NEXT LEVEL CLIMATE THINKING AND ACTION

CLIMATE ACADEMY

Chapter Two

Mass Extinction Events

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INTRODUCTION:

Spotting Mass Extinction Events

Spotting mass extinction events is a surprisingly difficult thing to do. For a start, such events only happen about once every 750 million years, on average,[1] so it is quite difficult to get any decent practice. Indeed, apart from the current extinction event, they all happened well before human beings landed on the planet - so we need the help of Geologists to see them.

As a spectacular warm-up act[2], the Earth was utterly transformed by tiny cyanobacteria 2.4-2.05 Ga (billion years ago)[3]. These microscopic organisms produced a chemical in vast quantities that was devastatingly toxic to most life forms. That chemical was oxygen. Of course, we are now very glad that these cyanobacteria had worked out the trick of photosynthesis. A decent level of oxygen in the atmosphere is rather important for us. But it was categorically not good news for over 90% of life on earth at the time, who could only function in anaerobic mode. This "Great Oxidisation Event" created the conditions for complex life on Earth to get started[4].

The biggest wipeout of the biosphere (in this advanced state) occurred approximately 251.9 million years ago[5], it is often referred to rather starkly as "The Great Dying" (or more technically as the "Permian-Triassic Extinction Event"). It was caused by formidable level of volcanic activity that poured out over a billion cubic kilometers of lava in the Siberian Traps. The scorching temperatures that followed (globally) eliminated over 80% of all marine life[6] and over 70% of all terrestrial life. If you would like to count, this was the third mass extinction event.

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[1] The age of the Earth: 4.54 ± 0.05 billion years. However, it might be more relevant to start the clock at the first mass extinction event which was 444 million years ago because it took quite a while for life to evolve into complex forms. If we count 6 events, there are 5 periods in between, thus the average period between mass events has been 444 / 5 = 88.8 ~ 90 million years.

[2] I write warm-up act, but as this paragraph is about the most significant cooling in planet Earth's long history.

[3] B. E. Schirrmeister, J. M. de Vos, A. Antonelli, H. C. Bagheri. « **Evolution of multicellularity coincided with increased diversification of cyanobacteria and the Great Oxidation Event ».** *Proceedings of the National Academy of Sciences*, 2013

[4] Interestingly, these cyanobacteria were so successful in transforming the climate of the planet they actually rather over did it. The astonishing amounts of oxygen they produced through photosynthesis cooled the planet so much, they almost wiped themselves out with the dramatic drop in temperature.

[5] The combination of the use of the word "approximately" with a number as precise as 251.9million years demonstrates the advanced methods and technology of Geology and its healthy scientific modesty about its conclusions.

6 Stanley, Steven M. (2016-10-18). "Estimates of the magnitudes of major marine mass extinctions in earth history". Proceedings of the National Academy of Sciences. 113 (42): E6325–E6334.

The fifth one started in Mexico.

More specifically, it kicked off in the Yucatan Peninsula. This is where a massive asteroid marked a massive full stop at the end of the dinosaurs' paragraph of history, 66 million years ago (66.043 ± 0.011 Ma). The poor old dinosaurs did not get much time to see the crisis coming. How could they? The Ampelosaurus had the biggest brain of all of them, but it was only the size of a tennis ball, and their club-like feet would also have made it difficult from them to grip a telescope.[7]

It was not just the dinosaurs who had a bad day; the bolide strike ended up wiping out an estimated 75% of all life on Earth. Who could really argue with a blast as strong as ~2 million thermonuclear Tsar Bombs?[8] Indeed, a group of fish found in North Dakota certainly did not get time to say much in response. Their fossilised remains were found in 2012; they had been caught with their mouths open and with tiny glass beads from the blast site lodged in their gills.[9] Who could blame them for gawping at bit? They must have been rather shocked to see a mega-tsunami, 100 metres tall, coming towards them.[10]

It took humans quite some time to spot the cause of this fifth extinction event: the Mexican crater where the bolide struck. Paradoxically, this is because the crater is so big - you need a plane to notice that it is there.[11] It is the Chicxulub crater, and the ring of the dent is 180 kilometers wide.[12] Half on land, half in the sea, it was detected from the air in 1978. The shocked quartz and highly unusual levels of iridium (Ir) at the site confirm to geologists that something truly cosmic[13] had happened.

Which brings us to the sixth wipe-out, today.

