FACT SHEET NUMBER #2

WHO OR WHAT IS GAIA? BLOOD MUSIC – THE EARTH FROM MYTH TO MOVEMENT

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ABSTRACT: *The realisation that the Earth is not just a passive home for life, but has many properties as a living system, enables us to connect modern science and ancient spiritualities, into an ethic for a common social movement. The care of the whole is thus deeply connected to the care of each part.*

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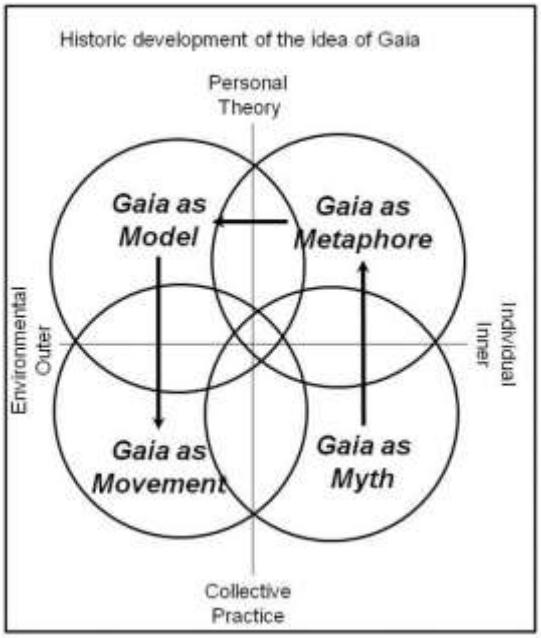
Lewis Thomas "The Lives of a Cell"

"My dangerous joy is still in bud
when everlasting moments cry
Like golden trumpets in my blood"

Unknown

WHO OR WHAT IS GAIA?



Dragon Dreaming emerged as a result of the work over 26 years of the Gaia Foundation of Western Australia. The Gaia Foundation is part of an informal world-wide network of individuals and other groups, which share concerns with learning to live more sustainably on the Earth. Members of the Gaia Foundation in Australia are committed to its three objectives;

- ***personal growth*** - commitment to your own healing and empowerment
- ***community building*** - strengthening the communities of which you are a part
- ***service to the Earth*** - enhancing the wellbeing and flourishing of all life

The structure of the Gaia Foundation avoids the central committee-passive periphery structure of conventional non-government organisations. It is modelled on the living ecology of the Earth itself. All activities of the Foundation are created as independent "projects" in which the participants involved in that project have all power and authority. This unique "chaordic" structure of the Foundation, designed as a number of inter-linked projects, works in a similar way that nature interconnects ecologies. Each project is independent, autonomous self-governing, and self-funded. All projects inform and support each other to meet the

three objectives. The Gaia Foundation is thus part of what has been called the "Blessed Unrest" unforseen by all – the largest social, environmental and political movement of the world.

But, who, or what is Gaia? How, in the 21st century can we to hear once again the voice of Gaia? Some readers may have heard the word before. Some may even think they have some idea on what it is. "Gaia" is both a fact in itself, and an idea about that fact. Caroline Merchant[1] has shown us that the idea of "nature" has a history that it is "inside" our own history. Gaia can therefore be seen as an "idea" or "concept" that has a history of its own. This is the "inner view". At the same time, Gaia can be described as an objective model of how the Earth System functions, maintained and maintaining itself as a living habitat of life. Eco-philosopher Ken Wilbur[2] would consider this an "outer view". At the same time, Gaia can be used by an individual ancient or modern writer as a specific metaphor for "life" or for the "Earth", and increasingly Gaia is being used as an image of collective inspiration for environmental and other social activists world-wide. Tom Ellis of GAIA International has shown that these four uses of Gaia, comprise simultaneously

- *A myth*, born from our ancient Civilisations from 5,400 BCE to 393 CE Civilisation as it grew and shifted from love to being based upon the killing or the controlling of Gaia. In the long Christian centuries that followed Gaia was reduced to
- *A metaphor,* for life itself. In classical Civilisations, from 776 BCE to 1789 CE, the cosmos was viewed as an organism, a living thing of which we all took part. But with the Enlightenment, and the shift from 1648 discussed in Chapters 2 to 4 to Industrial Growth Civilisation, the cosmos became clockwork, a mechanism, dead and inert. It was with
- *A model*, of Gaia, newly-hatched from within the bosom of modern science, that we see the reality of the ancient view of the Earth as a living system re-enter the modern world, beginning to completely restructure our view of reality. Out of this new planetary reality has emerged
- *A movement*, what has been called "the deep long range environmental movement" which is in the process of merging with other social change groups in the World Social Forum, and the Transition and Occupy movements, to become "the second world superpower".

Possibilities for the further development of the Gaia movement are discussed in future chapters of this book. Here we will be discussing the consequences and meaning for us and our destiny as human beings of the re-emergence of Gaia in recent times.

Dianne Skafte[3] in her book "When Oracles Speak", is of the opinion, that after an absence of seventeen hundred years, oracles are coming back into the world. She states the "To receive an oracle is to receive guidance, knowledge, or illumination from a mysterious source beyond the personal self". We have been exploring the nature of this "personal self" in the last chapter. We now have to understanding what is "beyond it" and "how this beyond can communicate with us"; this is a central theme Dragon Dreaming. How does the Earth speak through us? The oracle heard at Delphi was said to be the voice of the God Apollo, but Apollo is supposed to have taken the shrine at Delphi from Gaia, from the Earth itself. This usurpation was the result of a long historical process. It seems to have begun as the result of specific historical conditions, attendant upon the rise of warring, socially stratified leisured male elites and their subservient male and female dependents, beginning in a period of climate change and aridity in the cities of Southern Iraq, and along the Nile Valley some fifty centuries ago.

