Chapter 1

The beginnings of Life

In the beginning · Cells and non-cells · Life on the edge of Extinction · Universal Life

Dear Life, please hurry...
Grind me to crumbles
between the palms of your hands.
Shove me into a heap
in your cupped hand,
and lift me close to your mouth.
Blow me in among the trees,
down across the upturned eyes of life;
trachaea and seed leaves.
It's so cold closer to the moon,
and I'm so in love with the Earth.

Sandro Key-Åberg
(transl. Lennart Bruce)[1]

In the beginning there was only the darkness.

Out of the darkness were born the night and the male, Kumulipo, the essence of darkness, and the female PoÊele, darkness itself. These were the parents of the children of the darkness: the shellfish of the depths, the plants that grow out of the dark earth, and grubs of the earth.

One birth led to another, and then there were many kinds of animals and plants. The world began to grow lighter, but there were no people yet – only the god Kane-i-ka-wai-ola, who watered the plants in the diminishing darkness.

Eventually there was the male Pouliuli, or deep darkness, and the female Powehiwehi, or darkness with a little light. This couple parented the fish of the sea. The fish swam everywhere and multiplied: shark, mackerel, the hilu fish. At the same time things grew and grew on the land, but it was still dark. Then PoÊelÊele, (dark night·male), was born along with Pohaha, (night coming into dawn·female). These were parents to the insects that fly in the night and to the grasshopper, the caterpillar, and the fly …

Hawaiian Creation Myth[2]

According to mainstream cosmological models, the universe we live in is estimated to have come into existence just over 14 billion years ago. The first stars in our cosmos aged, died, exploded, and left gases and debris that would form the basis of the next generations of stars. Some became Neutron stars. Beginning between two and four times the mass of our sun, the light they were producing became insufficient to counteract the force of gravity, and the star started to implode. Passing the Chandrasekhar limit, atoms in the star's core collapsed, compressing protons and electrons together as temperatures rose to several billion degrees centigrade. The material from a stellar core that eventually forms a Neutron star is so compressed that a teaspoon-full of it weighs about the same as 100 cubic kilometres of rock. The less-compressed outer shell explodes outwards as a supernova – with a force capable of lighting up an entire arm of a spiral galaxy for several decades; melting planets within a radius of tens of light years.

In an event so improbable that it could only happen in a near-infinite and ancient universe, two of these Neutron stars collided: and in this unimaginably vast and violent furnace, the heavier elements of the periodic table were forged[3]. Gold, platinum and – most importantly – the trace elements that are needed to form complex life. The semiconductors that are used to form a computer processor are simple silicon (quartz) crystals doped with a tiny quantity of different atoms or molecules (e.g. Germanium). The non-uniformity in the crystal lattice gives the crystal semiconducting properties that we can use to construct computers. In a very similar way[4], heavier elements (e.g. Molybdenum, Cobalt, Barium, Copper, Manganese, Iodine, Selenium) from the fourth and fifth rows of the periodic table[5] create the possibility for more complex charge

distributions, molecular shapes and vibrational properties of organic molecules. Although we consist mainly of Carbon (C) Hydrogen (H), Nitrogen (N) and Oxygen (O) with a little Sulphur (S), the complexity of our organic metabolism as we know it can only really exist because the heavier trace elements arose from supernovae and collisions between Neutron stars. This makes biological life as we know it on Earth very rare and precious.[6] We are stardust, we are golden.

From this stardust, our Solar System then started to condense. Eventually, about 4½ billion years ago, the third big rock from the Sun collided with another slightly smaller rock. The result of this collision was a planet that would become the Earth, with an unusually large and close satellite, the Moon. Six other planets[7] also condensed from this "stuff of dead stars". Somehow, over this vast expanse of time, our planet Earth's orbit remained safely within the ideal "*goldilocks*" distance from its star, so that life would continue to be possible : far enough form the sun for liquid water to exist, and close enough to provide adequate power for life from the sun's rays.

I believe a leaf of grass is no less than the journey work of the stars

- Walt Whitman[8].

We know from our view of the wider universe that the materials of life – water (hydrogen, oxygen) and "organic" carbon compounds and nitrogen compounds and all the rest of the elements – are present wherever there is starburst debris. We really are made from stardust. Organic molecules such as polycyclic aromatic hydrocarbons (PAHs), ethylene glycol (antifreeze) and buckyballs[9] have been detected in the farthest reaches of space, concentrated around nebulae, so the likelihood is that Life exists (or has existed or will exist) pretty well everywhere in the Universe. Eventually the Earth cooled sufficiently for water to liquefy and other molecules to interact. When measured in Geological time, this happened very quickly. Fossils found in rocks in Australia show that primitive unicellular life had definitely come into existence by about 3.7 billion years ago. There are iron oxide filaments in Canadian rocks (the Nuvvuagittuq Supracrustal Belt[10]) as old as 4.28 billion years that could be the remains of fossilised bacteria[11].

Denser elements, mainly Iron and Nickel, sank deep into the core and generated a magnetic field, called the Magnetosphere – stretching several Earth diameters out into space. This protects the surface of this small planet from highly charged plasma flowing from the Sun that would have inexorably stripped the precious atmosphere away (as it has on all the other planets that do not have a magnetosphere, such as Mars). The iron-nickel core also contains a proportion of unstable radioactive atoms that continue to warm the centre of the planet to this day – warm enough to melt rock and squeeze the red-yellow liquid magma to the surface through volcanoes. Turnover of the crust over the top of this globe of liquid metal and rock, along with the volcanic activity it produces, helps maintain a global balance of atmospheric carbon that determines long term climatic

stability[12]; and makes one really wonder how much James Lovelock's "Gaia" really, truly exists as an intelligent force that maintains Life on a planetary level. A few meteors rich in heavy and precious metals remained floating in space long after the crust of the Earth had solidified. As these in turn were swept up by the Earth's gravity, they embedded themselves into the shallow crustal rocks, releasing molten quartz and becoming the easily accessible veins of copper, zinc, tin, silver and gold that would enrich the first human civilisations. It could even be that regular injections of element-rich dust from space provided the necessary mineral richness that allowed life to bloom[13].

Even ignoring the presence of interstellar organic material, experiments have shown that natural synthesis of complex carbon/nitrogen/water-based organic molecules is inevitable[14] – given the usual stew of material that floats round in space, a suitable temperature range to allow liquid water, and some external source of energy. Life itself seems to be inevitable. Whether there is a panspermia and life is seeded onto planets from interstellar dust clouds as proposed by Wickramsingh and Hoyle, or is brewed from a few simple organic compounds and organised by aqueous silicates[15], all it needs is enough energy to thrive but not so much that it gets fried in the process. And the early Earth was a very high energy environment. There was no ozone layer to protect us from Ultraviolet rays. Radioactive isotopes were commonplace. Meteors and comets were bombarding the surface as the Earth gradually cleared its orbital plane of debris. Water evaporated and fell continuously as rain in storms of such intensity that we will fortunately never experience. The rapid cycling of water through this primitive carbon dioxide-ammonia atmosphere produced electrical storms that – for a while – made the planet into a giant fluorescent light bulb. The moon's gravitational forces caused tides in the shallow primitive seas that would one day provide a nutrient-rich and welcoming environment – and become the means by which complex Life would emerge from the sea and colonise dry land. Tides[16] are a good example of how hardy Life is, and the kind of choices that it has had to make. They are a particularly difficult environment to live in due to the constantly changing conditions, including movement of sediment, strong currents, alternating exposure to air and water, sometimes very high salinity gradients due to evaporation... But they are also particularly nutrient-rich, and all that difficulty and danger is far less important than the availability of food[17]. In these early days of the Earth, the moon was so 17 times closer to the Earth, and the gravitational pull from such a close moon lifted those early tides into a tsunami up to several kilometres high, scouring the surface of the planet twice every day. So maybe it's not surprising that more complex life took a while to come into existence.

To be sensible, we can only look back in awe. How can we imagine the forces that created our world and made life possible? Or the extraordinary set of coincidences that conspired to make our planet favourable to life? Or, considering the way that cosmic events can snuff out planets and even suns as if they were moths near a candle, how can

we fathom the sheer inexplicable luck[18] of Life's continued survival here for a third of the lifespan of the cosmos since the Big Bang? We can only ask that question because we have survived – in a thin sliver of Biosphere that mainly clings to a zone within a few metres of the land surface; but also reaching from the edges of space (only 40 kilometres above sea level – about the width of the narrow strait separating England and France), through land and sea[19], down to many kilometres below the surface of the earth[20]. This layer of life is so thin that if the Earth were a billiard ball it would (even allowing for its mountains and oceanic trenches) be smoother than the smoothest billiard ball ever made. Wherever holes have been drilled in the Earth, to whatever depth, there is always bacterial life ticking away in the water that fills the pores and fissures of rock[21]; to the extent that the greatest population of identifiable bacteria is trapped deep in the Earths crust. These cells have extremely slow metabolisms, and some individual geo-bacterial cells may have lived for tens of thousands, or even millions of years or longer, and can live in temperatures well over 100°C trapped Merlin-like in their crystal-lined pores deep in the Earth. The ecological balance of Gaia (including the composition of the atmosphere, and geological processes that progress over tens of millions of years) are also dependent on these tiny creatures – in ways that we are only just beginning to realise[22].

As humans, as great apes, as mammals, as vertebrates, as complex colonies of Eukaryotic cells, as hunters, gatherers, farmers, and as great great grandchildren and as parents – we have always been a part of that biosphere. We are descendants and relatives of, and dependent on the "simple" single-celled organisms that dominate the global ecosystem. The main focus of this book is embodiment – but this does not only mean reconnecting with our own bodies. It means re-entering the Earth itself, and truly acknowledging the stream of life of which we are a part.

Breathing in, I see all my ancestors.
In me my mineral ancestors, plant ancestors,
mammal ancestors, and human ancestors.

My Ancestors are always present,
alive in every cell of my body,
and I play a part in their immortality.
-- Thich Nhat Hanh

Cells and non-cells

I died from mineral, and plant became.
I died from plant, and took a sentient frame.
I died from beast, and donned a human dress.
Where – by dying – did I ever grow less?

- Anon

It is surprisingly difficult to define life in a completely unambiguous way. In our science-aware culture, it has become commonplace to define life as cellular, and to assume that anything not cellular is not alive. However, there are many a-cellular organisms – such as slime molds[23], plasmids and viruses. These organisms do not conform to the usual definition of (animal) Life, but still behave in a way that suggests life; and they have enormous genetic diversity.