We are in the middle of a Mass Extinction Event. It is right under our noses. But again, with a bit of paradox, although it is happening now, it is such a big event it is hard to see it. If we were to read one research paper (for example, on biodiversity loss) and have it pinned up on a wall alongside all the other studies and data that confirm our invasive impact on the planet, then that wall would stretch for miles and miles in both directions. Many of the graphs on this wall would look like 'hockey sticks' as the current destruction has accelerated exponentially since 1950 – something often referred to as "The Great Acceleration"[14].

Rather appropriately, this image put humans in the middle of it all. As George Monbiot helpfully qualifies, "Let's stop calling this the Sixth Great Extinction. Let's start calling it what

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[7] www.bbc.co.uk/news/science-environment-61013740

[8] Or counted in proper scientific numbers, the impact created between between 1.3×1024 and 5.8×1025 joules, or 1.3–58 yottajoules of energy. cf. Durand-Manterola, H. J.; Cordero-Tercero, G. (2014). "*Assessments of the energy, mass and size of the Chicxulub Impactor*". arXiv:1403.6391 [astro-ph.EP].

[9] 14 PNAS, DOI: 10.1073/pnas.1817407116.

[10] Bryant, Edward, "Tsunami: The Underrated Hazard", p. 178. Springer (June 2014).

[11] A plane and some technical equipment are required. It was spotted as part of an airborne magnetic survey of the Gulf of Mexico, by geophysicists Glen Penfield and Antonio Camargo.

[12] https://www.nasa.gov/missions/earth/chicxulub.html

[13] Iridium is one of the rarest elements in the Earth's crust, it is found in great abundance in meteorites. The spike in iridium levels at the K-Pg boundary is important evidence in support of the Alvarez hypothesis that a space rock, roughly the size of Mount Everest, smashed into our planet.

[14] An interesting set of graphs on a 'dashboard' can be found by searching for "The Great Acceleration" on the internet.

it is: the "first great extermination" … describing the current eradication of living systems (including human societies) as an extinction event makes this catastrophe sound like a passive accident".[15]

To be very correct, a 75% wipe-out is normally required to qualify for a mass extinction.[16] But there is not much need to worry about reaching this high bar – we are doing our very best to reduce the natural world down to a domestic collection of cows and pigs, cats and dogs, at an extinction rate that is 100-1000 times the 'prehuman' or 'background' rate.[17] Indeed, if you then add on top the deep stress caused by climate change which wild animals have no facility or time to adapt to, we are pretty much guaranteed to get the three-quarters mark soon enough.

It does not need a meteorite strike or massive volcanic activity to throw the planet into an entirely different mode of operation; ask the tiny cyanobacteria. Small things can have a huge impact, ask anyone with a peanut allergy. We were never a match in size for the biggest mammals, but our diminutive size has been made irrelevant by the force of our technological power and by the sheer magnitude of our number. Not only is the human population just a few small steps away from reaching 8 billion, but if you count humans and add all the animals that we own, then we account for an astonishing 96% of the entire mammal biomass of the world.[18] Or maybe, once we are long gone from the Earth, it will be our mechanical control of the avian world that will be our lasting mark? The bones of the 50 billion chickens that we consume every year could end up as our permanent signature in the crust of the planet.

Whichever direction you look, something really big is going on. So big in fact that Geologists have now proposed that a slice of deep Earth time should be named after us: "The Anthropocene".

Questions

1. **What age do you think children should be taught about Mass Extinction Events?**
2. **Geologists will take decades to formalise the end of the Holocene and the start of the Anthropocene. James Watt's invention of the steam engine in 1784 was proposed as most appropriate starting point. What date or invention would you propose?**

15 George Monbiot, "The big polluters' masterstroke was to blame the climate crisis on you and me", The Guardian, 9th October 2019.

16 And to be fair, although we are all participants in the extinction event, the responsibility for it is not evenly shared.

17 "*Conservation Biology*" Volume 29, Issue 2 (April 2015) p452-462. (https://doi.org/10.1111/cobi.12380)

18 PNAS June 19, 2018 115 (25) 6506-6511; first published May 21, 2018

Main Text:

The Anthropocene

The term, "Anthropocene" comes from two Greek words: *Anthropos (*ἄνθρωπος) meaning "man" and "*-cene*" from kainos (καινός) meaning "new" or "recent". It is no small achievement to have a geological epoch named after you. The systemic effects of resource extraction (biomass in particular) and greenhouse gas emissions are the core reasons for geologists to consider getting their pens out to draw a new line in planetary time for the first time in 11,700 years.[19]

In the short time available here to throw a little light on the situation, attention will be given to the three most prominent features that future geologists will find characterise the Anthropocene:

a) Resource extractions (in particular biomass)
b) Mass extinction
c) Nuclear deposits

It is the first and second features of the Anthropocene, that deserve our attention - even if their stealth-like threat, off the radar of our attention, are a potent threat to human development. And for completeness, a bit of space should be given to nuclear power as its sheer power cannot be ignored in any account of the Anthropocene.