Before then the greatest mystery to the first cultures in Southern Iraq was thus the act of love, between a man and a woman, which led to the birth of a new child[4]. In this act of conception and birth, the most sublime act of creation conceivable, men and women were jointly and equally involved in the process. As a result the earliest Sumerians, like the substrate culture before them, saw the process of creation as a series of gods coming together with goddesses to give birth to the

next generation. In this period of climate change and resulting environmental pressures there was the shift in the metaphor away from that of a balanced loving between male and female principles used to describe the mystery of creation, to the slaying and dismemberment of an earlier female Goddess. This occurred at the exact time that a class of militaristic "Big men" was taking over political authority from gender neutral temple establishments, previously centred upon a sacred marriage between male and female. Furthermore this period shows a clear shift in a mythology from one in which male heroism was inclusive and concerned about maintaining ecological balance, to one where heroism was exclusive to men and concerned about conquest of fear of death and ecological destruction, and the quest for the immortality of the male rulers. As the demonising language of the recent Iraqi war shows[5], we still live out of these ancient patterns.

The name Gaia name comes from two much older words, *Ge (or "Earth" found in words like Geography or Geology), possibly derivative of the Sumerian Ki, and *aia, which seems to have originally meant "Mother" or "Grandmother". In the most ancient Greek times she was called "Gaia Urania" [6] or "Earth, the All Mother". Gaia as grandmother Earth re-entered the modern consciousness again after an absence of nearly sixteen hundred years, when this was suggested as the possible name that could be given to an important hypothesis that the Earth itself could be considered to be alive, developed by the British independent scientist, Professor James E. Lovelock, by his neighbour of Bowerchalke in Wiltshire, William Golding, the 1983 Nobel Prize winner for literature. Lovelock and Golding often used to walk to the local post office, half a mile away, together. When discussing exciting new ideas their walks would often take them further. Golding suggested that an important new idea about the Earth required an important name, in order to attract attention, and suggested the name Gaia. Lovelock at first thought he meant "gyre", an ancient name for whirlpool, which led to some confusion. Golding, a classical scholar with a training in science, explained that no, Gaia was the Greek Goddess of Earth. This was an inspired act. After an absence of more than a millennium, Delphic Gaia was now resurrected, this time in a modern scientific guise; as a model of how the Earth actually functions. With Lovelock's theory, once again, we were discovering ways in which our individual life, seen for so long as separate individual bodies, was in fact really part of something much larger and older than ourselves, a huge, ancient, evolving "being" whose collective interactions creates the conditions necessary for the continuation of all life upon the planet. Gaia, like the Sumerian Earth Goddess Ki, Lady Sacred Mountain - Ninhursag herself, in whose body everything existed, had been resurrected in a new way. The latest satellite tests and scientific evidence was confirming the inherent wisdom of these ancient cultures which showed that it was only by living in harmony with the natural rhythms and cycles of the Earth that all life could be maintained.

Lovelock had an intriguing scientific background. Always one to think "outside the box" of conventionality, his wide scientific reading in the public Brixton Library of London as a child did more than formal education to interest him in science, and he began work as an unqualified laboratory technician working for a small firm in the photographic industry where exactitude was essential. Putting himself through night-classes to earn a scientific qualification then took him to Manchester to finish a formal degree in Chemistry. There the exactness of his work led a professor to accuse him of cheating, but this exactitude, and a willingness to assist others in their problems led to employment with the British National Institute for Medical Research. It was a perfect job to nurture the skills of someone as creative as Lovelock. The institute handled most administrative matters and encouraged its staff, as valued professionals, to pursue their interests in what ever field of exploration took their interest, in the knowledge that free enquiry would eventually return commercial dividends. Lovelock's work there was in a wide range of fields concerned with "atmospheric hygiene", investigating airborne infectious diseases and the common cold, protecting cells and animals from freezing, and in calcium uptake in cells. This led eventually to the area how to detect the presence of chemicals in very small quantities, sometimes one part per trillion. Lovelock,

as a helpful individual and a well trained and accurate chemist thrived in finding ingenious technical chemical solutions such other people's biological problems.

Since 1950, more than 70,000 new chemicals, never before seen in Nature, have been released into the environment. In 1957 Lovelock invented a technology of electron capture detection system for spectroscopy, particularly sensitive to finding low concentrations for compounds like the DDT derivatives in the thinning eggshells of predatory birds. This technology had a major effect in assisting Rachel Carson in the research for her book "Silent Spring", where she was the first to draw attention to this problem of this load of toxic chemicals in the biosphere, so launching the modern environmental movement. Since the beginning of the 20th century, as a result of the Quantum and Relativistic scientific revolution, and wrestling to understand the complexity of the new sciences of ecology and cybernetics, scientists had come to recognise that "reductionism" only gave part of the picture and in fact Nature was organised as a much more complex system. Carson was aware of the work of the Russian ecologist, Vladimir Verdansky[7] who stated that a biosphere was a stable, adapting self-organising life support system with the potential to be a major geological force on a planet's surface and ecosphere. She also drew on the General Systems approach of Ludwig Von Bertalanffy[8] and the cybernetics of John Von Neumann[9]. Carson used these results to effectively demonstrate the ecological interconnectedness of all life, by showing how pesticides were eliminating bird life in different areas. Sprayed on insects, who were in turn eaten by small birds, that were preyed upon by larger raptors, they were concentrating in their body tissues, and only eliminated through the laying of eggs, thinning eggshells and causing the young to die. Carson's findings, based on Lovelock's technology, had a huge effect in galvanizing activists against chemically poisoning of pests, and led to the US Clean Air Acts and other Environmental Protection legislation to clean up the environment.

Lovelock's electron capture technology was also used by him two decades later making the first discovery of the accumulation of ozone destroying Chloro-Fluoro Carbons (CFC's) in the atmosphere, that are now known to puncture the hole in the Southern Hemisphere Ozone Shield, the shield that protects all terrestrial life from harmful Solar ultraviolet rays. However, in the 1970s under pressure from the Chemical Industry, these findings were ignored until irrefutable evidence of an Ozone Hole was seen at Antarctica by space and ground observations. By then the leading chemical companies had developed a replacement chemical to the CFC's and so an international protocol, signed in Montreal, agreed to phase out these chemicals from production.