> *The unconscious that wants to dismember everything, to disintegrate everything, to bring everything back into its beginning, is also creating the most beautiful jewel, the essence of synthesis, and that is so paradoxical that one is bewildered. ~*
>
> *Carl Jung, Visions Seminar, Page 91*

Although much effort has been put into trying to identify a single ancestral cell from which all present *cellular* Life evolved[24], biologists are increasingly coming to the conclusion that there was no single ancestor. This is because early cellular life was malleable. In the first few hundred million years of evolution, cells had not become stable – whether due to a lack of necessary structure, or the plain simple fact that the environment of the Earth was still too hostile (or probably both of these). So the Cellular life we are familiar with - having a relatively stable genetic code, requiring a continuously present cell membrane, etc - only represents one means by which Life can exist. Early life was only cellular for as long as this form was convenient. Given environmental pressures that were beyond the capacity of those primitive cells to overcome as cells – the obvious strategy was to escape the enclosing bounds of cellularity and to disperse their constituent parts back into the ocean. Once there, other molecules, complexities and cell-like entities would take up these fragments, make them their own, and create a new mode of life – rather as a child might dismantle yesterday's Lego sculpture and use it to re-create a new one today. Lego-Life continued to make and re-make itself, swapping minor molecules through to whole fragments of DNA and organelles until it discovered a generically stable form that might have some ability to persist for a few more billion years, given favourable circumstances. Whatever proto-life did in order to survive, one can be sure that the solutions that survived were robust – for remnants of that original Lego mix-and-match way of swapping genetic code seems to have survived up to this day[25] and rapid evolution occurs even in large complex life forms through viruses transporting large

snippets of RNA and DNA between host organisms. One particularly robust response consisted of packaging away a little bit of the salty ocean that gave birth to life in its own little snow bubble. No longer would there be complete dependence on the exact salinity of the external environment - because given a lipid or saccharide enclosure, organelles of the cell would be able to live inside their own ocean.

Humans also evolved from a pool of interchanging molecular material which was passed between several organisms, which may even have co-existed in a symbiotic complex. Recent evidence is increasingly pointing in the direction of intelligent uptake of genetic material by organisms – from other life (viruses, food), or even from the same species. For instance, learned sensitization can be transferred between slugs by transferring RNA via injection[26]. This raises significant questions about the nature of memory and the degree to which DNA is truly inherited/mutated (as opposed to it being exogenously collected and accumulated). Furthermore this kind of transfer of information also occurs outside of simple DNA. Even whole organelles (chloroplasts) have been observed moving between cells of plants[27,28] - which should really be a stark caution in terms of the kind of genetic modifications we allow ourselves to perform "because we can".

Gene-transfer means that bacteria and many single cells even today do not have a clear phylogenetic tree because they swap RNA and DNA fragments. What has only become evident with modern gene sequencing techniques is many ways that our bodies, our physiology, our brain and memory[29], our immune system function, and even the placenta[30] that defines mammalian life – came about as a result of DNA and RNA transfer mediated by viruses. So evolution turns out to be much more about accumulation of additional genetic material that "works" from elsewhere, and patching it in – as opposed to random variations in already existing genetic material. Rather like the way modern software is written by combining pre-tested code snippets, or the way that languages have evolved by taking in words from other languages. So far as we know as I write this, about 25% of the total mammalian genome appears to consist of endogenised viral RNA that has been accumulated some time during the course of evolution[31]. The DNA sequences containing these collected strands of RNA are particularly important for the workings of the immune system (the sense of biological identity) - which is an interesting paradox! The same goes for their necessity in evolving higher functions of the brain. Which is perhaps a call to some kind of humility and review of the notion that human DNA is somehow superior. Or even that cellular DNA is superior to viral DNA, because we would probably not last more than a few hours if all the viruses were miraculously removed from this planet[32]. They are important at the most fundamental levels, including controlling the proliferation of bacteria, taking part in symbiotic adaptations in the root zone, and enabling at least 50% of the oxygen replenishment cycle. Life does not rest on the shoulders of giants, but rather on a foundation of sub-microscopic Life-forms that are occurring all around and inside us – often without us even realising the fact.

The definition of "Life" (or what constitutes a living organism vs a non-living collection of molecules) is somewhat controversial and remarkably difficult to pin down. In terms of physics, Life is remarkable in that it reverses the 2nd Law of Thermodynamics[33] – i.e. it locally creates more order and more structure and more information. This always occurs in the presence of free energy[34,35], and technically, life may be defined as a "*Dissipative Structure*"[36] - i.e. it rides on and salvages tiny fractions of the vast flow of energy from the sun and from the decay of radioisotopes in the core of the Earth. Rather like beggars might survive by picking up accidentally dropped coins off the street in the City of London – in terms of the energy ratios that's probably quite an accurate analogy. Life is also *self-organising* and *autopoietic* (self-creating/self-reproducing).

> *When a system is far from equilibrium small islands of coherence in a sea of chaos have the capacity to lift the entire system to a higher order.*
>
> *– Illya Prigogine*

The fact that we can use words such as "*autiopoeiesis*" and "*self-organisation*" (or "*Life*") is rather deceptive, because this naming gives the subliminal impression that we know what they are. In reality, the ideas we have of how Life constructs itself are still very sketchy, with many "Gods of the Gaps", and they evaporate under the smallest amount of scrutiny. Biological life and its unique attributes offer no clean and easily definable boundary below which (what we might call) life does not exist. Guenter Albrecht-Buehler has observed that even cell *organelles* (the various sub-components of cells, including the cell membranes) behave as if they make intelligent decisions[37] and as if they are partaking intelligently in a collective relational and orchestrated dance. If the interactions were local and simple I might accept they were just chemistry, but they take place over large distances and are specific within a vastly complex, busy and closely packed environment. And it seems as if there is no detectable lower limit to this activity. Once one observes this level of creative intelligence in organelles, it becomes obvious that even molecules self-assemble and interact in similar quasi-intelligent ways. Indeed, both life and consciousness appear to be defined in our text books almost exclusively by pre-existing ideas as to what they might be. Someone who believes that life must by definition be cellular will define life to exclude what is not cellular. A belief in life being fundamentally chemical in nature and a byproduct of physics and time – will cause even the animate to be seen as mechanistic in nature. Someone who believes intelligence is only emergent from complexity in the human brain will not see any true signs of intelligence at any level below that. Likewise, someone who has a more catholic viewpoint and believes that even minerals and water are alive or conscious in their own particular ways – will define life accordingly. These are all complex perceptual Gestalts (Chapter 5). It would be handy if there were an unambiguous framework of reference for the three difficult topics of "Life" and "Consciousness" and Intelligence". But there is no such frame of reference other than the ones artificially (and tautologically) created by pre-definition – by metaphysical

choice. Whatever the definition used, the bar is set high because we consider life, along with consciousness and intelligence, to be something very special ... so the way we define them and therefore see them is also inevitably a reflection of our personal relationship with the ecosystem we exist in.

A typical modern mainstream biological definition of life would say that "*Living organisms possesses all* (or most..!) *of the following attributes*" :

> **Homeostasis:** Self-regulation of the "internal" environment, including self-repair.
>
> **Organisation:** This usually means composed of one or more cells, each of which is composed of an organ-ised set of organ-elles[38] (hence the word "organ-ism").
>
> **Metabolism:** Absorbs and uses energy; and disposes of waste by-products of that absorption and energy usage.
>
> **Growth:** Through increase in self-order (rather than just accumulation of matter).
>
> **Meaningful Response:** to stimuli.
>
> **Reproduction:** The organism replicates itself.
>
> **Adaptation:** Over long periods of time (evolution) and short periods of time (adaptive capacity – also may be considered to be aspects of *homeostasis* and *response*)

What should be evident in that list is the self-referential and unimaginable complexity that is inherent in the ideas it contains. All of those properties are dependent to some degree on several (if not all) of the others. With such a definition, one might think that life is easy to recognise, but it just isn't that simple. Viruses are one example, being "self-replicators" (they have recognisable DNA) that – so far as we know to date – are dependent on a parasitic relationship with cellular organisms so that they can metabolise. The virus relies on the host's protein-encoding DNA and protein-forming "machinery" to synthesise most of its structure as it replicates itself. Thus, viruses are intimately tuned to their hosts, and cannot replicate in a host that does not use the same building blocks. However, the degree to which viral DNA is embedded in critical portions of (e.g.) human DNA suggests that cellular life might not exist at all without viruses; and the mutual existence of viruses and their hosts is one indication that there is an optimum set/combination of proteins that Life has ended up using as building blocks. Maybe viruses had to exist first – a paradox given the current understanding of the relationship between cells and viruses, unless one looks to some organisational intelligence in molecules and organelles. The implication is that viruses evolved in a symbiotic and parallel relationship with their host organisms; and are therefore not inherently "bad", because if viruses per se were universally destructive of their hosts neither would have been able to co-evolve. Indeed, the inference of that argument is that viruses must be on the whole beneficial, and that pathological viruses are

aberrations, or that the organisms they "infect" are already unhealthy and unable to enter the usual symbiotic relationship. It is estimated that there is a ratio of about 200 viruses for every human cell (interestingly this happens to be the same proportion as mitochindria) peacefully coexisting in an average human cell.

Going to the opposite extreme, it is increasingly accepted that entire ecosystems (consisting of trillions of life-forms and thousands of different species in a self-supporting synergy) are life-forms in their own right. James Lovelock's *Gaia* hypothesis[39] takes this to its obvious conclusion and proposes that the entire biosphere of the Earth (including everyone reading this) is in effect a single and inherently *sentient* organism[40]. Not an unreasonable point of view given that cellular Life is never created anew – rather, every cellular creature from single celled bacterium through to a blue whale is created by cell division. If one follows that sequence of cellular division back through time, all life can be seen to have arisen from a common ancestral ur-cell and we (i.e. every single life-form on this world) are all cousins. My cousin the cockroach. My cousin the whale. My cousin the e-coli.

Francisco Varela had a slightly different definition – noting that ***Life alters its environment to better suit its own needs***, and the above list is merely the means by which this is accomplished. Life engineers its planet to best suit its needs, and the planetary conditions encourage certain forms of Life to prosper. Defining Life in this way requires that we cease to think of it as separate from its environment. Instead we have to think of Life and its environment (including all the other Life there) as a unitary organism. This organism can be separated out from everything else for inspection, but the act of separation requires something about both the organism and [all of] its environment must be discarded.

> *I cannot consider the organism without its environment ... from a formal point of view the two may be regarded as equivalent phases between which dynamic contact is maintained by the membranes that separate and link them.*
>
> *-- Dr. Peter Dennis Mitchell (& Jennifer Moyle)*

This sense of the irreducible unity of Life and its Environment has been further developed by modern biologists such as Professor Nick Lane[41] – who points out that *all of Life* is based on the reaction between Hydrogen and Carbon Dioxide. This may have originally taken place in a deep-sea alkaline (i.e. proton-rich) hot vent, but now all life-forms have developed a marvellous range of different ways to mediate the transfer of electrical charge as a source of energy by using membranes to create, exploit and manipulate charge gradients. The membrane (see Chapter 3.1, Boundaries) both connects and separates, and it is the membrane's status as a medium of relationship that makes life possible. Specifically, mitochondria operate across a boundary which maintains a proton

gradient - and operate somewhat like a hydroelectric turbine in a hydraulic gradient. It is *both* sides of the membrane and the relational potential that allows energy to be scavenged and used. Even membrane-less organisms such as slime molds have an effective membrane – the slime.

