GAIA 2

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Global climate change is a trending topic, with atmospheric carbon dioxide rising to 415 parts per million in the atmosphere, growing human impacts from sea level rise and atmospheric warming, and dire warnings from scientific and international panels that action needs to be taken soon to avert global ecological disaster. It is in this context that ideas emerge: the notion that ever weirder weather is to be expected, that action is required on a planetary scale to ensure humanity's survival, and the assertion that our species has set forces in motion that will forever change individual and collective human behaviour.

The concept of 'global weirding' has grown in popularity as an alternative to the phrase 'global warming'. The term was first attributed to American renewable energy guru, Avery Lovins, and then popularised by the centre-right economist Thomas Friedman in an op-ed piece for the *New York Times*. The neologism appears to have great currency given the incipient effects of global climate change, and the examples of weather, sea level rise, glacial melting and other events that exceed the norm. Examples include the highly variable atmospheric jet stream, polar vortex in the northern hemisphere, and other extremes in temperature, rainfall, wildfires, and flooding across the planet. Therefore, global weirding was intended to broaden the debate beyond sea level rise and abstract discourse about warming average temperatures and growing greenhouse gas emissions. David Wallace-Wells in 2019 catalogued the increasing costs of higher average temperatures and or feedback loops (potential black swan events) that could exacerbate warming even further. Among climate researchers and advocates, there appears to be consensus that global weirding and what Wallace-Wells calls 'cascading catastrophes' will occur if we do not act quickly, and are perhaps even likely given what we have already set in motion. The next question becomes what do we do about it, and the answer is complicated. The example of potential feedback loops to accelerate the warming process are considerable, including dramatic shifts in the Earth's albedo (or reflectiveness), methane release from permafrost and warming oceans, undoubtedly weird events if and when they happen.

Global weirding, as it has been addressed in the literature, has mostly referred to climate weirding, that is, the physical impacts of climate. But this weirding also extends to how we respond to climate change, particularly nascent attempts to affect geo-engineering and the growing international interest in approaches to technological fixes. We can even extend global weirding to consider the extinction connections to human-induced climate change, such as shifting climate zones, earlier spring, and longer fire seasons, movement of invasive species, pathogens, insects, and animals outside of their normal habitats. American futurist and postnormal times theorist John Sweeny expanded the notion of global weirding further by describing it as a 'meshwork' that includes not only cascading catastrophes, but also a growing technosphere upon which we are increasingly dependent, and the growing transnational drive and reach of postnormal actors.

To put global weirding in context we need to examine climate change over historic geological periods, and the best place to begin is the Gaia theory proposed by the British scientist and environmentalist, James Lovelock. We need to explore postnormal times (PNT) theory as PNT appears to me to be both an artefact of global weirding and a driver of it, because complexity, chaos, and contradiction are both features of the postnormal times we are living in, and will also have an impact on how we respond to climate change and our behaviour in a warming world. PNT theory, particularly postnormal creep, and the postnormal menagerie (black swans, jellyfish, and elephants) are useful tools to understand the challenges ahead of us and to better navigate our way to preferred futures.

According to Lovelock, the Earth's biosphere, atmosphere, and geologic systems are an integrated cybernetic system, with multiple, complex feedback processes. Some of those processes, such as glacial periodicity, deep ocean current circulation, carbon deposition in the oceans and limestone, plus many others, have time frames that extend from tens of thousands to hundreds of thousands of years in length. Key to Gaia theory is our understanding from cosmology of the evolution of our sun.

According to cosmology, the sun has increased in overall solar radiation by 30% since the beginning of life on the planet. While solar radiation received by the planet has increased, the overall temperature on earth has neither been cold enough to freeze the oceans entirely, or too hot for life to exist, nominally the boiling point of water (although some exotic microbes do manage). In other words, the greenhouse effect was an important regulatory process in early Earth history, but is of less value as the sun heats up.

Lovelock demonstrated how Gaia is not teleological or purposeful, but responds to sometimes fairly simple rules. The best example of this was his Daisy World model that showed how even two different colours (black and white) of daisies could regulate planetary temperature. The point is that while we may not, as a species, grasp all of the fine points and subtle nuances of the global chemical and biological systems, the broad parameters and dynamics can be understood, and arguably must be better understood collectively for us to survive as a species.