The same research, by Lovelock on the Antarctic supply ship Shackleton also confirmed the first scientific prediction made for his Gaia Hypothesis. Thus in a very real way, the whole of the modern concern about some of the major issues of our environment stems from Lovelock's little invention.

Partly as a result of the discovery of electron capture Lovelock was invited by NASA to work at the Jet Propulsion Laboratory in California, USA, in 1961, to assist with developing ways of devising tests for detecting life on Mars. The attempt to discover whether there was life on Mars, led Lovelock into the creative thought "If I were a Martian, how could I detect life on Earth?" Lovelock had been reading the influential book by quantum physicist Erwin Schrodinger on "What is Life?", written after a series of lectures he gave at Trinity College Dublin in 1943, that had also been read by James Watson and Francis Crick and had a huge impact upon the discovery of DNA. In his book Schrodinger suggested that the key feature of living tissue was to produce highly ordered, low entropy internal states through obtaining energy from and passing its wastes to the wider environment. Lovelock's creative way of thinking led him to think about the ways in which it was the environment itself that delivered the energy to and removed the wastes from the nearby local environment of the cell, because otherwise without this environmental cooperation the cell would perish from hunger or

from the accumulation of poisons. The environment was not passive but had become an active cooperator in this process.

There was a second impetus to Lovelock's development of the Gaia theory. It was Fred Hoyle, the British physicist who said "Once we digest the implications of the photo of the Earth from outer space, we release an idea as potent as any in human history". The photos have in recent years, become familiar as advertising slogans, but Peter Westbroek[10], for instance, has written that although

> *those pictures of the Earth [may] have become ordinary stereotypes, and it is difficult to remember their original significance, [yet] there can be no doubt that once and for all they have changed the perception of the world for billions of people. In the years following the Apollo voyages we became collectively aware of the vulnerability of the environment and of the risks of unchecked technological and economic growth. This marked the birth of the [modern] environmental movement.*

The amazing Apollo 8 photo "Earthrise", for instance of the pregnant living Earth rising above the sterile moon, too seems to have had an effect in the development of the Gaia hypothesis. It certainly created a powerful impression that the Earth was a unique, complex and dynamic living system. American poet Archibald MacLeish, for instance writing on Christmas Day 1968 said "To see the Earth as it truly is, small and blue and beautiful in that eternal silence where it floats, is to see ourselves as riders on the Earth together, brothers on that bright loveliness in the eternal cold—brothers who know now that they are truly brothers." Lewis Thomas in his "Lives of a Cell", where, responding to the same photograph, stated

> *Viewed from the distance of the moon, the astonishing thing about the earth, catching the breath, is that it is alive. The photographs show the dry, pounded surface of the moon in the foreground, dry as an old bone. Aloft, floating free beneath the moist, gleaming, membrane of bright blue sky, is the rising earth, the only exuberant thing in this part of the cosmos. If you could look long enough, you would see the swirling of the great drifts of white cloud, covering and uncovering the half-hidden masses of land. If you had been looking for a very long, geologic time, you could have seen the continents themselves in motion, drifting apart on their crustal plates, held afloat by the fire beneath. It has the organized, self-contained look of a live creature, full of information, marvelously skilled in handling the sun.*

Later in the same essay he wrote

> *I have been trying to think of the earth as a kind of organism, … The other night, driving through a hilly, wooded part of southern New England, I wondered about this. If not like an organism, what is it like, what is it most like? Then, satisfactorily for that moment, it came to me: it is most like a single cell.*

Thomas's view was ignored by scientists as a flight of poetic fantasy. Nevertheless he did supply a forward to Lovelock's second book "The Ages of Gaia", stating his belief that Lovelock's Gaia hypothesis may be, in time, "recognized as one of the major discontinuities in human thought". It was Lovelock, however, who was to carry this idea of a living Earth to a new level of complexity.

In the 1960s French infrared tests showed that the atmospheres of Mars and Venus were completely unlike that on Earth. With more than 98% carbon dioxide and 2% nitrogen, they were totally without oxygen and in fact resembled the Earth's atmosphere that would be created if everything combustible on Earth had burned, and all carbon dioxide, buried as limestone, was released. By

comparison the Earth's atmosphere with 78% nitrogen and 21% oxygen appeared totally unstable, a pre-combustion situation – comprising small amounts of flammable gasses like methane simultaneously present in association with oxygen. Oxygen, as the second most reactive gas after fluorine, should make such an atmosphere according to conventional science, a chemical impossibility. The formula of the reaction is easy to understand

(1) CH_4 (methane) + $2O_2$ (oxygen) → CO_2 (carbon dioxide) + $2H_2O$ (water) + energy

Methane, when it exists in the presence of oxygen gets converted into carbon dioxide and water with a release of considerable amounts of energy. Only through the continued addition of methane at the rate of more than a billion tones of each every year and oxygen at twice that amount explained their mutual presence, and Lovelock realised that only life as a whole could produce such results. In fact, the more he considered this the more he realized that not only did life produce such conditions, but the flourishing of life on any planet depended upon them. Inspired by the photos of the Earth from Space, as Lovelock wrote in his autobiography "Homage to Gaia", he came to see that the Earth was