What is striking about biological processes is that a detailed inspection of them at one level often reveals parallels to processes on other scales and in other contexts. For instance, whilst most single cells are so small as to be invisible, the largest known single cell – *caulerpa taxifolia* – is an algae that can reach thirty centimetres in length! But in accordance with its scale, *Caulerpa* takes on the root-stem-leaved form of a multicellular plant, and this single cell has complex pseudo-organs that have specialised functions – just as might be seen in a typical multicelled plant comprised of billions of cells. In fact, *Caulerpa's* DNA bears many similarities to a tomato plant, and it even shows differentiation between RNA in its different morphic parts, just as a tomato plant would[42], even though it evolved 500 million years before the first flowering *Solanum*. This suggests that either gross morphology is somehow archetypal *("form follows function, function follows form")* – and/or that the basic architectural principles of complex multicellular life are inherited from single celled organisms even older that *Caulerpa*. Strangely, a fragment consisting less than 5% of this giant single cell can regenerate into a complete and viable *Caulerpa* cell, just like a (multicellular) tree can re-grow from a cutting. Which raises interesting – and difficult - questions as to how its DNA is transmitted! In a similar way, it appears that neural cells in the human brain do not work as a single on/off morse code device. Rather, each synapse is capable of having a different function[43].

> *Our work on Caulerpa has given us a whole new way of thinking about plant structure and development ... It's clear that the basic form we associate with land plants can arise with and without multicellularity. In fact, because higher plant cells are actually connected to each other by channels — termed plasmodesmata — could we really think of higher plants, like tomato, more like a single cell instead of a multitude of cells? This idea is consistent with our observations of a shared pattern of RNA accumulation. Frankly, our results have caused us to think about plant structure from an entirely different perspective which is the most important outcome from this research.*
>
> — Dan Chitwood[44]

Indeed, it is a mistake to think of cell reproduction as only being about the transmission of DNA. Although DNA is important, DNA replication would be useless without the equivalent and timely reproduction of organelles – the transcribing mechanisms, the golgi apparatus, the centriole, actin fibres and microtubules, enzymes, mitochondria, cell walls, and so on. So whilst cell division / Mitosis is almost always described purely in terms of DNA, in fact <u>every</u> part of the cell must self-reproduce; and every part of the cell goes through a process of growth followed by self-division. For instance, in Eukaryotic cells,

the mitochondria multiply and then split by means of a ring that bifurcates the mitochondrial sac in almost exactly the same way that a complete cell divides.

This is a nice example of how functional and organisational **archetypal gestures** are very recognisable characteristics of Life. The same patterns / forms repeat and repeat over many orders of magnitude of scale of both size and number of participating cells. Indicating that the persistent form / shape (and the growth / developmental gesture that it arose from) gesture has fundamentally important qualities. Or perhaps even that the gesture / form is more fundamental than the thing expressing it - including DNA. The largest known bacterial cell[45] is about two centimetres long. It shows features that are somewhat hybrid between prokaryotes (bacteria and single-cell microbes called archaea), and eukaryotes (what makes up complex multicellular life, including humans). Perhaps even stranger than its vast size, being about 5000 times bigger than most bacteria, it has its DNA packaged in something resembling the nucleus of a human (eukaryotic) cell. Boundary creates complex relationality and allows for separation (de-coupling) of function – as will be described in Chapter 3.1.

Life on the edge of Extinction

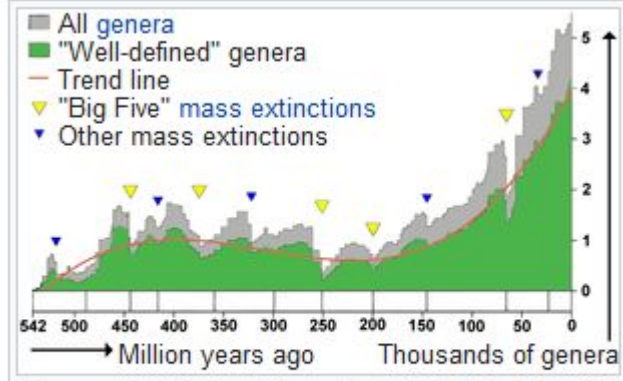
Your children are not your children.
They are the sons and daughters of Life's longing for itself.
They come through you but not from you,
And though they are with you yet they belong not to you.

You may give them your love but not your thoughts,
For they have their own thoughts.
You may house their bodies but not their souls,
For their souls dwell in the house of tomorrow,
which you cannot visit, not even in your dreams.
You may strive to be like them,
but seek not to make them like you.
For life goes not backward nor tarries with yesterday.

You are the bows from which your children
as living arrows are sent forth.
The archer sees the mark upon the path of the infinite,
and He bends you with His might
that His arrows may go swift and far.
Let your bending in the archer's hand be for gladness;
For even as He loves the arrow that flies,
so He loves also the bow that is stable.

On Children (from The Prophet) by Kahlil Gibran

Image (Right) : https://commons.wikimedia.org/wiki/File:Phanerozoic_Biodiversity.png



Phanerozoic biodiversity as shown by the fossil record

Although biodiversity has been identified as being important to the continuation of Life[46], we don't really know how to evaluate it. Exactly how many species[47] there are is very much open to question. A 2016 study[48] estimated that – instead of just a few tens of millions of species, the world today is home to *up to a trillion* species, of which most are bacteria. Bacteria have always dominated the evolution of cell-based Life here on Earth, and so far we have only catalogued less than one thousandth of a percent of the variety of life that probably exists.

Of the higher forms of life (differentiated eukaryotic multicellular organisms, including plants and animals) a recent estimate suggested there may be about 8.7 million species[49]. Larger more

complex life-forms are easier to identify. In this constantly shrinking world, new (previously undiscovered) species of larger animal bigger than, say, a pinhead are less and less likely to be found[50]. But nevertheless, new species of mammal, reptiles, amphibians and fish (along with all the other more primitive kinds of life such as jellyfish and insects, nematodes, etc.) – and of course, plants – continue to be discovered even today[51]. Allowing for the fact that the fossil record is even harder to explore, it appears that human beings have emerged from a period of 200 million years of grace during which an extraordinary and unprecedented diversity of life has literally bloomed on this Earth (flowers are one of the life-forms to emerge in this period). This explosion of diversity is currently coming to a small pause as human activity (pollution, global warming, habitat destruction, collapse of ecosystems due to removal of apex species) is triggering the latest of the great extinctions. In 2019 we are currently witnessing extinctions up to 1000 times the "normal" (pre-20th century) background rate, as the combined biomass of humans, domesticated animals and livestock has reached almost 18 times the combined biomass of of all other mammals and birds[52] (i.e. non-marine animals).

Image(Right) https://en.m.wikipedia.org/wiki/File:Extinction_Intensity.svg

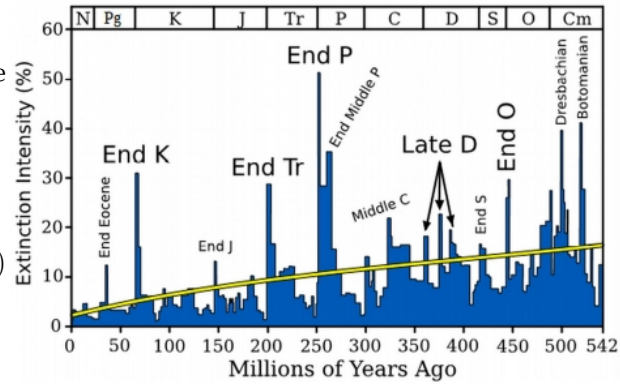


Figure 1.3 : Extinction rates
Wikimedia Commons / GNU Creative Commons

It is even more difficult to really know for sure the true biodiversity at any time in the past[53], because we can only inspect larger, visible fossils. There must be a million ways for an evolving life-form to die, and life may be unexpectedly fragile even when conditions are relatively stable. Over three billion years of evolution (of single cells and single cell agglomerates) resulted in the first known recognisable complex differentiated multicellular animal during the Edicarian period, about 700 million years ago. The Cambrian explosion (about 542 million years ago) saw animal life diversify at an unprecedented rate – a diversification that that has continued ever since. However, less than 1% of all animal species that have ever evolved still exist in the modern world. The other 99% didn't make it. Like the ancient God Cronus/Saturn, Life tends to devour her children if they are not perfect, and sometimes even if they are. Aside from a background die-off rate determined by random circumstance, the Earth a has seen at least five major global extinctions. And there have been many relatively minor die-offs, when species collapsed more suddenly and in greater numbers than can be explained by everyday processes. Despite their apparent distance in time (the last being 66 million years ago) these global extinctions have been significant – in that they have imposed extraordinary pressures on Life, and have therefore forced Life to become increasingly more resilient and adaptive and to re-imagine itself in new and increasingly

wondrous forms. Even then, in many cases an additional measure of sheer good fortune and luck must also have played its part. Any living thing that did not embody primevally gifted qualities of resilience, or was just plain unlucky – ended up as one of the 99% of complex multicellular life-forms that didn't make it this far.

It is worth contemplating that the ancestors of homo sapiens did make it this far. Not that it was a cake walk.

Biodiversity really only occurs when life becomes (relatively) safe and food (relatively) abundant and climatic conditions or seasonal fluctuations (relatively) stable and organisms reach a degree of complexity that encourages diversification – and *then* there is a sufficient level of stress applied that forces the inherent capacity for adaptation to express itself... It also requires that there are niches available in the ecosystem for expansion – something that really only occurs when some species already occupying a niche go extinct, because Life always expands to fill the energy-space available like a tree expands to fill the space available for gathering sunlght. Some of the ecological resilience that allows survival during times of extinction is redirected into the creative vessel of life's longing for itself. Insect pollinators and flowers or caterpillars and one specific species of plant pair up in a symbiotic and alchemic wedding. Birds and butterflies migrate impossible distances, or dance complex and bounteous courtship rituals. Animals evolve to fill more and more marginal and precarious climatic zones, or delicately balanced and unique ecological niches. In the past all of this ineffable and transient beauty has been repeatedly stripped away for periods of millions of years – until the next time that Life's longing finds the lack of variation unbearable, and sets out yet again to dazzle any sentience that might be around to observe it.

Almost as soon as the fossil record was first studied in detail, it became clear that species of animals had come and gone. At first this was attributed to the Biblical Flood, but as the immensity of geological time became evident, the question arose as to exactly what might wipe out half of the species on Earth in a (geological) blink of an eye? So there has been considerable thought put into how extinctions might occur. In fact, there are many possibilities. Climatic shifts that create snowball-Earths or millions of years of arid desert over most of the globe might be (at least in part) attributed to tiny systematic wobbles in the orbit of the Earth round the Sun[54].