Gaia has provided a complex, billion-year-old system of feedback loops between biota and chemical cycles. This robust system has protected life as a whole from extremely violent and endogenous and exogenous forces. Endogenous planetary events have included: one of the first extinctions caused by the production of oxygen in the atmosphere, super volcanism, and changes in ocean currents due to plate tectonics. Outside exogenous events have included impacts with comets and asteroids, variations in the sun's radiation, and cosmic dust storms. While the geological record shows vast periods of volcanism, resulting in periodic mass extinctions, yet there has been a continuation of life and greater diversity and complexity of life forms. Lovelock argued that our species' experiment with the atmosphere may propel the planet into a higher state of thermodynamic equilibrium. He argued that we should remember lessons from the planet's past. In his last book, *A Rough Guide to the Future*, Lovelock urged us to remember the past, particularly the Earth's climate 55 million years ago during the Paleocene-Eocene Thermal Maximum (PETM) when the planet was 6 to 8°C more than it is today. He described the planet then as a tropical system with no ice at the poles, with a highly coupled atmospheric system of giant Hadley cells that were like thermal pipelines between the equator and the poles, distributing solar energy. It is an ominous possible scenario for climate weirding in the not-so-distant future.

The Gaia theory argues that our species plays a new role in the climate system. For at least one million years our progenitors had little impact on the climate, and *homo sapiens* and archaic human species' migration patterns responded to the glacial cycles and sea level changes. Macro historians have described the cycles, rhythms, and evolution of human societies, yet agriculture and civilisation only emerged after the end of the last glacial cycle. In other words, the rise and fall of previous civilisations occurred during relatively moderate interglacial climate. Macro history and Gaia are useful to provide us with Big Picture contexts and underscore the importance of long timescales and broad horizons to consider the survival of modern industrial civilisation, or even our entire species. But the impacts of human migration across the planet, first agriculture, and then industrial activities and resource extraction from the planet have altered its face. We are advised to consider those long-term timescales and how climate change is a window into human values that are poorly aligned with planetary systems.

Also relevant to the futures of climate weirding is the famous 1972 report, *The Limits to Growth.* Funded by the Volkswagen Foundation and commissioned by the Club of Rome, it was the work of a Massachusetts Institute of Technology (MIT) team, headed by Donella H Meadows. The MIT scientists used a computer simulation model, dubbed World 3, to study the consequences of interaction between the earth and human systems focusing on population, pollution, food production, industrialisation and consumption of natural resources. Much-maligned and savagely attacked by conservatives and industrialists, the report of the MIT team posited that normal *standard runs* of the World 3 model forecast that population growth and industrial development would exceed carrying capacity by the mid-twenty first century. Lost in the controversy was the assumption of the modelers and futurists addressing the *global problematique* (species extinction, desertification, deforestation, pollution, climate change) that they were not *predicting* the future, but exploring the parameters of and consequences of system change. A member of the team, Joel Barker, wrote about his role in the MIT study as a young researcher. He noted that there was a lot of attention paid to assumptions and weaknesses of the models, but more importantly it is the lesson from the similarities between the models and realities, that complex phenomenon are full of delays and time lag, which 'blind us to large-scale change'. There are cumulative effects of billions more humans on the planet, increased patterns of consumption, resource use, and energy in the system. Those additional humans and complexities will create further uncertainty.

Climate has to be seen in a range of temporal time frames, from long-term glaciation (due to plate tectonics), 100,000 year glacial periods interrupted by warmer interglacial periods lasting on average 10 to 12,000 years, and shorter-term changes of solar radiation and volcanism (likely the cause of a mini-ice age in the sixth century). Thus anthropomorphic changes have to be seen in a broad context. The scientific consensus is that we would nominally be entering a new glacial period and ending the warmer interglacial period. The more recent periodicity of glacial cycles over the last million years appears to be causally linked to the nineteenth century Serbian astronomer Milutin Milankovitch's observation of cycles of axial tilt, eccentricity, and precession that force cooling by taking the northern hemisphere the furthest away in its orientation to the sun over a roughly 100,000 year period. There appears to be a general consensus that over the last million years, the generally stable homeostasis has cycled between glacial cycles and short interglacial cycles, with the Milankovitch effect triggering each new cold phase. Lovelock has argued that we may be fundamentally altering this pattern. Climate weirding becomes geomorphic weirding if humans alter normal glacial cycles.

The astrophysical and geological records support this theory and ironically, perhaps a contradiction, is that according to ice core analysis the Earth's atmosphere appears to have had higher concentrations of carbon dioxide immediately preceding glacier building in the northern hemisphere at the beginning of each of these cycles. One attempt to explain terrestrial feedback loops and ice ages was the work of John Hamaker, American engineer and climatologist, who argued that planetary biomass in glacial times is more productive than interglacial periods, due to the abundance of ocean life, particularly diatoms and other microscopic life that thrive on dust blown from continents. The key variable is ground rock dust, a product of glacial building and retreat, enormous dust storms produced between the warm tropics and increasingly cold polar north.

