the 'natal' moments of the Anthropocene: The Columbian Exchange, the Industrial Revolution, and the Great Acceleration, obscures the human costs in these movements. Hence, while the 'New World' Anthropocene beginning does stress the genocidal consequences of European colonialist expansion, the human factor is subsumed beneath relations of economic exchange, although this argument concerning the origin of the Anthropocene does unequivocally align death and displacement to represent the 'spatial inscription of colonialism (and race) into a monument of global environmental change' (2018: 32). The later origin moment of the Anthropocene, the Industrial Revolution, while focused on the inventions of figures such as James Watt to expand fossil economy, was also fundamentally built on relationships predicated on 'productive slavery and its organization of human property as extractable energy properties…an intrinsic and functional part of a capitalist system' (2018: 41). Finally, the radioisotopes signatures from nuclear weapons tests, one of the prominent confirmations of the mid-twentieth century Anthropocene foundation point of the Great Acceleration, obscures the ways in which Indigenous people in the Pacific Islands (but also in North American and Australia) were displaced or even exposed to radiation during the tests, with severe human costs:

> Islanders in the Atolls were both proximate to the nuclear fallout, where they were exposed to radioactive ash , and moved to uninhabitable islands…Islanders on Rongelap and Utrok exposed to the Bravo detonation (six islands were vaporized and fourteen left uninhabitable) were subject to immediate radiation from the blasts and suffered visible burns causing both immediate and lasting epidemiological

> legacies…The white power of irradiated coral dust that fell throughout the Atolls was dangerously radioactive (2018: 47).

The focus on differential human experiences throughout the differing ways of explaining the origins of the Anthropocene have given rise to the questioning of the validity of the designator, given that the 'anthropos' component implies a monolithic human impact on the planet. As Yusoff's analysis and critique illustrates, the economic system of capitalism runs throughout the distinct stages of the Anthropocene, from 1492 to 1945, and the driving force of these systems have been an elite that was not global or universal, and that it is capitalists, not the entirely of humanity, that drive the Anthropocene:

> The choice of a prime mover in commodity production could not have been the prerogative of the human species, since it presupposed, for a start, the institutions of wage labour. Capitalists in a small corner of the Western world invested in steam, laying the foundation of the fossil economy; at no moment did the species vote for it either with feet or ballots, or march in mechanical unison, or exercise any sort of shared authority over its own destiny and that of the earth system. *It did not figure as an actor on the historical stage* (2016: 267).

Therefore, if capitalism, and its attendant scientific and technological forces, is argued to be the harbinger of climate change and its deleterious environmental effects, should the epoch of the Anthropocene be called the Anthropocene?

Anthropocene, Capitalocene, Technocene, or Necrocene?

In the view of Jason W. Moore, the Anthropocene needs to be remade as the Capitalocene, which represents 'an ugly word for an ugly system' (2016: 5). The Capitalocene position stresses that the history of capitalism is a relation of capital, power, and nature as an integrated whole, but it transcends the view that the system (and the attendant beginning of the Anthropocene) predates the fossil-fuel economy and the industrial system of late eighteenth and early nineteenth century England and rejects the Eurocentric view of the origins of capitalism. The roots of this system lay in the long sixteenth century, spanning 1450-1640 that ‘marked an epochal shift in the scale, speed, and scope of landscape transformation across the geographical expanse of early capitalism’ (2016: 96). The consequences of the rise of capitalism were a process of rapid ecological transformations to become a global system of human and environmental exploitation to the point that the ‘genius of capitalism – from the global conquests that commenced in 1492 – has been to treat the work of nature as a “free gift”’ (2016: 112) and that the ’Anthropocene did not arise fully armed from the brain of James Watt, the steam engine and coal’ (Bonneuil and Frssoz, 2017: 229). The system of exploitation of humans and the natural world from the sixteenth century is what created the foundations for industrialization, and so, looking at the relevance of Marxist ideas in the context of the Anthropocene, it is argued that there is a need for an alternative degrowth communist system. As Kohei Saito argues:

> Many people are well aware of the fact that the current mode of living is heading towards catastrophe, but the capitalist system does not offer an alternative to the juggernaut of overproduction and overconsumption. Nor is there any compelling reason to believe that it will soon do so because capitalism’s systemic compulsion continues to employ fossil fuel consumption *despite* consistent warnings, knowledge and opposition (2022: 1).