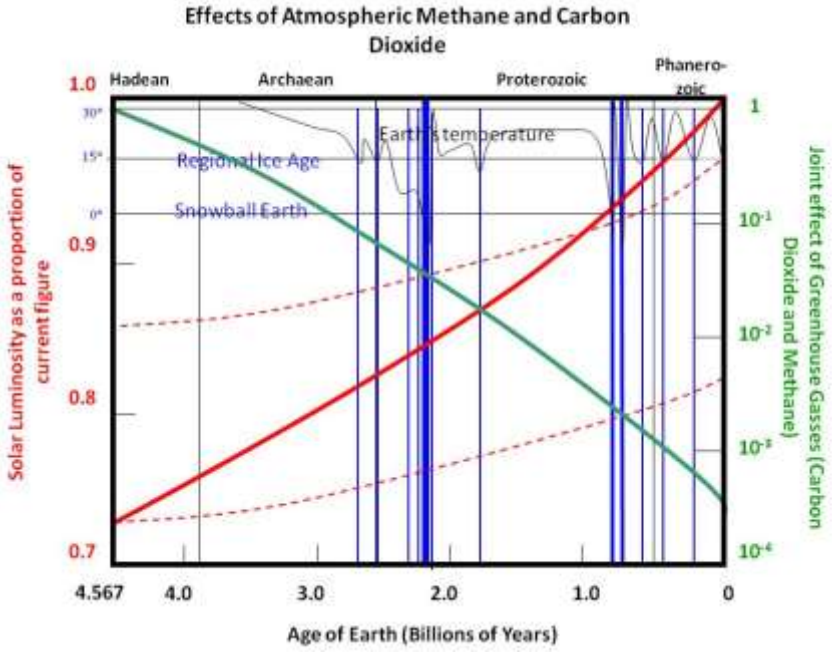
> *" much more than just a ball of rock moistened by the oceans or a spaceship put there by a beneficent God just for the use of humankind. I saw it as a planet that has always, since its origins nearly four billion years ago, kept itself a fit home for the life that happened upon it and I thought that it did so by homeostasis, the wisdom of the body, just as you and I keep our temperature and chemistry constant."*

Life as a collective whole seemed to be generating the conditions necessary for its own future survival. These thoughts led Lovelock to realize that these "far from equilibrium" conditions could be detected telescopically from Earth, far from the surface of a planet. One did not need to visit Mars or Venus to know that they were lifeless in comparison to the Earth – we could tell that this was so from here. This was clear a message that the National Aeronautics and Space Administration, who were planning send Mars probes to the planet did not want to hear.

The Earth's atmosphere is clearly a strange mixture. Oxygen is a strange material, it will oxidize, rust and corrode any metal exposed to it except gold. By all the known laws of chemistry, with sufficient energy, oxygen even reacts with nitrogen to make nitrous oxide (the anaesthetic "laughing gas"). Over time one would expect the amount of such gas would increase and the concentrations of pure oxygen and nitrogen would fall, but this does not happen.

Even stranger, as Carl Sagan, the astronomer, suggested to Lovelock, was the way in which the Earth has been maintained as an environment of liquid water for the whole of its existence. In fact Lovelock initially thought that temperatures world-wide had remained between 10 and 20 degrees Celsius, but it is today known that in its early history the planet was less sophisticated at homeostatic regulation than it is today. At the time the Earth was formed, after the end of the hot T Tauri stage at the time the Earth solidified about 4 billion years ago the sun was less than 72% as hot as it currently is. An earth with our current atmosphere, before 800 million years ago, would have been frozen solid, an iceball world completely devoid of life, like Jupiter's moon Europa. In fact, recent paleoclimatological studies suggest that this very nearly happened, but rather than being the result of the cooler sun, it was a result more of the rapid reduction of the Greenhouse effects of carbon dioxide, which had been reduced to a little more than one thousandth of its earlier effects. A similar "Snowball Earth"[11] period was found in the Huronian Ice Age, some 2,300 million years ago when methane was largely eliminated from the atmosphere by the presence of oxygen. But studies of the Earth's past temperature, have shown that since the end of the formative Hadean period and the end of the Late Heavy Bombardment, temperatures on the planet have largely oscillated

between just under +30 and +5 degrees Celsius. Despite the frozen conditions of the Earth at these periods, the freeze can never have been total, as life on Earth would not have continued, a fact which required the continued presence of liquid water on the planet. Furthermore, the fact that the Earth has not irretrievably frozen or boiled has been shown by the fact that fossil Zircons from the Narilyer Jack Hills region of Western Australia formed beneath the sea, showed that liquid water was already present 4.15 billion years ago, despite the much cooler sun. Lovelock's research first showed that this continual presence of water was another unexplained paradox.



Our strange atmosphere, with 21% oxygen and 78% nitrogen, with only traces of other gases, so different than the atmospheres of Venus and Mars which are nearly 98% carbon dioxide and less than 2% nitrogen, must therefore be a comparatively recent phenomenon, specifically adapted for a hotter sun. With the sun growing hotter, one would expect temperatures of the oceans on Earth at that time of its formation to rise to the extent that all oceans would long ago have evaporated, any water present at that stage should have boiled away by now as steam vapour, leaving a dry Venusian world, but this is not so. We are still a water world and since the beginning seem to always have been so.

A third puzzling piece of evidence concerns the salinity of our oceans. Fresh water evaporates from our seas to fall upon the land as rain. There it dissolves the chloride ion out of calcite, and the sodium ion out of granites, to wash both into the ocean as sodium chloride – sea salt, at the rate of 800 million tones per annum. This is enough to achieve the current salinity of 3.4-3.6% within a few years. As this process has continued throughout geological history, we would expect the salinity of sea water to increase over time. However, a number of tests suggest that this is not so, the salinity of sea water appears to have been maintained constantly at about 3.6%. Any change from this figure makes it difficult for marine life to continue.

Whilst puzzling over these three pieces of information, Lovelock found that ultimartely there was one possible explanation. He realized that similar paradoxes are found in the case of living tissue in the human body. For instance just as we breath in oxygen and breath out carbon dioxide, so equally the Earth as a whole, inhales nitrous oxide to make nitrate fertilizers for plants, and after denitrification and photosynthesis exhales nitrogen and oxygen, in exactly the right proportion to maximize the energy available for life without risking the conflagration of wildfires in which everything flammable would be consumed. Equally, just as our body maintains a temperature range between 36 and 37 degrees Celsius, so the Earth as a whole would appear to maintain an atmospheric temperature and pressure within limits that enables water to exist in close proximity in all three states – as ice, liquid and as a gas – at a current planetary average temperature of nearly 15^{o} Celcius. Finally, just as we maintain the salinity of the blood within certain medical limits, so the

Earth, in some way, through regulation of sources and sinks, is doing the same for the oceans as a whole.