According to Hamaker, during interglacial times the ground up rock dust is blown across the lower temperate zones and accumulates, creating rich soils such as the loess soils of China that become depleted of minerals over the 10 to 12,000 years of the interglacial period. As demineralisation leaves temperate and alpine forests less healthy, insects and fire take their toll. Hamaker believed that the normal end of the interglacial would be characterised by massive forest fires that would actually raise the level of carbon dioxide. Massive fires would affect the solar albedo, and he argued that the reflection solar radiation from these massive firestorm clouds would actually trigger global cooling in alignment with the orbital forcing of Milankovitch cycles. Hamaker predicted a return to glaciation by the end of last century, and in spite of ever increasing volumes of smoke – particulate matter – in the atmosphere, global warming accelerates. His theory is perhaps a reminder that we need to recognise our limitations in understanding the various positive and negative feedback loops, and consider the outlier possibilities. We would do well to remember that climate history reveals that return to glaciation can happen quickly. This may be an example of the unknown unknowns that face us in a weirding world.

Another parallel geophysical actor in the climate picture is the deep ocean current. The deep ocean current story extends back hundreds of millions of years before continental drift remade the face of planet Earth. Conventional scientific consensus is that prior to the breakup of Pangaea – the supercontinent that existed during the late Paleozoic and early Mesozoic eras – the Earth's climate was much more tropical, but there were also periods of much colder climate. Continental drift and the emergence of a deep ocean current appear to have had a moderating effect on the overall planetary temperature. Without the deep ocean current, there would not be local currents at the ocean surface, such as the Gulf Stream, that distribute heat across the North Atlantic. Similar currents operate in other oceans, as well. Scientists believe that the absence of that deep ocean current has been the source of rapid planetary cooling in the geological record. For example, at the end of the last glacial period, ice dams collapsed in northern Canada that released vast amounts of fresh water into the North Atlantic that appear to have stalled the deep ocean current, creating a mini ice age as the planet was entering the interglacial period.

Our understanding of the geological and climate history has improved recently thanks to ice core sampling, ocean floor drilling, and tree ring and other dating processes. There are, however, lots of ifs and buts - obviously a lot we still do not know, and this ignorance can be compounded with all the uncertainties involved. Yet, we are now engaged in the grandest laboratory experiment ever, using the entire atmosphere as a laboratory. There is little doubt that humans have become a species with global impact, but given the complexities, the uncertainties, and the contradictions in our behaviour, we cannot know what the consequences will be. Is our experiment only forestalling or inhibiting or even accelerating the return of northern hemisphere glaciers? Or will the experiment result in accelerating warming, perhaps reestablishing the climate regime during the PETM 55 million years ago?

We have yet to create, generate, or adopt a collective mythology that is consistent with Gaia theory. For the past decade or so, the trending neologism to describe the coming limits to growth and what researchers describes as the coming 'biological annihilation', or the Sixth Mass Extinction, has been the word Anthropocene. The word acknowledges the planetary impact and long-term consequences of human civilisation. American feminist and science critic, Donna Haraway, suggests that Chthulucene is a better neologism to replace Anthropocene as the proper term to identify the geological period to follow the Holocene. Chthulucene, from the Greek *chthonios* means: 'of, in, or under the earth and the seas'. 'The chthonic ones', Horroway notes, 'are precisely not sky gods, not a foundation for the Olympiad, not friends to the Anthropocene.' Haraway takes the radical view that we need to embrace our grief and face the realities of the interconnected, intertwined, web of life that includes other species, fish, animals, birds, insects, and other living parts of the biosphere as kin. We need to appreciate not just that we have become the dominant predatory species on the planet, but that we need to put our hugely successful skills at adaptation and resilience to work in service of the planet instead of seeing it as a resource. Thus, we are not only entangled with the climate, but also in webs of life that dynamically change and evolve. We have already set the sixth extinction in motion and will have to deal with the consequences of that over millennia. More time lag. Kurt Vonnegut would say 'and so it goes'.

We can contribute to better regulating of feedback in the Gaia system, and potentially make it smarter. We will have to find the wisdom to get there.