Opening up these two risks is not a distraction. Climate change will rightly remain the central concern throughout this book, and for the Academy, because it is the most acute crisis of the Anthropocene. Climate change grabs the headlines for good reason.

However, it is not the only threat to human civilisation and an understanding of the bigger picture of sustainability is essential: firstly, because all these problems are all interconnected. Secondly, because climate change is rooted in these two issues.

a) Resource extractions

The most important feature of the Anthropocene is our rampant extraction of resources.

We have converted about two fifths of the Earth's land surface to serve the demands of our food production[20], and we take one quarter of all biomass that plants produce in a year[21]. In

[19] ://www.britannica.com/science/Anthropocene-Epoch
[20] Faostat Land Use (https://www.fao.org/faostat/en/#data/RL)
[21] https://www.mdpi.com/2071-1050/13/15/8606/htm

addition, we have dug out thousands of mines and quarries all over the face of the Earth. This resource extraction and consumption is responsible for 90% of all biodiversity loss[22].

These extractions have relentlessly increased year on year, and the consequences have been formidable. Indeed, the wider consequences of our resource consumption are too big to open up here. It deserves our fuller attention in the next chapter.

b) Biodiversity

Biodiversity loss is a problem that is deeply systemic – both in terms of the causes of the problem and in terms of its consequences. Indeed, the roots of this issue are rhizomatic, making the puzzle of protecting and restoring our precious ecosystems very difficult; and the negative consequences of widescale biodiversity loss pose a threat to the entire operating system of human life.

In the absence of a long-term rational framework for our economic development, humans are currently ripping into their habitat with a savage energy. The "Great Acceleration" has wiped out an epic proportion of the Earth's biodiversity. In 1992 the UN opened up the Convention on Biodiversity (CBD), but every target has been missed because of our tentative and fragmentary responses. Indeed, in 2019 the UN published a landmark report[26] (Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES), May 6th, 2019) on the monumental depth and speed of this loss.

The former Chair of the IPBES, Sir Robert Watson, notes that:

"The overwhelming evidence of the IPBES Global Assessment, from a wide range of different fields of knowledge, presents an ominous picture. The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide."[27]

In other words, it is rather like we are playing a game of Jenga with the natural world: Bio-Jenga. Pulling out key blocks of the architecture of the biosphere, and at the same time placing more demands on it. This is not a clever strategy for building a civilisation. Each time a brick is removed and then replaced at the top of the system as another weight, the more the tower becomes destabilised. The natural world used to be so immense and diverse, compared to the *homo sapiens* within it, that this wide base looked invulnerable to our ambitions.However, that pyramid shape has now been inverted.

The documentaries "Apocalypse Cow" and "Seaspiracy" illuminate the unsustainable path that agriculture and aquaculture are on. Millions of species are clinging to the last fragmentary pockets of habitat that our great vacuum cleaner of 'civilisation' has not yet hoovered up. We have tacitly endorsed the evisceration of a bewildering array of biological

[22] United Nations Environment International Resource Panel. Natural Resources for the Future We Want. Key fact: "90% of biodiversity loss is caused by extraction and processing (consumption) of natural resources" (2019).

[26] 160 https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report.

[27] https://www.ipbes.net/news/Media-Release-Global-Assessment.

niches, all for the sake of things as banal as a packet of cheap supermarket ginger biscuits or a pack of fishfingers.

On its own, this ecocide poses a grotesque danger to our future. But biodiversity loss also has a direct impact on climate change. The planet is marked by tree cover loss that is driven by deforestation, wildfires, commodity markets and agricultural farming practice changes. The loss is happening at a consistent rate of around 240,000 square kilometers per year[28] - an area the size of the UK. Within this total, the destruction of primary tropical forests (the world's most biologically diverse ecosystems), released 2.64 billion tons of carbon[29], more than 1 % of the remaining carbon budget for 1.5C (83% likelihood).

In a dark grey parallel to this, we are currently producing 4 billion cubic tonnes of concrete every year. If this was made into patio slabs 2.5cm thick, it would mean that we would have been able to cover up 130,000 square kilometers of land with concrete - an area the size of Greece. This global concrete production is responsible for around 8% of all CO_2 emissions annually[31].