Yet, Justin O’Brien pushes the concept of the Capitalocene further because the system of capitalism ‘was born from extinction, and from capital, extinction has flowed. Capital does not just rob the soil and worker, as Marx observes, it necrotizes the entire planet’ (2016: 116). Here, the Capitalocene represents the Necrocene, the “New Death,” a system that is predicated upon causing extinction, from peoples, cultures, biodiversity, and the Earth itself through its relentless exhaustion of natural resources, from fossil fuels and minerals to chemicals, deforestation, extensive nuclear weapons testing, widespread plastics waste, ocean acidification desertification, melting ice sheets and the resultant rise in sea levels. Extinction, then, is at the core of capitalism to the extent that the ‘Necrocene is the Capitalocene’s shadow double…its monstrous sublime and uncanny paradox’ (McBrien, 2016: 117). However, there are issues with giving the new epoch the name Capitalocene, from the focus on the industrial nature of Great Britain, which gives the epoch a distantly Eurocentric quality, to the ways in which the foundations of the Industrial Revolution and capitalism predate fossil capital by centuries (Ejsing, 2023). As such, there are other terms for the Anthropocene. For instance, in the wake of the extensive environmental effects of transportation technology and human mobility, Nathalie Roseau (2022) suggests the Kinocene is an accurate term, while, given the essential driving forces of technology that have transformed the processes that govern the Earth System, it is suggested that the epoch should therefore be called the Technocene (Lopez-Corona and Magallanes-Guijon, 2020). While Ivan Ivakhiv opts for the 'AnthropoCapitalocene, or A/Cene' (2018: 26), there are a myriad of alternative appellations, such as: Accumulocene, Carbocene, Corporatocene, Econocene, Idiocene, Plantationocene, Pyrocene, Manthropocene, Misanthropocene, Thermocene, Traumacene, and the Urbocene (Bould, 2021).

Alternatively, Bernadette Bensaude-Vincent and Sacha Loeve stress that the concept of the Anthropocene has acquired the status of a new grand narrative of modernity, the latest iteration of a story in which the passive Earth is an object of human management and engineering that privileges humanity and places anthropos 'on an overhanging pedestal to contemplate the passage of time' (2024: 2013). As they argue, given the differing ways in which carbon is present in the Earth System and interacts with numerous other natural processes, it is inaccurate to place humans at the centre of the planet in an exalted position compared to all other species. This is because humans 'may be a geological, telluric and climatic force, but so are coccolithopores, bacteria and worms' (2024: 2019). Therefore, to counter the catastrophes that the Anthropocene has and will continue to create if humanity takes no mitigating action, Bensaude-Vincent and Loeve call for new narratives to preserve life in the Anthropocene. These must consist of multiple perspectives and climatic effects and natural conditions and processes, and so responses to the realities of the Anthropocene should be 'chthuluiform' in their nature, drawing from Donna Haraway's concept of the Chthulucene. Derived from the Pimoa Cthulhu spider (and not H.P. Lovecraft's literary deity), which lives under tree stumps in redwood forests in North Central California, Haraway prefers the 'tentacular' essence of what is dubbed the Chthulucene to that of the Anthropocene or the Capitalocene as its focus is on a multispecies understanding of the planet and the realization humans are not the imperative species to which all other species can only react to, but rather, there needs to be the recognition of the symbiosis that exists between the human and the non-human. In this regard, the concept of the Chthulucene presents a more optimistic, or at least less cynical, view of the future than those of the Anthropocene and the Capitalocene:

> The unfinished Chthulucene must collect up the trash of the Anthropocene, the exterminism of the Capitalocene, and chipping and shredding and layering like a mad gardener, make a much hotter compost pile for still possible pasts, presents, and futures (Haraway, 2016: 57).

Haraway argues that a primary way to establish such changes and offset unquestioned anthropogenic environmental effects is the need to recognize connections with other species because the destructive processes affect the human and the non-human alike, and so there is the imperative in the Chthulucene to 'make kin' with other species and recognize the myriad connections that exist on the planet (Haraway, 2015: 162). Yet, while the 'age of humanity' has now acquired multiple names, Ian Angus, who agrees that capitalism needs to be replaced by an economic and social organizational structure based on Eco-socialism, also argues that in terms of nomenclature, there is no need for any renaming: the Anthropocene *is* the most appropriate appellation to describe the geological epoch.

The crux of critical responses to the term Anthropocene lies, from its basis in the Greek root word Anthropos, in its inference that the innumerable environmental changes affecting the Earth System are the responsibility of *all* humans, but the adding of differing words to the suffix of 'cene' does not capture the nature of a new epoch. As Angus explains, the suffix of cene derives from the Greek word kainos, which means 'recent,' introduced by the geologist Charles Lyell in the nineteenth century to distinguish between differing layers of rock in terms of the presence of extinct and non-extinct fossils in these layers. Therefore, the intervals of Miocene, Pliocene, and Pleistocene progress in terms of how recent the fossils are, naming the last stage as Recent, until renamed the Holocene in 1885. Therefore, the fusion of kainos with anthropos is not a universal designator that humans are universally complicit in forces such as climate change, but instead signals, in accordance with Lyell's methodology, the most recent epoch, 'a time when geological strata are dominated by remains of recent human origin' (2016: 231). Furthermore, concepts such as anthropogenic climate change do not implicate all humans in environmental changes, but stress those that differ from natural processes to understand 'an epoch of global change that would not have occurred in the absence of human activity' (2016: 232). Similarly, while Anthropocene does not capture all aspects of human activity (hence the alternative names), Anna Lowenhaupt Tsing et al. reason that the term Anthropocene 'has become a gathering point for discussion of environmental dangers, across disciplines and political divisions, and this seems to us a good enough reason to use it' (2024: 23).