The most recent report of the United Nations and the Intergovernmental Panel on Climate Change (IPCC) made dire predictions for the planetary climate by 2050 if zero omissions of carbon dioxide are not realised by 2030. Sadly, it appears the reduction of carbon dioxide production to preindustrial levels is not only unlikely, but there has been an increase in the overall production of greenhouse gases and their release into the atmosphere. It is argued that the 2050 timeline closely aligns with the average run of the MIT World 3 model, as noted earlier, and it begs the question of whether the Earth's carrying capacity has actually already been passed. Mark Lynas, the British author and journalist, provides a litany of worsening environmental consequences for each additional degree of warming past the preindustrial baseline. Even the smallest of changes, even 2°C to 3°C – not far from the nominal projections of the IPCC – will have enormous negative consequences. Heating more than 6°C above pre-industrial levels would result in civilisational catastrophe, and yet the lag in carbon dioxide absorption in the environment means that even if we achieved zero emissions tomorrow, it would take decades, if not centuries for carbon dioxide levels to stabilise. And we are not even accounting for the other major greenhouse gases such as water vapour, methane, chlorofluorocarbons that continue to accelerate warming. Those are examples of the potential reservoirs of uncertainty in the current climate models.

As I write, there are extreme flooding events throughout the Mississippi and Missouri River basins in the US, widespread flooding in East Central Africa, and extreme heat and drought in China and Australia. Examples of extreme weather events now abound in a litany of multiple destructive cyclones and hurricanes, drought, wildfires, and even increasing tornado activity. Climate catastrophe is happening now! It is not something out there in 'the future'. Part of the reason I am drawn to the Gaia theory is that it provides a scientific basis for the claims of accelerating warming, a measurable cybernetic system, that follows fairly simple rules of systems, although there are layers of complexity, nested biological, chemical, and thermal systems that in concert sustain a larger dynamic, and somewhat stable system – over the millennia.

We can see some of those systems unravelling. As the oceans become more acidic, the result will be less diversity as ocean reef communities die, potentially releasing undersea continental methane ice, releasing methane from the tundra and Arctic areas, and of course the loss of trees from Australasia and South America not only release more carbon dioxide but are also lost as a carbon sink. It results in a runaway train phenomenon, where the warming creates a vicious negative feedback loop, and it tends to become self-reinforcing. Lovelock posits that there are mechanisms that may eventually check those feedback processes, but it could take centuries, if not millennia, to return to stability, even if we were able to reverse or halt accelerated warming.

And so to postnormal times (PNT) – the period of accelerating change and disorder we find ourselves in. PNT theory holds that growing complexity, chaos, and contradiction inherently create greater uncertainty about scientific and policy decisions. Furthermore, a postnormal creep tends to shift the baseline, so that increasingly the unexpected happens. That clearly fits the model of global weirding and accelerating climate change. Some of the models for the tools of PNT theory, such as black swan, black jellyfish, and black elephant are drawn from climate change or apply to it.

The black elephant (in the room) metaphor is a classic point in case, particularly in the political culture of the United States of America, where the captains of industry and political leadership currently reject the idea of anthropogenic climate change. The elephant in the room is not only climate change itself, but the use of fossil fuels, consumer culture, and even fundamental economic models as well. The idea of growth itself is being questioned by social critics and the environmental movement. Measures of economic growth, for example, are being questioned because they account for the economic costs of recovery and disaster. Disaster should not be good for business. David Wallace-Wells noted the analysis of the actual economic costs of climate change by the end of the century are likely to exceed the total wealth of civilisation.

From a radical deep ecology perspective, it has even been argued that not only is civilisation unsustainable, but even agriculture may be at the root of our problem as a species. There are ample social critics of progress and civilisation that have fuelled that fire, such as Diamond, 2005; Ehrlich & Ehrlich, 2013; Slaughter, 2010; Wallace-Wells, 2019; Wright, 2004.

There are those that advocate for return to a Paleolithic, hunter-gatherer lifestyle. It is an extreme view, but suggests that even civilisation, as a concept, may be an elephant in the room. Another elephant in the room, in the shared space of climate and culture may be the negative images and apocalyptic cultural memes that drive popular culture. For example, in the USA, there is a sizable population that holds that End Times are coming. Such beliefs could accelerate careless behaviour and encourage a 'party till the end' mentality.

Many coming changes will be of the black jellyfish sort, unexpected high impact events or developments driven by positive feedback loops to produce even further chaos. Examples of that include melting permafrost that have had serious consequences for roads and bridges, the potential for melting ice and permafrost to release pathogens for which humans have few immunities, and the multiplier effect of methane released as permafrost melts. In recent decades, the permafrost zone has moved hundreds of miles further north towards the poles.

Invasive species have been spread around the globe thanks to global supply chains and transportation networks. Climate change only exacerbates that problem as tropical and subtropical species move further north with warmer temperatures. Forecasts for the 2019 summer in the Great Lakes anticipate large algae blooms due to the wet spring and flushing of phosphates and agricultural runoff into the lakes. Florida and the United States' Gulf Coast continue to struggle with algae blooms, while coral bleaching continues across wide swathes of the oceans. Instances of black jellyfish events will become the norm in a postnormal global weirding environment.