Despite all this, you might have sometimes spotted a weed that has somehow managed to push its head and body through the tiniest of gaps in the tarmac of a road. The sheer tenacity and stubbornness of that plant is a helpful reminder of how quickly nature can restore itself - from whatever base of biodiversity is left in place.

Indeed, the pause for breath in human consumption caused by the COVID-19 pandemic also provided a bit of space for nature to reclaim some ground. Among all the tragic stories of the pandemic there was a clear signal about what makes humans happiest – and those things were emphatically not material. We were reminded that our true nature is driven by the need for community and relationships, and by the sense of meaning that comes from the different projects of our lives.

c. Nuclear

Briskly then, nuclear power is given some attention.

Our ability to harness nuclear energy is a vivid demonstration of how extraordinarily probing the human mind is. We can now unlock one of the elemental forces of nature through both fusion and fission – and although the byproduct of these processes is dangerous nuclear waste, this type of power generation does not cause greenhouse gas emissions once the carbon costs of building the station have been covered. In the absence of a war-like effort to leverage renewable green energy to the capacity required, nuclear power arguably remains an important component of a manageable pathway towards retaining a stable climate.

[28] www.globalforestwatch.org/dashboards/global. (For details, see Hansen et al., *Science* 2013)
[29] https://news.mongabay.com/2021/03/global-forest-loss-increases-in-2020-but-pandemics-impact-unclear/
[31] https://www.chathamhouse.org/2018/06/making-concrete-change-innovation-low-carbon-cement-and-concrete

Yet, the insights of Physics that took humans to a sub-atomic level of the universe did not just make nuclear power possible, it also facilitated the production of nuclear bombs. Every noble advance in science carries with it the possibility of ignoble consequences, the human condition a deeply conflicted one. This tragic double aspect of advancing knowledge was captured with vivid clarity by Mary Shelly in her prophetic novel, "*Frankenstein*" (1818).

Her horror story "*Frankenstein"* (1818) depicts the harnessing of the 'elemental principle of life'[32] to animate the body parts of a gigantic cadaver by a scientist called Victor, a name that takes on a deeply ironic meaning as the novel develops. The clean slate of consciousness that the creature is born with is soon filled with fear and rage as he struggles to understand his place in the world. As the tragic tale of loss unfolds, we are left to wonder at the subplot to all of our victories over nature.

The mushroom cloud is a potent symbol of the dark underside of scientific knowledge. If we ever lost control of "Oppenheimer's deadly toy" [33] a bleak, definitive radioactive line would settle into the strata of the Earth during the quiet winter that would follow. A nuclear apocalypse would be an astonishing finale to human life on Earth.

The mushroom clouds that surged up over the cities of Hiroshima and Nagasaki in 1945 could still turn out to be a definitive image of our age. Indeed, our ability to harness atomic power has advanced much further since then. The explosion triggered on October 30th 1961 when the Soviet Union detonated their 'Tsar Bomba' over the Novaya Zemlya Island demonstrated an entirely different level of power. This RDS-220 Hydrogen bomb had the capacity to release 100Mt of nuclear energy, the equivalent of 7600 Hiroshima A-Bombs.

Indeed, in the early, heady days of nuclear power[34] some rather imprudent plans were proposed by the USA. The 'Father of the H-Bomb', Edward Teller, championed 'Project Plowshare' (PP) - a set of proposals that sought to use the new technology in various construction projects. The plans included the use of 300 bombs to create a second Panama Canal through Nicaragua, nicknamed the 'Pan-Atomic Canal' and the use of 764 bombs to blast a new canal through Columbia. They even proposed a 22 A-bomb plan to make a hole through the Bristol mountains of the Mojave Desert for Interstate 40 ('Project Carryall). Teller wrote an article in 'Popular Mechanics' entitled, "We are going to work miracles".

Thankfully, none of these projects to domesticate nuclear bombs ever went further than a desk. And although Vladimir Putin stirred up the nightmares of thermonuclear war with his genocidal invasion of Ukraine in 2022, we have so far avoided this M.A.D. conclusion to human life. Nuclear physics is here, the toothpaste cannot be put back into the tube. Given the acutely difficult timeframes of the climate crisis, these horror stories must not distract us from the safe potentials of that understanding. The case for massive investment in fusion technology remains a strong one. [36] * should be footnote 35!