Telling Anthropocene Stories

Paul Crutzen has argued that fixing the inception of the Anthropocene is a principal element in understanding it, yet others, such as Roy Scranton, present an alternative view:

> The Anthropocene: Is it an "epoch" like the Holocene, or merely an "age" like the Calabrian? Did it start with the beginning of the Industrial Revolution, around 1800, or during the Great Acceleration in the middle of the 20th century? With the dawn of agriculture, 12,000 years ago, or on July 16, 1945, with the first atomic bomb? Whenever it began, it is the world we now live in (2015: 18).

For Lewis and Maslin, in understanding the Anthropocene, 'stories matter' (2018: 397) and in essence, the Anthropocene is now a process that lies at the heart of numerous 'natal' stories, all of which stress a different point of origin and set of processes that have enabled humans to become a planetary force, but which are united in the view that humans *have* become such a force and are actively transforming the Earth System. It is in this sense that the Anthropocene cannot be used as 'a proxy for saying that the world is facing an environmental crisis. Instead, it is meant to suggest something far more profound and lasting' (Kress and Stine, 2017: 4), myriad processes that, due to climate change and warming, are rendering more parts of the planet uninhabitable and producing increasingly erratic weather patterns to the point that, if 'unchecked, constitutes an existential threat to our civilization' (Giddens, 2011: 1). As such, an important element in the academic study and understandings of the Anthropocene is that it has become 'a topic of interdisciplinary interest' to the point that the 'Anthropocene has evolved from its original meaning…to encompass a global and diverse range of expertises, fields, and backgrounds' (Henderson and Vachula, 2024: 2). As such, while the Anthropocene has yet to be formally ratified:

> The Anthropocene is better understood as an ongoing, intensifying planetary event…The concept has opened up interdisciplinary advances on crucial planetary issues, including discussions of societal transformations to reduce and reverse humanity's damage (Maslin, Edgeworth, Ellis, and Gibbard, 2024: 41).

For instance, in evaluating the value of the Anthropocene concept, from the perspective of its relevance for design and architecture, Etienne Turpin argues that:

> Regardless of the eventual conclusion arrived at by the geo-scientific community of experts considering the merit of this new era, the concept of the Anthropocene affords contemporary scholars, activists, and designers a unique opportunity to reevaluate the terms of theory and practice which have been inherited from modernity. Not least among these inheritances is the assumption of an ontological distinction between human culture and nature (2013: 3-4).

Culture is indeed an essential element as understandings of the Anthropocene encapsulate more areas of understanding beyond geology, because, as Taffel states, the 'narratives we propagate about our past and present actions have important consequences for the future that comes to pass' (2016b: 2019), and popular culture is a significant voice in this regard. As Amitav Ghosh stresses, the 'Anthropocene presents a challenge not only to the arts and humanities, but also to our commonsense understandings and beyond that to contemporary culture in general' (2016: 9), such as literary fiction. However, Mark Bould stresses that it is not merely 'serious' fiction that is confronting climate change and the Anthropocene, but also wider popular culture, from film and television to graphic novels and science fiction, all of which articulate differing conceptions of the Anthropocene, to the extent that 'the Anthropocene *is* the unconscious of the 'art and literature of our time'' (2021: 5). Popular culture, therefore, has something profound to say about the Anthropocene, and in many ways with many different visions. Thus, if, as Scranton envisions: 'Our future promises to be as savage as our past' (2015: 53), Anthropocene cultural stories enable us to explore the differing natal points of the epoch and its varying effects and potential outcomes, however imaginative these may be, because, as Haraway reflects on in relation to the speculative value of a multi-layered science fiction, storytelling can enable the conception of worlds of the past, present, and future, which is a vital element because: 'Myriad tentacles will be needed to tell the story of the Chthulucene' (2016: 31).

As Nigel Clark argues, while the acceleration of a fossil-fueled industrial society may well be the period in which humans decisively began to affect the Earth system, 'the pivotal significance of climate change also suggests that we may have yet to witness the Anthropocene's full unfurling' (2014: 23), but popular culture, in a multitude of ways and differing visions, speculatively imagines and warns of what this unfurling might be. Moreover, this is essential, as Jamie Lorimer asserts in relation to the value of science fiction, because the

Anthropocene ‘requires an act of speculation alien to the retrospective periodization of the geosciences’ (2017: 128). If, therefore, as Fry argues, ‘ecological disasters - actual and expected – are now one of the staples of the media, movies and novels’ (2017: 32), it is novels and fiction, the cultural forms that Fry argues in terms of speculation and ‘what if?’ scenarios that can ‘create the conditions that make the seemingly impossible possible as an actuality or appearance’ (2022: 13). These stories now represent essential critical readings, understandings, and warnings of the Anthropocene, and popular culture is a rich seam.