Black swan events, outlier events and developments appear to arrive 'out of the blue,' with the potential for disruptive impacts at a systemic level. The near total destruction of the water and electrical infrastructure of Puerto Rico after two hurricanes is one example. A sudden shift in the Earth's magnetic field has been suggested as one such possible black swan planetary-scale event. The collapse of the deep ocean current might be another. Bee colony collapse disorder, and the disappearance of pollinators, may be harbingers of more systemic ecosystem failures.

One of the key messages of postnormal times theory, particularly postnormal creep – increasing numbers of unexpected black swan and black jellyfish events – is that the breadth and scope of uncertainty will grow. Events and discoveries continue to unfold showing our limited understanding and outright ignorance about Gaian systems. One recent discovery by glaciologist Michael Willis found that even glaciers in cold, dry areas are being affected by global warming. Since 2013, the outlet glacier on the Vavilov Ice Cap has shifted from advancing 60 feet a year to 60 feet per day. 'The fact that an apparently stable, cold-based glacier suddenly went from moving 20 metres per year to 20 metres per day was extremely unusual, perhaps unprecedented,' Willis said. 'The numbers here are simply nuts. Before this happened, as far as I knew, cold-based glaciers simply didn't do that … couldn't do that.' This is just one example of the litany of recent discoveries about the acceleration and pace of melting of Alpine glaciers, Greenland ice sheets, both West and East Antarctic glaciers that consistently exceed previous expectations.

Postnormal times may parallel longer-scale planetary changes. For example, there may be a kind of punctuated equilibrium as humans and planet co-evolve and seek resilience during the coming troubles. Haraway's advice is that we 'stay with the trouble' and come to terms with the fact that a new era, the Chthulucene, is underway. There does appear to be growing consensus that the midcentury is likely to present this culmination of forces, playing out of variables, a hyper postnormal times period, beyond which we will either see our civilisation decline and collapse, or be transformed by some Singularity beyond our current imagination, or transformed to a Green Gaian society. All are still possible at this point. However, increased complexity and unknown unknowns, more black swans, may emerge. Those may preclude other preferred futures we might desire now, and may regret foreclosing on in the distant future.

Gaia is an extremely complex system, that has over time balanced fairly fine-tuned geochemical and biological processes that now sustain life on earth by balancing temperature, atmospheric chemistry, ocean chemistry, and cycling minerals through the Earth's crust. There are vast changes that have occurred due to the different species that have evolved over the planet's history, but the basic patterns are mostly driven by microorganisms, another key element in planetary functioning of which most people have very little knowledge or awareness. The forces of nature are also obviously very chaotic, as can be seen in rock deformation and the effects of plate tectonics deep within the Earth's crust. The forces of contradiction, between neither too hot nor too cold over a billion years have managed to find some balance. We need to keep these elements constantly in mind. But we need wisdom, not just know how.

As the dominant species on the planet, as a species that has managed to live in outer space, harness the atom, and now alter our own genome, we need to figure out a way to live in harmony with the planet and in a way that does not destroy the regulatory system that keeps the glacial cycle working. We were blessed to have civilisation emerged during a benign interglacial period, but we may need to come to terms with the fact that glaciation is what is normal. We truly have been living in postnormal times during interglacial times. Glacial is normal. If that were true, what would it mean? What would our responsibility be as a species if, to sustain life on the planet, we are obligated to keep it cooler?

Lovelock laid out many of his concerns about the consequences of our inability to rein in carbon dioxide emissions and made a strong argument that IPCC forecasts were far too conservative. He posited that positive feedback loops, such as methane release from permafrost, changing albedo, and other large-scale physical processes were already accelerating, well underway, and have self reinforcing tendencies that could potentially take humanity in short order to a much warmer thermal regime, potentially as much as 6–8° C warmer. That would likely leave Antarctica as the only habitable place left on Earth. Terraforming Mars might then be more than just science fiction, but a good investment. The point is that Gaia theory suggests that Earth may go on just fine without us, that is the biosphere, the biomass as measured by the totality of creatures in the ocean and on land will probably still exist, it just would not be hospitable for humans.

I hope Lovelock is wrong; and it is not too late. I also am optimistic that we can find a way to mitigate the damage we have caused, yet it will take a global effort, a paradigm shift of planetary proportions, a true global brain in some form of scientific Gaia 2.0. Meantime, the global climate weirding will continue to add to the acceleration, uncertainty, chaos, complexity, and contradiction of postnormal times. Welcome to the Chthulucene, all of our Gaian kin.