And space itself can be a dangerous place. It is usual to assume that interstellar space is uniformly empty and the Sun relatively stable in its output of energy, but neither is necessarily the case. Aside from vast cosmic events that have been mentioned previously – gamma ray bursts or supernovae within several hundred light years that could sterilise or even melt this tiny world. It is suspected that a supernova explosion some 65 light years away was the cause[55] of the late Devonian extinction about 360 million years ago. And asteroid impacts have been a major source of environmental disruption right from

the very beginning. The degree of cratering on the surface of the moon (figure 1.2) is an accurate indication of the number of impacts that must have peppered the surface of the earth[56] when life was first starting out.

> *Strength does not come from winning. Your struggles develop your strengths.*
>
> *When you go through hardships and decide not to surrender, that is strength.*
>
> *- Mahatma Gandhi*

Unsurprisingly, the last great extinction most probably came about through the impact of the 12-kilometre wide Chicxulub asteroid that punched a180-kilometre crater in the Yucatan peninsula and Gulf of Mexico[57]. We know more about this specific details of this impact and extinction that the previous ones merely because it is closer to us in time so the evidence is still easily accessible and has not been erased. Chicxulub is sometimes called "the asteroid that killed the dinosaurs", or more technically, the "Cretaceous-Tertiary (or K-T) event" – a single and almost instantaneous shift in climate and ecology that heralded the start of a new geological Age.

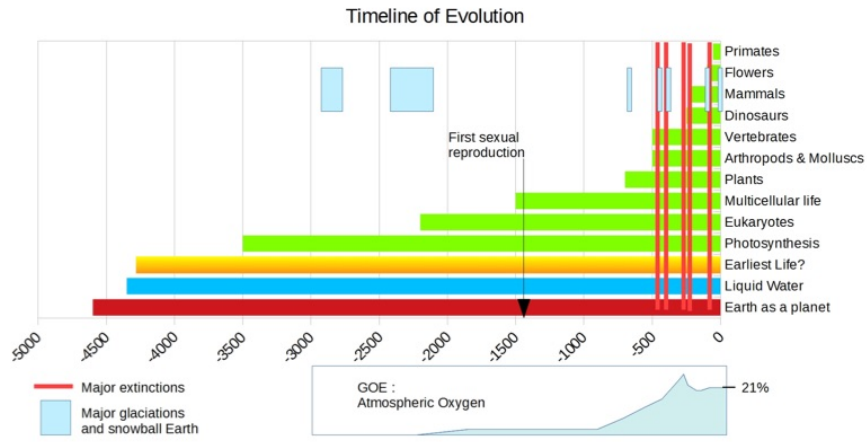


Figure 1.4 : Evolutionary Timeline
(scale in millions of years)

It is hard to really imagine how Life survived this impact at all[58]. The entry path friction heated a strip of atmosphere to the extent that every living thing below the track of the asteroid was turned into charcoal by the resultant infra-red/microwave radiation and all surface water was boiled[59]. The air blast generated 1000 kilometres per hour winds that would have shredded everything within a 1500 kilometre radius. As the asteroid punched a 20 kilometre-deep hole into the earths crust, shock waves exited on the opposite side of the globe, and started lava flows that covered almost 1/3 of what is now India (the *Deccan Traps*)[60]. The accumulated soot from all this burning reduced average global temperatures by 7ºC for several decades. The impact rebound shot debris tens of kilometres into the sky, almost back out into space – and this also fell back to Earth, and buried the previous land surface up to 300 metres deep at a distance of over 400 kilometres from the epicentre; some pieces even falling back to

earth as far away as Canada. A vast quantity of gypsum (Calcium Sulphate) at the impact site was vaporised almost instantaneously, resulting in pure sulphuric acid rain. The tsunami that followed was almost a damp squib of an afterthought. Being about 100 metres high, it penetrated up to 100 kilometres inland from the coast before dragging (literally) everything living and every grain of loose material back into the sea in an awful porridge of destruction up to several hundred metres thick. The sonic boom would have triggered landslides and liquefaction of sand around the whole world.

So what was the net effect on life on Earth? As you can see from Figure 1.1, Life on Earth just paused briefly[61], and shrugged. Despite a very temporary and (geologically) short-lived loss of over 60% of larger species (and about 30% of genera), after an almost imperceptible pause biodiversity continued to *increase* with even more vigour.

How is this possible?

> *Verily destruction is the foundation of existence,*
> *And the tearing down thou seest*
> *Is but the assembling of material*
> *for a greater structure...*
> *Deluded are they who say,*
> *"Man liveth by the Mercy of the Lord."*
>
> *Know ye*
> *That the balance of Mercy and Severity*
> *Is the continuance of every life,*
> *Yea, and of this whole universe.*
>
> *- P.F. Case -- The Book of Tokens*[62]

Global extinctions are not trivial, and affect every corner of the planet and every ecosystem. Given that the Permian-Triassic (K-T) meteorite-induced extinction killed off about 97% of all animal life, one wonders how the last 3% managed to survive at all. But if one looks at the estimated extinction rate over the past half a billion years, there is quite an interesting trend line (Figure 1.3). On the whole, the total effect of extinctions are declining over geological time. It may be that the causes of extinctions (e.g. meteorite strikes) are occurring less frequently and the interplanetary debris that remains has gradually reduced in size over hundreds of millions of years. But it may equally be that Life is simply becoming ever-more resilient.

Sometimes as an antidote
To fear of death,
I eat the stars.

Those nights, lying on my back,
I suck them from the quenching dark
Til they are all, all inside me,
Pepper hot and sharp.

Sometimes, instead, I stir myself
Into a universe still young,
Still warm as blood:

No outer space, just space,
The light of all the not yet stars
Drifting like a bright mist,
And all of us, and everything
Already there
But unconstrained by form.
And sometime it's enough
To lie down here on earth
Beside our long ancestral bones:

To walk across the cobble fields
Of our discarded skulls,
Each like a treasure, like a chrysalis,
Thinking: whatever left these husks
Flew off on bright wings.

Rebecca Elson : Antidotes To Fear Of Death[63]

There are many difficulties in understanding the relationship of Life to these events, possibly the main one being the rate at which biodiversity rebounded and increased following them. A modern development in biological science is the splicing of Darwin's theory of evolution with genetics. Evolution is seen to be a series of small "mistakes" in the reproduction of DNA or chance mutation that happen to produce small but significant useful modification, and which is also passed on to future generations. It's a nice theory, but very few people seem to have asked how that can come about. Firstly, differentiated organisms (such as mammals) are incredibly – unimaginably - complex, and the way that they unfold from a single fertilised egg themselves means that a mutation in DNA often can have several effects throughout the entire organism, some of which may be useful, and some of which may be harmful. So the DNA-Darwin theory presents something of a paradox. If mutations occur later in development (when they are less likely to create harmful knock-on effects), then it's hard to see how they can be passed on to future generations, because as development progresses they are increasingly local –

chimeric fragments in an otherwise uniform animal. If they occur earlier – so that the whole animal develops with that mutation, the survival rate is so low for truly random mutations that evolution would take orders of magnitude more time to progress than is actually seen in the fossil record[64].

The last (so far) known major climate-changing impact was an iron meteorite about a mile across, travelling at about 20 miles a second. It hit the north west corner of the Greenland ice sheet about 13,000 years ago, is probably the reason that the last ice age came to an end and the ice-age megafauna went extinct; and its impact marks the beginning of human "civilisation" as defined by constructed stone dwellings identified in archaeological digs. Locally, there was desolation and devastation – from a crater some 300 metres deep and 31 kilometres in diameter[65]. The tsunamis and floods (from vaporised ice falling again as rain) pulverised whole forests and washed the matchsticked wood and vast herds of animals into the thick beds of detritus described by Velikovsky[66]. They may even have been the origin of the many flood and creation myths (and tales of war between the Gods or of dragons) that exist in ancient cultures. The meteor may have been the cause of about 10% of the Earth's forest and grassland catching fire leading to the Younger Dryas glacial event[67]. But most of the world continued to thrive, and the change to a more temperate drier, warmer climate allowed the expansion of the first vestiges of human civilisation. The Burckle comet event[68] was a multiple meteor strike in the South-West Indian Ocean about 5000 years ago – the same time as the origin of a host of flood myths around the world – including the flood of the Bible. It produced a few weeks of truly biblical rainfall as a vast volume of ocean was vapourised, and a tsunami a few hundred metres high that scoured all of the continents surronding the Indian Ocean. A much smaller air burst meteor about 3700 years ago[69] sterilised 500 square kilometres of once densely populated land in Mesopotamia, and may be the origin of the Biblical story of Sodom and Gomorrah, or the fire and thunder Gods of the ancient world. And around 500BC Britain experienced a loss of about 50% (about 2 million) of its population overnight, accompanied by vitrification (turning to molten glass) of the upper parts of hill fort walls in Scotland – a certain indication of one or a pack of medium-sized meteorites passing overhead had superheated the local atmosphere. There be dragons and heroes who vanquish them. The land was re-populated within less than a decade, largely by settlers moving in from elsewhere in Europe, so – just like Chicxulub, Life shrugged and then thrived, and the human population of the British Isles increased in genetic diversity. Terrible events for one part of Life always create opportunities by opening up ecosystems. These one mesolithic and two bronze/iron age impacts alone probably had radical effects on the whole of subsequent human civilisation and history.

The fact that we have only just recognised these three most recent meteor strikes in the past few years suggests that impacts are far more numerous than has been previously thought. Maybe the pressure from this constant background of destruction from meteors

and volcanoes is a real part of the now largely discredited idea of "survival of the fittest". Around 56 million years ago, hominids emerged at the same time as a Krakatoa-scale explosion on the modern-day Isle of Skye, whose ash cloud temporarily reduced global temperatures. Was this a coincidence?

> *We need to change our way of thinking and seeing things. We need to realise that the Earth is not just our environment. The Earth is not something outside of us. Breathing with mindfulness and contemplating your body, you realise that you are the Earth. You realise that your consciousness is also the consciousness of the Earth. Look around you – what you see is not your environment, it is you.*
>
> *– Thich Nhat Hanh*

The Earth's biosphere has itself self-created at least one major catastrophic extinction, as cyanobacteria produced oxygen as a waste product. The Great Oxygen Event (GOE) began around 2,450 milion years ago when there was almost no atmospheric oxygen (air being mostly composed of Carbon dioxide and Methane). Cyanobacteria produced oxygen as a waste byproduct[70], rather like we produce carbon dioxide, and that oxygen accumulated over about two billion years. Eventually (maybe 250 million years ago) oxygen stabilised at its present-day level of just over 20%. The end result of the GOE was a complete shift in the composition of the Earth's biosphere, with most of life now dependent on an Oxygen-based metabolism via Mitochondria (as Eukaryotic cells), whilst the previously dominant anoxic bacteria retreated to niche environments. Oxygen creates Ozone, and this new atmosphere also provided a shield against ultraviolet (UV) radiation – thereby making the sunlit environment above ground level less hostile to life. This in turn allowed Life to use a less harmful sunlight as an energy source, leading to an expansion (or explosion) in the use of photosynthesis[71] and plant life. Ocean chemistry was also altered, as suspended iron and other toxic materials were oxidised and precipitated, leaving relatively clean water. This cleansing is not always a Good Thing. Some extinctions appear to have been exacerbated by chronic shortages of trace nutrients such as Selenium. And in contrast (somewhat ironically) soil trace nutrients are sometimes boosted by the metallic content of asteroids that impact and vapourise! Modern oceans tend to be nutrient-depleted, particularly with regard to iron. A major exception to this rule is the equatorial Atlantic Ocean, which benefits from trade winds depositing organic dust originating in the Sahara desert. So much of the ocean is relatively empty, but blooms of algae and plankton – along with all the life that feeds on them – are seen wherever nutrients occur; at sea mounts, in the outflow of rivers, at the foot of glaciers, and where trade winds blow constant supplies of dust from dry land.