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[32] James Whale's popular adaptation of the book to cinema in 1931 depicts this as electricity.

[33] Sting, "Russians" (1985).

[34] Mostly before the 'Partial Test Ban Treaty' came into force 1963.

[36] If Nuclear Physicists could crack the puzzle of triggering nuclear fusion in a domesticated way, that would open up a revolutionary clean power source. However, despite recent advances, this technology remains a distant dream - and later chapters will underline just how short the timescales are for reducing our emissions.

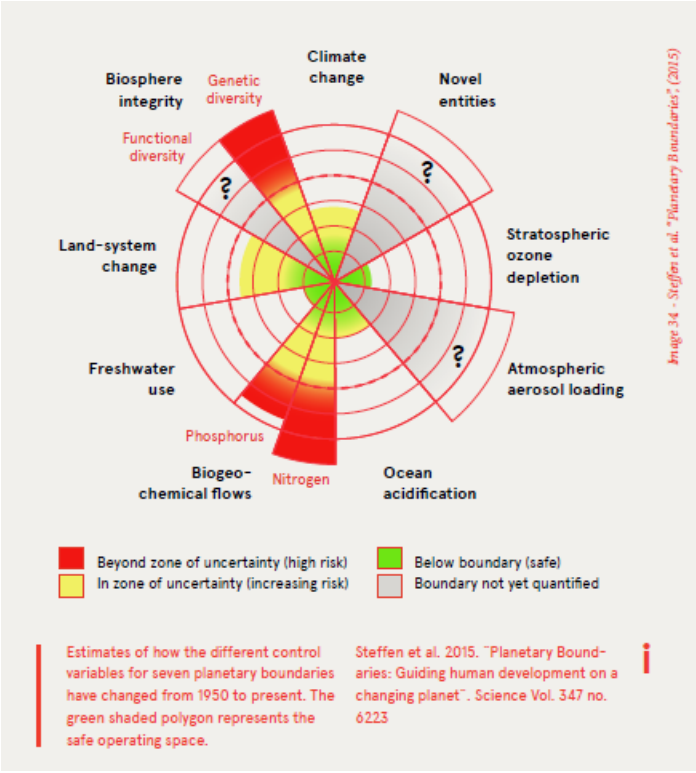
Either way, when the International Commission on Stratigraphy (ICS) meet to decide on when and where to draw the lines in geological time – they have a basic technical requirement that the change must be evident in the strata of the Earth's crust.

Nuclear deposits help meet this condition.

Planetary Boundaries

Plugging our brains into realities as big as Mass Extinction Events or new geological epochs such as the Anthropocene can be rather overwhelming. These are seismic changes and big concepts to wrestle with. A sharper, more defined image has been provided in the acclaimed research, compiled by Professor Johan Rockström. This summary from the 'Stockholm Resilience Centre'[37] pictures different aspects of our incursions into the planet's natural systems into a radar like image. It shows where our economic activity has led us to overstep numerous planetary boundaries. The dashed border drawn represents the boundary lines for different aspects of our environmental situation. The further we overstep the boundary the higher the risk is that we throw the whole system out of balance and render it hostile to us.

This 'radar' summary chart represents thousands of scientific papers. Any summary would require references to the original sources to justify the conclusions for which there is no time at all here. However, it remains a valid move to provide an overview of the current science with a wider zoom lens. Summaries serve an important role in making the main conclusions clear. Namely, the future of human civilisation will only be a prosperous and peaceful one if we take a major step back from the limits of the natural world.



There are two red zones of particular concern: the integrity of the biosphere and the crisis we have in biogeochemical flows. The threat of degrading biodiversity has already been noted. Indeed, the farming practices that are a primary drive behind this loss are also the cause of the red signal that can be seen for Phosphorus and Nitrogen flows. The unsustainable use of fertiliser (and pesticides) is covered with striking images and analysis in the Netflix documentary "Kiss the Ground".

[37] Steffen et al. 2015. "*Planetary Boundaries: Guiding human development on a changing planet*". Science Vol. 347 no. 6223.

To conclude this section on planetary boundaries it is worth noting that there is one area of the radar that is in the safe green zone – Stratospheric Ozone depletion. The hole in the Ozone layer that opened up above Antarctica is no longer a threat to human beings. The Montreal Protocol was adopted in 1989, just 16 years after the danger had been uncovered by scientists. The agreement to cull CFCs to a safe level was a quick and highly effective step by the global community of nations, as Kofi Annan, the former UN Secretary-General noted, the Montreal Protocol is "perhaps the single most successful international agreement to date".