The leap in thinking that Lovelock made today seems almost self evident. It was not so evident at the time. Lovelock in his autobiography described how in September 1965 it came to him with a flash of inspired insight that the Earth, itself, was alive, as some kind of gift of creation itself. His theory was publicly announced for the first time in 1968 in the Journal of the American Astronautical Association, and caused barely a ripple of interest. Looking back, this was probably to be expected. The Mahatma Gandhi once stated that "first they ignore you; then they laugh at you; then they fight you; then you win." This is exactly what seems to have happened with this first mention of the Gaia hypothesis. Lovelock's Gaia was at first ignored.

But to become accepted Lovelock had to demonstrate "how did a living planet achieve such amazing achievements." It was Carl Sagan's ex-wife, Lynn Margulis who supplied the answer. Over twenty years younger than Lovelock, Margulis, who had been something of a scientific prodigy, had entered university at the age of 14. There she had in her doctoral thesis been storming the citadels of conventional biology by suggesting that cooperation was as important a factor in the evolution of complex life as was competition. In fact at a bacterial level survival of the fittest seemed to suggest that the competitive advantage of "fitness" was conferred on those that could best cooperate with others. The mitochondria and chloroplast organelles found inside higher Eucaryotic plant and animal cells, she demonstrated were once free-living purple bacteria and blue-green algae. Finding a way inside larger yeast-type cells without getting digested led to benefits all around. The cells were given new powerhouses of energy and some protection against the harmful oxygen atmosphere, produced as a by-product of photosynthesis, in return for being protected from predators and given a comfortable future existence in which many of their needs were automatically provided for. Margulis, demonstrated how these metabolic cycles were assembled through the cooperating symbiotic activities of trillions of bacteria, which collectively weave the web of life through an organic chemical "language" of exchanges driven ultimately by sunlight that keeps us all alive. This can even be expressed as a simple chemical formula

(2) $106\ CO_2 + 90H_2O + 16NO_3^+ + PO_4^{3+}$ + minerals + 5.4MJ light=3,258gm of living protoplasm + $154O_2$ + 5.35MJ (heat)

The chemical composition of 3,258 grams of protoplasm is as follows

106 mole atoms	1272grams	carbon
180 mole atoms	180grams	hydrogen
46 mole atoms	736grams	oxygen
16 mole atoms	224 grams	nitrogen
1 mole atom	31 grams	phosphorus
Various	815grams	minerals (including suphur and iron)[12]

And through respiration of plants and animals

3,258gm of living protoplasm + $154O_2$ + 5.35MJ heat = $106\ CO_2 + 90H_2O + 8N_2 + 24O_3^+ + PO_4^{3+}$ + minerals + 5.4MJ heat.

Multicellular creatures like you or me, Margulis suggested, rather than the results of a single line of evolution from a Last Universal Common Ancestor are rather cooperative alliances forged between many different species of bacteria through "horizontal gene transfer" (HGT). Such cooperation first evolved on Earth within ecosystems such as stromatolites, the first "living fossils" found widely in

the oldest rocks of the planet, and today in Shark Bay and in Lake Clifton, near my home in Western Australia.

Lovelock and Margulis met briefly in 1968, at Princeton, but it seemed to have little effect either way. Margulis was interested in the origins of the oxygen atmosphere, important for understanding the evolution of aerobic oxygen breathing bacteria from anaerobic bacteria, and asked Sagan for help. He suggested Lovelock, and in 1971 they met again in Boston. It was a meeting that seemed it was meant to happen. For Margulis Gaia provided the ultimate field of cooperation for the swarms of living bacteria, which through HGT were to show that they comprise a single gene pool, cooperatively freely swapping pieces of DNA between what scientists had previously thought of as mutually exclusive and competitive species. Margulis supplied Lovelock with the detailed microbial understanding upon which all future Gaia theory was to be based. Lovelock with Gaia theory provided a stage big enough for Margulis's principles of cooperative bacterial symbiogenesis to have their ultimate and greatest impact, that of shaping and reshaping a whole planet.

She encouraged Lovelock to publish his theory, but no front-line peer reviewed scientific journal could handle so radical a theory named after a Greek Goddess. In 1972, in the little known journal Atmospheric Environment Lovelock wrote an article, "Gaia as seen through the atmosphere", in which the theory was publicly mentioned for the first time.

In 1974 Margulis and Lovelock then worked together for three articles which also were published in small circulation out of the way scientific publications. "Atmospheric homeostasis by and for the biophere: the Gaia hypothesis" was a mere 10 pages, published in Tellus, (No.26 (1974) pp.1-10). Here Lovelock defined the Gaia hypothesis as the view that "the biosphere as an active adaptive control system [is] able to maintain the Earth in homeostasis". In "Biological modulation of the Earth's atmosphere" Lovelock and Margulis explained the outline of the theory in Icarus (No.21 (1974) p.471), a journal edited by Carl Sagan, and another 10 page explanation on "Homeostatic tendencies of the earth's atmosphere", was printed in the Origin of Life (No.1 (1974) pp.12-22).

In all three articles, the Gaia Hypothesis was presented as a homeostatic balancing act, in which life itself acted to balance the atmosphere and keep it fit for life itself. The journals were not "mainstream" by any means but they did attract the attention of the British journal the "New Scientist". In their February 1975 issue Lovelock, in association with Sydney Epton published an article, "The Quest for Gaia". The public response was suddenly overwhelming. The New Scientist was later to report that this article generated more popular response than any other article it had published to date. Lovelock was immediately approached with more than 20 offers to produce a popular book on the theory. Gaia had returned to popular consciousness with a bang, and now could no longer be ignored by the scientific establishment. Lovelock wrote

> *"The best explanation of the physical and chemical impossibilities of the Earth is that the Earth is a living organism"*

Gaia was defined by Lovelock as

> *a complex entity involving the Earth's biosphere, atmosphere, oceans, and soil; the totality constituting a feedback or cybernetic system which seeks an optimal physical and chemical environment for life on this planet.*