There are a few repeated patterns in this tale of extinctions, though there may be a repeat of abut 200 million years that coincides with the Sun's journey through spiral arms of the Milky Way. Many appear to be associated with significant outbursts of volcanic activity

in the form of flood basalts, and the side effects of their gaseous discharges to atmosphere[72]. It is very possible that large increases in global volcanic activity may always have been related to large asteroid impacts or other phenomena that reach beyond the confines of a single planet. Many extinctions can be correlated with atmospheric warming due to volcanic sulphur dioxide emissions. Being rained on by concentrated sulphuric acid (and breathing in air saturated with sulphuric acid vapour) is not good for species survival. Or the same emissions may create widespread anoxic effects in oceans, or may be sufficiently large to create significant increases in acidity, or may even cause a turnover of deep anoxic oceanic bacteria, releasing vast quantities of highly toxic Hydrogen Sulphide from the ocean depths. Events of this magnitude are not just local. Atmospheric processes tend to link marine and terrestrial extinctions, which may be (more or less) constrained to a single hemisphere, or which may have truly global effects. In these cases, in addition to highly acidic rain there may be substantial atmospheric loading of toxic heavy metals (such as arsenic or aluminium, etc.), and the ozone layer may be temporarily destroyed, leading to fatal levels of UV radiation.

But every single one of of the big global extinction events is quite unique, and can rarely be wholly attributed to one-off events such as asteroid impacts. More typically there has been extensive environmental stress for some time, which is then compounded by one large shock or a series of shocks – which do not need to be particularly spectacular[73]. Human history shows similar patterns. The late Bronze-Age collapse of Mediterranean civilisations was something that had many causes. The combination of an unusually long drought and earthquakes happened to precipitate an existential crisis around 1177 BC[74, 75] that saw the demise of every cultural centre with the exception of Egypt (and Egypt was still diminished). The simultaneous collapse of several great human civilisations and the aftermath were not unlike extinction events. The previous order didn't completely disappear. Ecosystems (local societies) were themselves badly disrupted or destroyed by displaced populations from elsewhere. The eventual consequence in the eastern Mediterranean was a set of more isolated communities that largely lost the capacity to write; but writing was still preserved in a few centres and then spread back out again. Some languages were lost (such as Minoan "Linear B"), and others evolved their own dialects in isolated pockets. Not so different from local isolation of animal groups with reduced genetic diversity, that results in formation of individual species, which in turn are re-invigorated by animals still close enough to their genetic make-up to cross-breed.

We have also benefited from this separation and re-combination as a species. Early humans interbred with Neanderthals and Denisovans and maybe one or two other species, resulting in a very mixed modern human DNA pool. And this happened several times. The first humans to move out of Africa – the far eastern Asians (Europeans were part of a second wave of hominid emergence) – eventually brought their blood line back into Europe when the Mongols conquered half the world in the 13th-14th centuries CE.

Which is an interesting piece of historical juxtaposition because it shows how genetics, civilisation, language, art – even religions[76] or the plants and animals that are domesticated for agriculture by certain cultures - are part of the same continuity of evolution as it plays out over time and across continents.

Historically the shallow seas and tidal zones have been the richest environments for life. So sea level changes that rapidly shift or reduce availability of shallow and tidal marine environments can cause unusually large extinctions. This kind of change would normally be associated with "snowball Earth" events – globally extensive glaciations. Global warming has also occurred a few times in the earth's history, such that vast areas of continent have been transformed into sandy deserts (e.g. the 50 million year-long Triassic period). Both cooling and warming (and their resultant changes in sea level of up to several hundred metres) may be linked to both volcanic activity and Milankovitch cycles (systematic wobbles in the Earth's orbit); or even long term shifts in continental mass converging at the polar regions.

Given that these extinction incidents tended to be bigger and more frequent in the first 95% of Planet Earth's existence, it is perhaps not so surprising that Life took so long to reach a form that could survive these events. And it is more than slightly surprising that Life managed to survive at all in the face of such overwhelming and inescapable Armageddon. Figure 1.4 shows a timescale of the best current estimate of life's progress through geological time, alongside other significant events.

There are several features of Figure 1.4 that are worth a brief comment...

- The rapidity of Life's emergence as soon as the Earth cooled enough to allow liquid water to exist.
- The fact that extinction events are only indicated in the last 500 million years is purely due to them being measured by large multicellular organisms (these only really became widespread in the past 500 million years). In fact, events even greater, with greater frequency most probably occurred pre-500MY ago. Similarly, there may have been more glaciations, but as we go backwards in time it becomes more and more difficult to identify these in the geological record.
- The rapid expansion of biodiversity (Figure 1.1) goes hand in hand with high atmospheric oxygen levels (the final stages of the GOE), which allows Eukaryotic cells to dominate (which can generate high energy from Oxygen via Mitochondrial ATP). Which then leads to the possibility of larger animals with higher metabolic demands.
- It is thought that the formation of Eukaryotic cells was a direct result of the harsh and restrictive conditions during Snowball Earth – which was itself a direct result

of the GOE, and reduction in greenhouse gases.

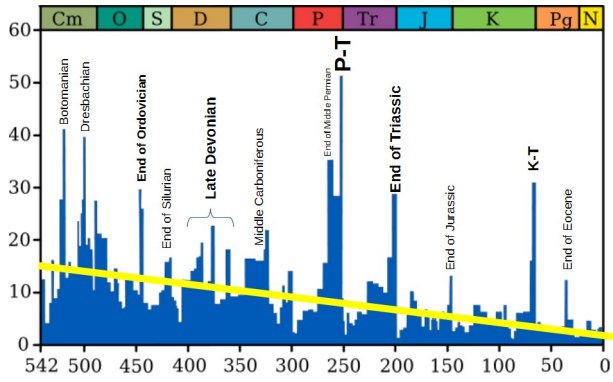


Figure 1.3 : Marine Genus Biodiversity Extinction rates
Wikimedia Commons / GNU Creative Commons

Figure 1.4 Q. Is this reduction in background extinction rate caused by an increase in safety of the planetary environment over time (less meteors, less supervolcanoes, less global anoxic events, etc)? Or does it reflect an increase in genetic and ecosystem resilience?
https://en.wikipedia.org/wiki/File:Extinction_intensity.svg
(yellow trend line added by AC)

> ...Constant destruction is thus the complement to an ongoing self-reconstruction. In each instant, everywhere and always, unheralded work re-starts life by putting in motion billions of Sisyphuses. When reflecting on the constancy of RE, we realize the nature of something in the physical universe that is truly irregular and rare. This something called life has proliferated on the planet earth. It is determined even though it is physically marginal. With each breath, each movement, each computation, life incessantly produces new living beings, new individuals, and new subjects[77].

Universal Life

> *"When one tugs at a single thing in nature, he finds it attached to the rest of the world."*
>
> *— John Muir*

An adult human being is an expression of the potential of the fertilised egg... One could say that we ARE the egg – because our cells were not created, they are the result of the egg constantly dividing and multiplying itself; and it may be that each cell even carries a few atoms of that original single cell. Jaap van der Wal[78] poses a very interesting question

– what is the true human? Is it the adult? Or are adults (and all multicellular life forms) just means by which another single cell/egg might come into existence? In reality, *all* of life on Earth is just one organism. The entire biosphere really is the cell, because every living cell is part of a previous cell that duplicated and divided itself. Life only ever starts once... the two cells that came after the first cell were effectively the same cell as the original cell – it's just that the original cell split into two so that it could be more than one. All life after that point is both a division and a multiplication and complexification of the life that came before. There is no such thing as "*New Life*", but rather, there is a direct and unbroken continuity of transmission of Life that goes back to the very first Life – whenever that was, and if that can ever be defined. Thus, every animal (and even every plant, and every bacterium) one way or another is a relative of everything else that is alive. Not only a relative. Although we think of life as consisting of discrete organisms, in reality there is no organism that has not evolved without the presence of other organisms. No complex organism has ever evolved - that did not rely directly on the bacteria and viruses pre-existing in its environment for both its evolution and its moment-to-moment metabolism. The previously evolved ecosystems and Life-forms/organisms are the milieu that new life forms grow into and out of. And the local and planetary environment likewise (along with supporting food chains) are equally dependent on and altered by its companion life-forms. From this point of view, the idea of "human" DNA defining a human being is lamentably narrow and incomplete. The idea that organisms are not intrinsically separate (even if they are conceptually separ-able) has been given a new lease of life in more ecologically aware trends in biology; such as the "holobiont" principle[79] and Hologenomics[80] (which states that genetic evolution of higher organisms is inherently dependent on and influenced by their microbiome). Gilbert et. al. (2012) convincingly argue that *all* aspects of evolution are mutual between symbiont organisms. Looking at the bigger picture, the open question is – for any one given organism such as a human being, are any other organisms not symbionts? Is there any twig of the ecological tree of life that we do not rely on[81] in one way or another?

Another way of thinking of this familial relationship is that everything living today in all its splendour and complexity – is an expression of the *potential* of that single original life form/cell that survived repeated extinction-level events for a few billion years. The fact that the origin of life is blurred due to RNA/DNA transfer may in turn imply that really was not a single progenitor cell – and many cells came about in many ways. However, they all combined and recombined in that first billion or so years so that the life that survived was imbued with resilience, and in that time period it is almost impossible that whatever life did first evolve did not either become a part of the whole or was simply wiped off the tree of life because it was not fit. Many of the strange and somewhat alien creatures that lived in the Edicarian seas some 600 million years ago were Life's experiments, and were lost to time after 50 million years of exuberance. The ones that did continue (from which we are

descended) were tougher, more adaptable, more resilient, and intimately related. At the very least we are cousins to the whale and to the krill, to the sequoia and the grasses, to the jellyfish, and most probably to the billions of bacteria that colonise our digestive tract. There is some scientific recognition of that, even if we have forgotten it from a spiritual point if view. Humans share 60% of their DNA that controls basic cellular function – with the banana. The implications of this reality are harder to grasp. The cellular and physiological functions that are at the heart of our capacity to maintain homeostasis and survive - also keep the cells of the banana tree alive. Surely this also says something about their hardiness? And also about the fact that homeostasis and the continuation of life demands a robustness of organisation that can only be (best) achieved in certain ways?