A fuller guided tour through the different segments of this model is available with Sir David Attenborough, in the documentary “Breaking Boundaries” (2021). Attenborough comments, there has “never been a more important time to communicate the science of what is happening to our planet. The research featured in *Breaking Boundaries* is one of the clearest explanations I’ve seen of the threats we face and how we might tackle them.”

Conclusion

The earth as a 24-hour clock

Planet Earth will keep on spinning around. It has no preference for the number of species alive. It does not favour greenhouse or icehouse conditions. The Earth has seen both extremes of the temperature scale. In the Hadean Period[38] the average temperature was around 230°C, and in the Archean Period that followed, insanely powerful hurricanes steamrollered across the surface of the warm oceans. Yet, any alien passing by in a UFO during the Cryogenian Period (700 million years ago) would have seen the Earth as a giant “Snowball”[39].

But we care.

The fragile experiment that we call human civilisation has all happened in the narrowest segment of planetary time. Our advanced society only got started after the frosty fingers of the glacial maximum started its retreat in 17,000BC. To put that in its proper perspective, the fragility of our enterprise is best appreciated by thinking of the 4.54 billion year history of the Earth as a 24-hour clock. It was bombarded by meteorites until 03:00 in the morning, after which organic life mysteriously appears at 04:00 which starts to provide us with the first fossils to look at from 05:36. Single-celled algae show up at 14:00 in the afternoon, but we need to wait until as late as 22:56 to observe the first dinosaurs. Mammals arrive at 23:39. Finally, humans turn up at 23:59:43, just 17 seconds before midnight. We have been on this planet for a mere 0, 02% of its existence. Within this tiny percentage *homo sapiens* have only recently just got going with our major construction

[38] Appropriately named after Hades

[39] Or « Slushball » if you are Geologist who thinks that the ice didn’t quite cover the Equator.

projects – the Egyptian pyramids, the Medieval Cathedrals, the Sydney Opera House… they were all put up within the last second of this 24-hour clock.

When geologists create visual simulations of the planet to show how it must have looked in the deep past, as a snowball earth or a greenhouse earth, it is hard to imagine the size of the forces that must have been at work over millions of years to make such transformations possible.

Curiously the most visible thing on Earth today, as seen from space, is Belgium. The country famous for beer, chocolates and Kevin De Bruyne, is less well known for its remarkably complete set of street lights. The 2.2 million bulbs (at an average ofor 233 per square kilometer) create the most intense cluster of light on the planet. Indeed, aside from Belgium, the street lights that are scattered across the surface of the Earth represent the awesome power of the nearly8 billion humans who populate it. These lights represent just a fragment of the energy that human beings are affecting the planet with, on every spin.

Our glitzy lights have turned the Earth into a giant Disco Ball. Perhaps a 'Disco Ball Earth' could work as an apt symbol for the Anthropocene? It certainly sums up the scale and style of the human colonisation of the planet.

***Homo Sapiens*?**

If the current slice of geological time needs a new label, maybe it is also time for us to rethink our own? Maybe *homo sapiens* is a bit of an overstatement? Our name literally means "wise human". We got this official classification in 1758, a date that was right in the middle of "The Enlightenment". It was a time when our capacity for reason and reasonableness was widely celebrated. We were making great progress in science, politics, and a wide spectrum of the Arts. It was not a surprise then that the Swedish scientist Carolus Linneaus thought so highly of us when he was working out his taxonomy of the natural world. The good vibes of the Enlightenment led him to put the sticky label, "*homo sapiens*" on our backs.

However, overstepping so many planetary boundaries is arguably a good moment for a rethink. We could just suspend the label *homo sapiens* for the moment, until we have some proper control of emissions, resource extractions and biodiversity destruction.. Given that the fundamental force behind all these problems is over consumption, maybe the best label for us is "*promo sapiens*", in recognition of all the shopping we do. Or to match the disco ball of the Anthropocene, we should rename ourselves 'party animals'? And to keep things consistent with Linneaus' Latin labels for all the other species, that then becomes '*festivum animal*'.

The only problem with this new label is that it distorts the fact that only a small minority of humans are at the party causing all the disruption. But that is an issue for Chapter 6, "Who is responsible?".

Further reading:

Facing the Anthropocene

Bankrupting Nature – Club of Rome

Documentaries:

“Breaking Boundaries” (Netflix)

“Kiss the Ground” (Netflix)

“Seaspiracy” (Netlfix)

“Apocalypse Cow” (Channel 4)