I can remember the day I first read the article. I was staying with friends from Australia, who, like me, were completing post-graduate work in London. Since the age of sixteen I had been impressed by the work of the French Jesuit priest and scientist Pierre Teilhard de Chardin. It was whilst working

as a paleontologist in the Egyptian desert that Teilhard's evolutionary vision sprung like a mystic eureka almost fully formed to his mind, like a preliminary pre-vision of the returning Gaia. Whilst looking for the remains of ancient fossils, he turned over a stone, dusted it off, and suddenly realized that everything around and beyond him was beautifully inter-connected in one vast, pulsating web of an unfolding divine life. Teilhard thereafter proposed that evolution itself had a general direction towards states of increasing complexity and with this – of increasing "interiority" – led to the state we recognize as consciousness. He proposed that evolution could be divided into three great separate categories, discussed more fully in Chapter 9; they were

- cosmogenesis – the birth and development of the cosmosphere of the Universe, based upon physics and chemistry;
- biogenesis – the birth and development of the biosphere of Life, based upon biology and ecology; and
- noogenesis (sometimes called anthropogenesis) – the birth and development of the noosphere – the network of interacting minds.

Teilhard argued that each stage of evolution emerged from the prievious, but in each case the whole was far greater than the sum of the parts. Thus while cosmogenesis was dominated by physical sciences, biology saw an additional phase of inherited evolution and the life sciences, that derived from the physical world, but gave a greater directionality to the process. Equally, historically humankind, Teilhard saw, in covering the face of the Earth with a cultural and technological web of communication, could not be wholly subsumed within biology. Seeking a way of unifying his firm belief in scientific evolution with his Christian beliefs, he saw that the direction of evolution was leading to an apotheosis, an end which he called the Omega point in which the noosphere itself achieves self-consciousness, and self-awareness giving the evolutionary process itself a divine centre, which he identified with Saint Paul's vision of a coming of a cosmic Christ.

Like the later Gaia hypothesis, Teilhard's theories were attacked both scientifically and theologically. Teilhard's science was subsequently dismissed by fellow French scientist Jacques Monod, who argued that as contingent chance played as big a role in the evolution of life as necessity and the direction pointed by evolution that Teilhard saw, did not in fact exist. Rather than following a pre-ordained evolutionary path, evolution could simplify just as much as it increased complexity and it was human choice that directed our current unfolding scientific evolution, Monod argued, not some divine plan which in any case could not be either confirmed or denied by scientific experiment and was therefore improvable. The debate has still not been settled as the work of biologists Stephen Jay Gould, and Richard Dawkins have shown[13]. As supporters of Monod's views, they have reacted against the work of Teilhard as it seems to them to propose a teleological directionality or purpose to evolution, that is considered totally unscientific. The Catholic Church too felt its traditional beliefs threatened by Teilhard's radical recasting of Christian doctrine and theology and responded by silencing him during his life – his books were only published after his death. Fundamentalist Christianity in the USA too has carried this faith based critique against evolution further and has attacked the fact of evolution as a theory contradicting the inerrant truth of the scriptures[14].

But when I read the New Scientist article, I immediately saw that Lovelock was speaking about an intelligence of the Earth far older and far wiser than Teilhard's noosphere, which seemed puny and recent by comparison. Teilhard was for me too unashamedly anthropocentric in his thinking, and believed that the noosphere, through a process of spiritualization, would jettison its physical connections to the biosphere, as a butterfly sheds its cocoon[15]. Such a scenario, whilst poetic, was as Thomas Berry was to show, would ultimately mean not only the extinction of life, but also the extinction of humanity as we know it.

When Lovelock published his first book on "Gaia: A New Look at Life on Earth", with Oxford University Press, in 1979, it attracted an instantaneous following amongst ecologists and activists. His theories now could no longer be ignored by the Scientific establishment. Gaia theory was not just going to go away. Ridicule was now brought to play and in certain circles this still remains a common scientific response. Francis Bacon, who called for this scientific revolution, stated "We should endeavour to establish the power and dominion of the human race over the universe…." And also "I am leading you to nature to bring her to your service and make her your slave". Galileo Galilei wrote "The book of the universe is written in the language of mathematics and its characters are triangles, circles and geometric features…hence I think that tastes, colours and so on are mere names". The sensory experience of the world was clearly not to be trusted. The French philosopher Rene Descartes wrote "I have described the Earth and the whole visible universe in the manner of a machine". Speaking of the human role and their destiny he stated it was "therefore to become like the lords and possessors of nature". Just as Europeans were enslaving the Africans to install their colonial empires in the Americas, so nature itself was rendered a possession to be used at will.

Descartes thus spoke of the fact that the world was totally soulless and without sensation. He claimed that the cries of fear and pain witnessed when an animal was slaughtered or cut up alive and vivisected was nothing more than the creaking noises of a machine.

Isaac Newton stated "For the rays of light, to speak properly, are not coloured. In them there is nothing else than a certain power and disposition to stir up sensation of this or that colour".

The conventional reason, given by scientists ever since the days of Francis Bacon and Rene Descartes has been to gain knowledge for control of life and power over the world, viewing the world and everything except the human soul as a lifeless machine. This forms a part of the current delusory "de-ligions" that separate us from each other and from the world were created from out of the hierarchical attempts of some humans to get "power over" others, began in a systematic and organised way with the building of the first civilisations, five thousand years ago. Of such systems, Gregory Bateson[16], the systems thinker, for instance has argued

> "*The myth of power, is of course, a very powerful myth; and probably most people in this world more or less believe in it... But it is still epistemological lunacy and leads inevitably to all sorts of disaster... If we continue to operate in terms of a Cartesian dualism of mind versus matter, we shall probably also come to see the world in terms of God versus man; élite versus people; chosen race versus others; nation versus nation and man versus environment. It is doubtful whether a species having both an advanced technology and this strange way of looking at the world can endure...*
>
> *The whole of our thinking about what we are and what other people are has got to be restructured. This is not funny, and I do not know how long we have to do it in. If we continue to operate on the premises that were fashionable during the Pre-Cybernetic era, and which were especially underlined during the Industrial Revolution, which seemed to validate the Darwinian unit of survival, we may have twenty or thirty years before the logical* reductio ad absurdum *of our old positions destroys us. Nobody knows how long we have, under the present system, before some disaster strikes us, more serious than the destruction of any group of nations. The most important task today is, perhaps, to learn to think in the new way.*"