The universal commonality of cellular functions, cellular morphology, organelle types and functions, DNA segments ... has arisen from those first few billions of years of evolution being common to everything that is alive. So the processes that arise in a human body and in a human brain are essentially the same processes that arise in a geranium, a giraffe, or in an e-coli bacterium. Genetic diversity is therefore something of a two-edged sword. Whilst a simple organism might be more able to tolerate a high variance in genetic makeup[82], more complex organisms (such as human beings) have a far more finely tuned balance between internal processes. We need genetic diversity, variance, evolution, change – if only because it confers protection against disease. But too much change is also destructive, because too many cross-adaptations and adjustments have to be made in the whole organism. I suspect there are optimum ranges of both genetic diversity and genetic change that could be defined for a particular level of organic complexity. For plants, the loss of protective genetic diversity must necessarily be matched by an increase in some other protective mechanism – and in particular, toxic metabolites. So there is a strong argument that excessively hybridised and selected crop lines can *potentially* result in a higher toxic load[83] on the people who consume it. I admit to having relatively little interest in the specific labyrinthine chemical interactions that arise as these processes play out[84]. However, I am interested in the ways that this affects my qualitative experience and the capacity of my body and mind – my whole being - to be resilient; and it would seem that the extreme hybridisation of our food supply chains is not a good idea.

> *Whether we are inveterate inlanders or dwell perpetually on the tide line, we have an oceanic memory. Indeed, such are the correspondences between ocean and our psychic depths that the two might be visible and invisible forms of the same reality. ... 'Living fossils' in the sea, like the archaic energies in the psyche, have remained largely unchanged over millions of years, lurking in the icy darkness of the bottom waters. Whole ecosystems, untouched by sunlight, flourish in the sea just as networks of accumulated experience flourish in the psyche... In each of us, salty, amniotic waters run in our mnemonic veins. Tidal currents course through our deeps and shallows, yielding to the rhythmic pull of moon and sun.*
>
> *– The Book of Symbols: Reflections on Archetypal Images*[85]

Practical application

Much of the above might seem irrelevant to the topic of dissociation. However it is very relevant and all topics covered in this book are highly relevant in their own ways.

One aspect of the body-mind is that – whatever your attention focuses on immediately creates a response where the rest of your organism organises itself around that as if it is your present immediate reality. Most people are unaware of this response because it is generally subtle when buried under the mental chatter that in Germany is called *Kopfkino* ("head-cinema"). In this case, thinking about dissociation (to write about it) started to induce dissociation, and the writing quickly turned into structureless drivel. I had to find a way to prevent this happening. The answer was to focus on its opposite – resilience, and in this case biological resilience. After all (as will be more obvious in Section 2) dissociation is a survival adaptation, and so the main remedy for it is to provide suitable messages of safety.

So this book is written in pretty well the same format as a programme of treatment for severe dissociation. The first stage is stabilisation, which more or less involves circling round the dissociation finding "resources" (non-dissociated parts) that can be used as a platform. To frame this another way, it is the wellness that resolves the dissociation. So Section 1 is largely about identifying the phenomenally potent biological and other resources that are our inheritance – that are everybody's inheritance. And an awareness of the inherent resilience of the organic life form you inhabit and walk around in is an extremely useful starting point when the intention is to "treat" dissociation. As again you will see later, "treatment" is the wrong word. Dissociation is an adaptive state, and so all we actually need to do is provide information to your body-mind in such a way that it recalibrates and re-adapts to the relative safety of your present reality. This is both simple in principle and at the same time may be complex (considering the specific circumstances in the lives of each individual, many of which we might never really know the full details of). As it turns out much – far more than you can imagine – can be achieved without need to engage with all that complexity "simply" by re-focussing on resources and then communicating that deep into your physiology. "How" this is done will be the topic of Section 3.

Notes : Chapter 1

1 Modern Swedish Poetry in Translation, Edited by Gunnar Harding and Anselm Hollo (Minneapolis: University of Minnesota Press, 1979) ISBN-13: 9780816608706

2 David Adams Leeming (1994) Creation Myths of the World : An Encyclopedia (2nd Edition) Publ. Greenwood ISBN-13: 978-1-59884-174-9

3 Sloan Digital Sky Survey (SDSS) blog by Jennifer Johnson (January 9, 2017) Origin of the Elements in the Solar System http://blog.sdss.org/2017/01/09/origin-of-the-elements-in-the-solar-system/

4 In fact, connective tissues – bones, ligaments, etc. – are semiconductors, and the body exhibits electronic activity. Not because it is "doped" like a silicon semiconductor, but because of the presence of semi-crysatalline "EZ" water – **see** Gerald Pollack (2013) Fourth Phase of Water: Beyond Solid, Liquid & Vapor. Publ. Ebner & Sons. 357pp ISBN-13: 978-0962689543 **and** James L. Oschman (2003) Energy Medicine in Therapeutics and Human Performance : Energy Medicine in Therapeutics & Human Performance. Publ. Butterworth-Heinemann 402pp ISBN-13: 978-0750654005

5 The periodic table of elements is a way of organising them according to the number of electron shells and the number of electrons in the outer shell. The number of shells is in a very rough sense an indication of how difficult it is to create them. The number of electrons in the outer, most responsive shell is a strong indication of the ways in which these elements react with other elements.

6 On the other hand, if you were to believe the "Electric Universe" (EU) model https://www.thunderbolts.info/wp/ – in which vast rivers of electrical charge pass along lines of stars and power them, then life would be as common in the universe as buttercups are in a summer meadow. The EU model is supported by a substantial number of scientists, is able to make sense of phenomena that our normal cosmological models cannot explain (such as the fact that the plasma outside the sun is hotter than the sun itself), and considers that the electrical energy in circumsolar plasma is capable of reaching intensities sufficient to create fusion of heavier elements. I'm not suggesting that you believe this EU model. But rather recognise how the current version of cosmology – Big Bang, thermonuclear fusion, etc. – has become a belief system in our culture despite the fact that it is only a theory – and at that a theory with some very ragged edges that are rarely given public airing. Personally, I would guess that the mainstream cosmological model and the EU model are both somewhat correct; and their combination would still be an incomplete description of the universe.

7 There is ongoing controversy about this number. Whilst scientists have been stating for some time that the asteroid belt is a field of debris that has existed from a time before the planets formed (or during their formation – see https://phys.org/news/2017-09-theory-asteroid-belt.html) – there is some evidence that it (also?) contains debris from the collision of several small planets. https://www.nature.com/articles/s41550-018-0482-4

8 From Walt Whitman's "Song of Myself" (Leaves of Grass) https://www.gutenberg.org/files/1322/1322-h/1322-h.htm

9 A "Buckyball" or "BuckminsterFullerene" is a molecule joining 60 atoms of Carbon in a hollow sphere, comprised of 20 hexagons and 12 pentagons. This is the architecture of a small Geodesic dome – "invented" by Buckminster Fuller in the 20th century, but probably originating in 13th century Islamic tiling. The middle of the C60 molecule is of the correct order of size such that quantum effects can be sustained, and it is the largest object within which wave-particle duality has been observed. Buckyballs

also seem to provide an ideal substrate for life.

10 The Nuvvuagittuq Greenstone Belt is a sequence of metamorphosed volcanic and associated sedimentary rocks, located on the eastern shore of Hudson Bay, 40 km southeast of Inukjuak, Quebec.

11 It should be noted that the fossil record generally speaking does not show individual bacteria. A visible fossil indicating bacteria requires many thousands or millions of bacteria to be in a colony. So the fossil record from this early time does not show the development of first life – it shows the presence of the first colonies of (what are assumed to be) single species of (what are assumed to be) bacteria. Hoyle and Wickramsinghe's theory of Panspermia – the origin of viral and bacterial life in interstellar space – is still a possibility. As described in Chapter 2, life is extraordinarily resilient.

12 See Tom Pike's podcast on Jonathan Amos BBC Science Correspondent : InSight: The jeopardy of landing on Mars, 2 November 2018 https://www.bbc.co.uk/news/science-environment-46074794

13 Meghan Bartels (September 19, 2019) Asteroid Dust Triggered an Explosion of Life on Ancient Earth. At 466 million years ago, the breakup of a large space rock may have led to major changes in our planet's biodiversity. Scientific American https://www.scientificamerican.com/article/asteroid-dust-triggered-an-explosion-of-life-on-ancient-earth/

14 The first production of rich organic chemicals from a "primordial soup" was the famous Miller–Urey experiment, in which water, methane and ammonia were subjected to intense electrical discharges in an attempt to recreate the environment on a newly created Earth. Experiments since then have shown that the initial constituents and the kind of energy required for creation of organic molecules are not so critical. Ever since Mary Shelley's novel "Frankenstein", everyone loves using electricity to create life!

15 Juan Manuel García-Ruiz, Mark A. van Zuilen & Wolfgang Bach (2020) Mineral self-organization on a lifeless planet. Physics of Life Reviews 34-35, pp 62-82 https://doi.org/10.1016/j.plrev.2020.01.001

16 Animation of tides... A lot of information! If you focus on just one part of the map, and remember that high tide (red) occurs about twice every day. https://www.youtube.com/watch?v=5zi7N06JXD4

17 David Attenborough on Talbot Bay, Australia... https://www.youtube.com/watch?v=mJ9kdhVJT0U

18 The Earth's biosphere is vulnerable to stellar explosions up to 3000 light years away – depending on the type of supernova. A very distant supernova is one possible cause of the Ordovician–Silurian extinction, in which nearly 60% of the (oceanic) life on Earth and many species were destroyed. The continued long term stability of the orbits of planets in the solar system (so that they do not plunge into the sun within a few million years) has been shown by computer modelling at NASA's Jet Propulsion Laboratory to be a combination of good luck and gravitational resonance.