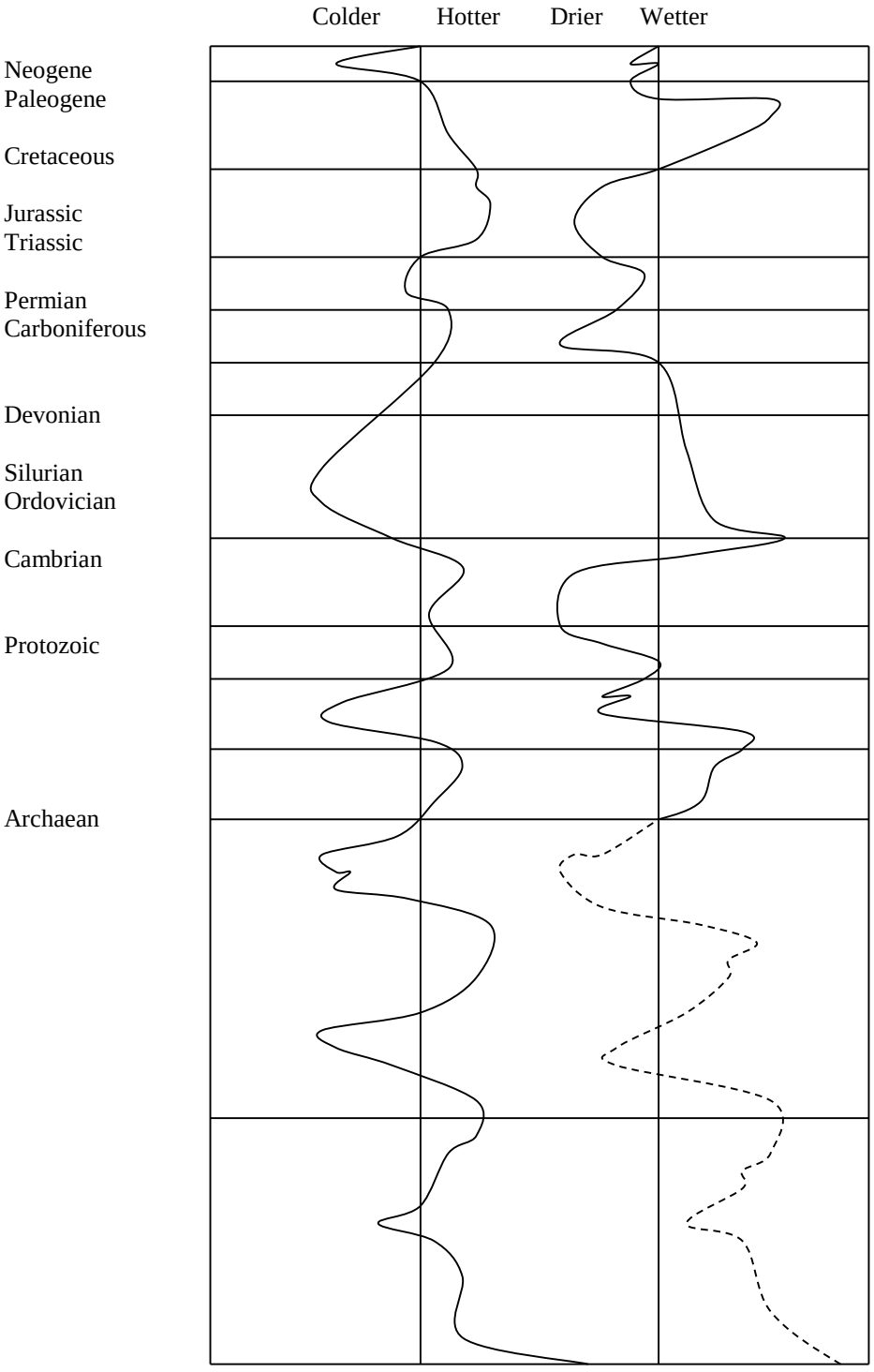
The "power over" model, has been upset by the Gaia theory of Lovelock and Margulis, as control over a living entity as large as the living world is simply impossible. Lovelock has called it the "ultimate act of hubris". Paraphrasing the earlier British biologist J.B.S.Haldane [17]we can remark,

"the world is not only stranger than we imagine, it is stranger than we can imagine". At a climate change conference when a delegate asked about the effect of Dimethyl Sulphide in regulating the climate one conventional scientist amongst the convenors interjected "Gentlemen, we are here to discuss serious science, not fairy stories about a Greek goddess."[18] Stephen Jay Gould in speaking of the Gaia hypothesis, reacted in saying "Gaia strikes me as a metaphor, not a mechanism. (Metaphors can be liberating and enlightening, but new scientific theories must supply new statements about causality. Gaia, to me, only seems to reformulate, in different terms, the basic conclusions long achieved by classically reductionist arguments of biogeochemical cycling theory.)" The neo-Darwinian orthodoxy, led by Richard Dawkins and W. Ford Doolittle attacked the Gaia hypothesis for the same reasons that neo-Darwinists had earlier attacked Teilhard's work as implying that the world was teleological, that is, that it had a purpose and a direction. On these grounds Dawkins proclaimed Gaia theory as "profoundly erroneous". Doolittle claimed that Gaia theory also could not be falsified and therefore was impossible to prove. On these grounds it did not even qualify as scientific.

Once Lovelock announced the Gaia theory, some scientists denied that it said anything that was new. Reductionist science had long showed that life did have an influence on the atmosphere. They were aware that an oxygen atmosphere was part of the by-product of photosynthesis. Other scientists argued that an oxygen atmosphere was the result of non-biological, non-living processes, such as the photodissociation of water into hydrogen and oxygen by ultra-violet light, as follows.