19 Joseph Stromberg (March 17, 2013) Nearly 8 Miles Down, Bacteria Thrive in the Oceans' Deepest Trench : The Mariana Trench may serve as a seafloor nutrient trap, supporting remarkable numbers of microorganisms. https://www.smithsonianmag.com/science-nature/nearly-8-miles-down-bacteria-thrive-in-the-oceans-deepest-trench-3298109/

20 Hannah Hoag (18 December 2014) Earth's deep crust could support widespread life. Discovery of hydrogen-rich waters hints at unexplored microbial ecosystems. Nature | News https://www.nature.com/news/earth-s-deep-crust-could-support-widespread-life-

1.16575

21 Ravindran, S. (2017). Inner Workings: Bacteria work together to survive Earth's depths. Proceedings of the National Academy of Sciences of the United States of America, 114(5), 788–790. http://doi.org/10.1073/pnas.1621079114

22 Maria G. Pachiadaki, Eva Sintes, Kristin Bergauer, Julia M. Brown, Nicholas R. Record, Brandon K. Swan, Mary Elizabeth Mathyer, Steven J. Hallam, Purificacion Lopez-Garcia, Yoshihiro Takaki, Takuro Nunoura, Tanja Woyke, Gerhard J. Herndl, Ramunas Stepanauskas. (2017) Major role of nitrite-oxidizing bacteria in dark ocean carbon fixation. Science, 358 (6366): 1046 DOI: 10.1126/science.aan8260 : Also see Bigelow Laboratory for Ocean Sciences (November 27, 2017) *Deep ocean bacteria discovered to play large role in carbon capture. Nitrite-oxidizing bacteria contribute to the capture of carbon dioxide in deep, unlit ocean waters.* https://www.sciencedaily.com/releases/2017/11/171127124706.htm

23 Slime molds such as Physarum polycephalum – or the "man-headed slime" – see (e.g.) https://en.wikipedia.org/wiki/Physarum_polycephalum, or YouTube videos https://www.youtube.com/watch?v=mvBSkt6LhJE and https://www.youtube.com/watch?v=olCEGsKWQ3c and https://www.youtube.com/watch?v=Nx3UIu1hfl6Q

24 A unique LUA (Last Universal Ancestor) has proven to be impossible to identify. Just as early hominids interbred, creating a *Homo Sapiens* human gene pool that contains at least three identifiable early human species, the earliest cellular life forms combined and recombined with each other many times.

25 Elizabeth Pennisi (Jul. 15, 2021) Mysterious DNA sequences, known as 'Borgs,' recovered from California mud https://www.sciencemag.org/news/2021/07/mysterious-dna-sequences-known-borgs-recovered-california-mud

26 Alexis Bédécarrats, Shanping Chen, Kaycey Pearce, Diancai Cai and David L. Glanzman (2018) RNA from Trained Aplysia Can Induce an Epigenetic Engram for Long-Term Sensitization in Untrained Aplysia. eNeuro 14 May 2018, https://doi.org/10.1523/ENEURO.0038-18.2018 It's something of an odd coincidence that this research came out immediately after a very widely publicised report that women may carry DNA from all the men they have slept with – in their brains! Which has become something of an internet meme. Whilst it's true that microchimaerism (the existence of cells in the body whose DNA does not match that of the host, and definitely comes from another individual) has been identified in women's brains, the jury is still out as to what its origin is and how it got there.

27 Alexander P. Hertle, Benedikt Haberland & Ralph Bock (2021) Horizontal genome transfer by cell-to-cell travel of whole organelles. Science Advances ¦ Research ¦ Cell biology 1 Jan 7(1) • https://www.science.org/doi/10.1126/sciadv.abd8215

28 Samuel G. S. Hibdige, Pauline Raimondeau, Pascal-Antoine Christin, Luke T. Dunning (2021) Widespread lateral gene transfer among grasses. New Phytologist, 230(6) pp2474-2486) https://doi.org/10.1111/nph.17328

29 An Ancient Virus May Be Responsible for Human Consciousness By Rafi Letzter, Staff Writer | February 2, 2018 12:18pm ET https://www.livescience.com/61627-ancient-virus-brain.html *"…long ago, a virus bound its genetic code to the genome of four-limbed animals. That snippet of code is still very much alive in humans' brains today, where it does the very viral task of packaging up genetic information and sending it from nerve cells to their neighbours in little capsules that look a whole lot like viruses themselves. And these little packages of information might be critical elements of how nerves communicate and reorganize over time — tasks thought to be necessary for*

higher-order thinking…". **Original article**: Elissa D. Pastuzyn, Cameron E. Day, Rachel B. Kearns, Madeleine Kyrke-Smith, Andrew V. Taibi, John A.G. Briggs, Cédric Feschotte & Jason D. Shepherd (2018) The Neuronal Gene Arc Encodes a Repurposed Retrotransposon Gag Protein that Mediates Intercellular RNA Transfer. Cell 172 (1) pp275-288.e18 Jan 11 https://doi.org/10.1016/j.cell.2017.12.024

30 Chuong E. B. (2018). The placenta goes viral: Retroviruses control gene expression in pregnancy. PLoS biology, 16(10), e3000028. https://doi.org/10.1371/journal.pbio.3000028

31 Parrish NF & Tomonaga K (2016) Endogenized viral sequences in mammals. Curr Opin Microbiol. 31 (Jun) pp176-183. https://doi.org/10.1016/j.mib.2016.03.002

32 Rachel Nuwer (18th June 2020) Why the world needs viruses to function. BBC | Futures https://www.bbc.com/future/article/20200617-what-if-all-viruses-disappeared

33 The 2nd Law of Thermodynamics states that energy always dissipates and order always decays, ultimately causing uniformity in everything. One modern scientific model of the universe is therefore a gradual cooling and dissipation, to the point that suns can no longer fuel themselves, and so all the lights just gradually fade out and there is perpetual darkness. Although this popularised end to the universe has become very familiar, it is only one of many possibilities : if only because the "singularity" at the beginning of the universe/big bang could well be a universe of uniform potential such as that predicted by the 2nd Law. The 2nd Law of Thermodynamics also only applies to closed systems, and although it is theoretically possible to create an almost-closed system, and the universe/cosmos is considered by definition to be a closed system; in practice truly closed systems may not exist. This is certainly true for all of Life – Life by definition in physical terms is an open system. The Planet Earth is not a thermodynamically closed system, receiving about 10^{17} watts radiant solar energy at its surface.

34 Ilya Prigogine & Isabelle Stengers (1984) Order out of Chaos. Publ. Bantam Doubleday Dell Publishing Group. Paperback, ISBN-13: 978-0553343632

35 Ilya Prigogine (1997) The End of Certainty: Time, Chaos and the New Laws of Nature. Publ, The Free Press. Hardcover, 208pp, ISBN-13: 978-0684837055

36 Dissipative structures are self-referential energetic systems that exist inside large energy flows. A simple example is a vortex in a river – a recognisable though somewhat ephemeral and shifting pattern in an internally chaotic flow of liquid. The river transforms a vast amount of potential energy (elevation) into kinetic energy (movement), and dissipates that energy as it moves towards the ocean. The initial creation of a vortex takes a lot of energy, but given that the vortex is in the form of a **soliton** (see later chapters), once formed it is self-sustaining. The river is essentially a large movement of energy, in which vortex can have something of an existence of its own. Life is also by definition a dissipative structure, being a small island of order ("*negative Entropy*") with internal energy transfers that are relatively tiny when compared to what sustains it. Dissipative structures order and sustain themselves by skimming off a small amount of energy from a relatively massive dissipation of energy – in the case of Life on Earth, this energy flow is the radiation of energy from the sun. The Earth receives 0.00000000003 of the total solar radiation, the long-term carbon cycle uses up a small fraction of that, and Life is only a small part of the carbon cycle (most consisting of the transfer of carbon dioxide to and from the oceans).

Notes : Chapter 1

37 Albrecht-Buehler G. (1985) Is Cytoplasm Intelligent Too?. In: Shay J.W. (eds) Cell and Muscle Motility. Publ. Springer, Boston, MA. pp1-21 ISBN-13: 978-1-4757-4725-6 **and** http://www.basic.northwestern.edu/g-buehler/FRAME.HTM

38 "Organisation" and "organism" both derive from Ancient Greek ὄργανον (órganon, "tool, instrument"), from Proto-Indo-European *werǵ- ("work"). (Wiktionary) It is one of those strange quirks of European language and cultural history that a term referring to a man-made device is used to describe the process of life. An organelle is a sub-component of a cell. See Chapter 8 (Consciousness) and the work of Gunter Albrecht-Buehler (op. Cit.) on "*Cell Intelligence*".

39 James Lovelock (2000) Gaia: A New Look at Life on Earth. Publ. OUP (Oxford Landmark Science), Paperback, 176pp ISBN-13: 978-0192862181. Or for a summary see https://courses.seas.harvard.edu/climate/eli/Courses/EPS281r/Sources/Gaia/Gaia-hypothesis-wikipedia.pdf

40 The biosphere consists of the larger life that inhabits the oceans (fish, cetaceans, etc), the land (mammals, reptiles, etc.) and the air (birds, bats), plus al the smaller life (down as small as it is possible to get) in the rocks many kilometres deep, the soil and water and air – right up to the fringes of space, plus any space-borne viruses that may participate in that terrestrial life. In addition, the rocks and air and water themselves can be considered to have an intelligence of their own that also participates in the total field of consciousness of the living being that we call Earth. When viewed in this light, the sun also may be considered to be a living being. For thought-provoking science fiction treatment of this theme, see e.g. *Whipping Star* (1970) by Frank Herbert, or Ursula K. Le Guin's 1972 novel *"The Word for World is Forest"*.

41 Professor Nick Lane (Feb 14, 2018) How Energy Flow Shapes The Evolution of Life. https://www.youtube.com/watch?v=oXeozqH5auQ&t=480s

42 Structure of world's largest single cell is reflected at the molecular level https://www.sciencedaily.com/releases/2015/01/150129160728.htm

43 David Beniaguev, Idan Segev & Michael London (2021) Single cortical neurons as deep artificial neural networks. Neuron 109(17) pp2727-2739.e3, Sept 01 DOI:https://doi.org/10.1016/j.neuron.2021.07.002

44 Research associate at the Donald Danforth Plant Science Center, St Louis, Missouri www.danforthcenter.org : Quotation from the 2015 annual report, page 21.

45 Elizabeth Pennisi (23 Feb 2022) Largest bacterium ever discovered has an unexpectedly complex cell: Giant microbe from a mangrove could be a missing link between single-celled organisms and the cells that make up humans. Science ¦ Biology https://www.science.org/content/article/largest-bacterium-ever-discovered-has-unexpectedly-complex-cells

46 May RM (2011) Why Worry about How Many Species and Their Loss? PLoS Biol 9(8): e1001130. https://doi.org/10.1371/journal.pbio.1001130

47 Officially, a species is a group of similar life-forms that can not normally interbreed successfully with another species and produce non-sterile offspring. And a subspecies is a group of animals that are able to successfully interbreed with others in the same species, but possess noticeably and consistently different features from other animals in the same species. Ever since Linnaeus's

classification of life into a tree-like set of interrelationships of distinct species, we have tended to assume that the species boundary is absolute. DNA sequencing has changed that view. It appears that every form of life that reproduces sexually has interbred with similar species during its early transition into a separate species. So, for instance, about 10-15% of human genetic ancestry is now known to be Neanderthal; and an unknown proportion of DNA in humans from Asia and Australasia is probably Denisovan – another extinct branch of early hominids. We would not expect this kind of cross-fertilisation to occur outside a single Family (e.g. Hominids). And normally interbreeding would not be expected to have effect outside a Genus (a subset of Family). For instance Horses and Donkeys are in the same Genus, and usually produce infertile offspring (mules) – so Horse-Donkey (Honkey?) offspring would not normally breed back into either horse or donkey genetic lines..

48 Kenneth J. Locey and Jay T. Lennon (2016) Scaling laws predict global microbial diversity, Proceedings of the National Academy of Sciences (PNAS) May 24. 113 (21) pp5970-5975. DOI: 10.1073/pnas.1521291113 Also see: https://phys.org/news/2016-05-earth-home-trillion-species.html

49 Lee Sweetlove (2011) Number of species on Earth tagged at 8.7 million : Most precise estimate yet suggests more than 80% of species still undiscovered. Published online 23 August 2011 | Nature | doi:10.1038/news.2011.498 https://www.nature.com/news/2011/110823/full/news.2011.498.html Also see Mora C, Tittensor DP, Adl S, Simpson AGB, Worm B (2011) How Many Species Are There on Earth and in the Ocean? PLoS Biol 9(8): e1001127. https://doi.org/10.1371/journal.pbio.1001127

50 Science is very parochial in this regard. Indigenous tribes often have a broad and comprehensive knowledge of the wildlife and plants that inhabit their world. There are several projects currently running to assist tribes in (e.g. India and South America) to catalogue their knowledge and make it available for biologists. This process is particularly important in preserving the natural botanical wealth, since it creates an archive of information for herbalists and ethnobotanists which then may help to prevent large pharmaceutical interests from patenting those plants as medicines. Remarkably, India recently staved off a legal attempt to patent the Neem tree – a plant that has been used by people as an antibiotic across three continents, probably throughout the entire history of humanity.

51 For instance, in 2017, 85 plant and animal species new to science were catalogued and added to the official tree of life, including 16 flowering plants, three scorpions, 7 species of ant, 22 fish, 10 sharks, a lizard, and an elephant-shrew (a small mammal more closely related to elephants than to rodents).

52 Yinon M. Bar-On, Rob Phillips & Ron Milo (2018) The biomass distribution on Earth. Proceedings of the National Academy of Sciences May, 201711842; DOI: 10.1073/pnas.1711842115

53 Rosing, M.; Bird, D.; Sleep, N.; Bjerrum, C. (2010). "No climate paradox under the faint early Sun". Nature. 464 (7289): 744–747. Bibcode:2010Natur.464..744R. doi:10.1038/nature08955. PMID 20360739.

54 There are three Milankovitch cycles that superpose to cause glacial periods. (1) Eccentricity (or elipticity) if the Earth's orbit takes it closer and further from the Sun in a cycle of about 100,000 years. (2) Avial tilt of the earth affects the strength of seasonal variations in climate, the day-night ratio and the amount of solar radiation that can fall on the poles. This changes between 21.5 and 24.5 degrees over a 41,000 year cycle. (3) the direction that the earth's axis of rotation points relative to its orbit around the

sun changes ("precession") over 23,000 years, and this affects the relative contrast of summer vs winter. At the moment we are at a time when this contrast is at its minimum. http://www.indiana.edu/~geol105/images/gaia_chapter_4/milankovitch.htm

55 Brian D. Fields, Adrian L. Melott, John Ellis, Adrienne F. Ertel, Brian J. Fry, Bruce S. Lieberman, Zhenghai Liu, Jesse A. Miller, Brian C. Thomas (2020) Supernova triggers for end-Devonian extinctions. Proceedings of the National Academy of Sciences Aug, 202013774; DOI: 10.1073/pnas.2013774117 and https://phys.org/news/2020-08-stars-mass-extinction-earth.html

56 It has been suggested that large scale circular features such as the west coast of Africa, Hudson's Bay, the continent of Antarctica, or the string of Aleutian Islands off Alaska may show the location of very ancient impact supercraters. Their survival undistorted over geological time would require the crust to retain a ring of weakness – as can be seen in the way karst features (limestone caves) occur along the circular edge of the Chicxulub crater. Smaller craters tend to be deformed – such as the 1900 million-year old Sudbury crater in Canada (the location of the richest Nickel deposit in the world), which has been squeezed into a long ellipse. At only 130 kilometres wide, it is one of the smaller craters from the first half of the earth's history.

57 Splosh! How the dinosaur-killing asteroid made Chicxulub crater by Jonathan Amos BBC Science Correspondent, 25 October 2018 https://www.bbc.co.uk/news/science-environment-45986449

58 Douglas Preston (March 29, 2019) The Day the Dinosaurs Died : A young paleontologist may have discovered a record of the most significant event in the history of life on Earth. The New Yorker. https://www.newyorker.com/magazine/2019/04/08/the-day-the-dinosaurs-died

59 Lunar and Planetary Institute (part of the Universities Space Research Association of the US National Academy of Sciences) : Regional effects of the Chicxulub impact event. https://www.lpi.usra.edu/science/kring/Chicxulub/regional-effects/

60 The P-T extinction event Siberian Traps may also have been caused by an asteroid impact. Their start is coincident in time with the probable age of the 245-kilometre wide Wilkes Land gravitational anomaly in Antarctica – which is itself probably an impact crater, that lies on the opposite side of the Earth to the Siberian flood basalts.

61 The timescale is somewhat deceptive, being in millions of years. There can be no doubt that this single event would have buried all traces of any civilisation, had humans existed at the time. Estimates of how long ecosystem and biodiversity recovery might take after this kind of event vary from one or two million years to over 30 million years.

62 Commentary by James deKorne on second line of Shock the Arousing, hexagram 51. The gnostic book of changes. http://www.jamesdekorne.com/GBCh/ichingdl.htm

63 Rebecca Elson (Eds. : Anne Berkeley, Angelo di Cintio, Bernard O'Donoghue) (2018) A Responsibility to Awe. Publ. Carcanet Classics ISBN-13: 978-1784106553 https://www.amazon.co.uk/dp/1784106550?linkCode=gs2&tag=braipick-21

64 Mathematical Challenges to Darwin's Theory of Evolution (Jul 22, 2019) The Hoover Institute https://www.youtube.com/watch?v=noj4phMT9OE

65 NASA Goddard (Nov 14, 2018) Massive Crater Discovered Under Greenland Ice. https://www.youtube.com/watch?v=vTr3VdGlFr8

66 Immanuel Velikovsky (2009) Earth in Upheaval. Publ. Paradigma Ltd ISBN-13: 978-1906833121 (first published Doubleday 1955).

67 https://www.smithsonianmag.com/science-nature/comet-upended-life-paleolithic-village-12800-years-ago-180974575/

68 The Burckle Crater Mega Tsunami (Documentary) https://www.youtube.com/watch?v=ewZEg6WwA2s

69 https://www.livescience.com/64179-ancient-cosmic-airburst-middle-east.html

70 Richard Allen White III, Pieter T. Visscher & Brendan P. Burns (2020) Between a Rock and a Soft Place: The Role of Viruses in Lithification of Modern Microbial Mats. Trends in Microbiology | Opinion 29(3), pp204-213, March DOI:https://doi.org/10.1016/j.tim.2020.06.004

71 Blankenship RE (2010) Early Evolution of Photosynthesis. Plant Physiology 154(2) October pp434-438 doi: http://dx.doi.org/10.1104/pp.110.161687 available online at http://www.plantphysiol.org/content/154/2/434.full.pdf+html

72 David PG Bond & Stephen E Grasby (2017) On the causes of mass extinctions. Palaeogeography, Palaeoclimatology, Palaeoecology 478, 15 July, pp 3-29 https://doi.org/10.1016/j.palaeo.2016.11.005

73 ... and this is interesting as an analogy to trauma. Most "traumatisation" of individuals is not caused by single large events, but rather is the result of long term stress, compounded by a few relatively small additional stressors (e.g. a family death or an operation or an accident, or even just a visit to the dentist).

74 Eric Cline (Oct 11, 2016) 1177 BC: The Year Civilization Collapsed. https://www.youtube.com/watch?v=bRcu-ysocX4

75 Fall of Civilizations (Apr 8, 2020) Episode#2. The Bronze Age Collapse - Mediterranean Apocalypse. https://www.youtube.com/watch?v=B965f8AcNbw

76 Karen Armstrong (2007) The Great Transformation: The Beginning of Our Religious Traditions. Publ. Vintage Books ISBN-13: 978-0676974669

77 Edgar Morin (2006) RE: From Prefix to Paradigm. World Futures: The Journal of New Paradigm Research 61(4) 19 Aug pp254-267 https://doi.org/10.1080/02604020590952583

78 The Embryo in Motion, http://www.embryo.nl/english-1?sitelang=EN

79 Gilbert SF1, Sapp J & Tauber AI. (2012) A symbiotic view of life: we have never been individuals. Quarterly Review Of Biology. 87(4) pp325-341. PMID:23397797 https://works.swarthmore.edu/fac-biology/165

80 Rosenberg E & Zilber-Rosenberg I. (2016) Microbes Drive Evolution of Animals and Plants: the Hologenome Concept. MBio. 2016 Mar 31;7(2):e01395. doi: 10.1128/mBio.01395-15.

81 Whilst predation is often considered to be a good reason to look at life as merciless and "red in tooth and claw", this view must change if Life is considered to be a single organism. The eating of one life-form by another becomes no different from the Krebs cycle or some other biochemical cascade that achieves efficient energy conversion, and bacteria-eating-bacteria were chomping away at least two billion years ago. Predation has been one of the greatest driving forces for evolution. Rapidly firing neurons and eyes were developed during the Cambrian explosion, and may have even evolved twice, in bilaterians (vertebrates) and cnidarians (cuttlefish and octopuses). See Monk T. & Paulin M.G. (2014) Predation and the Origin of Neurones. Brain Behav Evol

2014;84:246-261 https://doi.org/10.1159/000368177

82 Charlie Wood (September 12, 2018) World's Simplest Animal Reveals Hidden Diversity | The first animal genus defined purely by genetic characters represents a new era for the sorting and naming of animals. Quanta Magazine | genomics. https://www.quantamagazine.org/worlds-simplest-animal-reveals-hidden-diversity-20180912/

83 National Academies of Sciences, Engineering, and Medicine; Division on Earth and Life Studies; Board on Agriculture and Natural Resources; Committee on Genetically Engineered Crops: Past Experience and Future Prospects. Genetically Engineered Crops: Experiences and Prospects. Washington (DC): National Academies Press (US); 2016 May 17. 5, Human Health Effects of Genetically Engineered Crops. Available from: https://www.ncbi.nlm.nih.gov/books/NBK424534/

84 ... partly because these are determined in a reductionist experimental framework, so despite the care taken, they may bear little resemblance to the integrated processes in a living cell

85 Archive for Research in Archetypal Symbolism (Editor-in-Chief Ami Ronnberg) (2010) The Book Of Symbols: Reflections on Archetypal Images. Publ. Taschen ISBN-13: 978-3836514484