$2H_2O + uV \rightarrow 2H_2 + 0_2$ Later studies in detail showed that such reactions while possibly explaining some of the oxygen on the Earth, they were not sufficient to explain why our atmosphere now remained at about 20% oxygen for geological periods. Dissociation could explain at best an oxygen atmosphere of only about 2-5% of the oxygen present. It seemed, when the studies were done, that life had taken over and amplified these non-living chemical processes, through its photosynthesis

and respiration cycles. Lovelock was also keen to refute these critics who accused him of unscientific teleology. To demonstrate that the balancing equilibrium of homeostasis of a planetary temperature was possible under conditions of natural selection, Lovelock developed the computerised "thought experiment"[19] of Daisy World, hypothetical planet, whose star, like the sun, was slowly growing hotter. Daisyworld had one type of flower, a daisy, which came in two varieties – black and white. Lovelock showed that black daisies, which warmed their surroundings, would be selected by evolution when the planet was cool. And white daisies would be selected when it was hot. Acting together the two create a stable temperature regime, which eventually breaks down when temperatures become too extreme for even white daisies to handle. The system proved



surprisingly resilient. Introducing different varieties of grey daisies, daisy eating rabbits, and rabbit eating foxes, only increased the overall resilience of the system – demonstrating the ecological principle of increased systems resilience with increased biodiversity. Even major perturbations such as an occasional meteoric impact like that which eliminated the dinosaurs proved just a temporary hiccough to Daisyworld.[20]

This homeostatic balance is very important, because an Earth with no atmosphere, or even an atmosphere as thin as that which is found on Mars, would never have a temperature above freezing and so also could never have developed life. Rather than daisies, Gaia in fact seems to use the mixture of planetary gases to regulate its temperature, and maintain the presence of water in all three states; solid ice, liquid water and gaseous vapour. The presence of liquid water, despite three periods when ice extended almost to the equator[21], demonstrates that since the early Archean period over 2.9 billion years ago, the overall temperatures on earth never got below zero and not much above 50° Celsius, less than 12%, a remarkable balancing act given that the temperature of the solar environment increased by about 30%.

This was achieved by constantly drawing down the level of greenhouse gases from a figure close to those of Mars or Venus, 4 billion years ago, to a proportion less than 0.28% in our recent past.

One of the founders of the neo-Darwinian approach, William (Bill) Hamilton (1936-2000), who had coined the term "the selfish gene" used by Richard Dawkins as the title of a very successful book, at first had difficulty accepting any Gaian approach. It seemed to involve a kind of selfless altruism on the part of all living organisms that could not have evolved. His neo-Darwinian explanation for the evolution of altruism demonstrates that altruism only evolves when its existence favours the survival of the survival of the altruists, through the increased survival of kin who shared the same genes. With superorganisms like ants, termites and bees, the worker's genes are passed on through the queen. If this did not happen, Hamilton, Dawkins and Doolittle argued furthermore, selfish species would be "free riders" who, not behaving altruistically could take advantage of the cooperators, and, not being prepared to sacrifice themselves, they would quickly outnumber and replace the altruists. They argued that there was no possible mechanism for the evolution of a planetary wide Gaian cooperation of the kind that Lovelock and Margulis seemed to be advocating. More recently, the existence and importance of Horizontal Gene Transfer (HGT) amongst bacteria, undermines this case against altruism[22], by proposing that rather than separate species, bacteria are in an important way, all members of a single gene pool, and can be considered as just one species, even as one incredibly complex individual.

Nevertheless, Lovelock saw logic in these neo-Darwinian arguments, "They were right", he said, "there was no way for organisms by themselves to evolve so that they could regulate the global environment. But, I wondered, could the whole system, organisms and environment together, evolve self-regulation?"

Hamilton was intrigued by the Gaia Hypothesis, and after many meetings with Lovelock, sought to investigate some of its claims more seriously. Hamilton worked with the Gaian scientist Tim Lenton, who had showed how bacteria producing dimethyl sulphide (DMS), essential in the formation of clouds over the oceans, and thus important in reflecting sun-light and keeping the Earth cool. Together they showed how it was the storms developed by these clouds that spread DMS bacteria into new environments. It seemed for a while that Gaians may have found their regulatory daisies. But for each homestatic preserving mechanism found, there were others which seemed to have built-in amplifying effects. For example, photosynthesisers, by drawing down carbon dioxide excessively, cooled the world down precipitously 2.25 billion years ago in the Huronian and again between 735 and 682 million years ago, (the Sturtian and Maranoan periods) causing near planetary

Ice Ages. Reflecting the sunlight cooled the Earth further causing the icefields to spread, and a rapid "ice-house" condition seems to have developed threatening the very extinction of all life. But with the limitation on photosynthesis, carbon dioxide escaping from volcanoes accumulated, breaking the cycle. As the ice and snow melted, the planet grew warmer, developing a reverse cycle, heating the planet rapidly and kickstarting photosynthesis once again. The cycle repeated itself at least twice; in the Sturtian and Maranoan "snowball-Earth" episodes. It was only the evolution of herbivorous multicellular animals, grazing on the blue-green algal stromatolites that prevented a third pulse in the slowly oscillating ice-house/green-house cycle. Clearly the physical environment was as active a player as the biosphere in these Gaian feedback circuits of the planet.

Lovelock has changed the Gaia approach appropriately. After three scientific conferences on Gaia theory, by 1981 Lovelock now defined Gaia theory as "The evolution of organisms and their material environment proceeds as a single tight-coupled process from which self-regulation of the environment at a habitable state appears as an emergent phenomenon."[23] "Natural selection", he says, "favours the improvers", as those who make things worse for their descendents, will be replaced by those creatures that leave the environment in a batter shape, who will survive best. As a result of such modifications, Hamilton conceded that Gaia Theory has merit[24] and that Lovelock was "a Copernicus awaiting his Newton." From ignoring it, ridiculing it or attacking it, it appears that Gaian scientific approaches were winning.

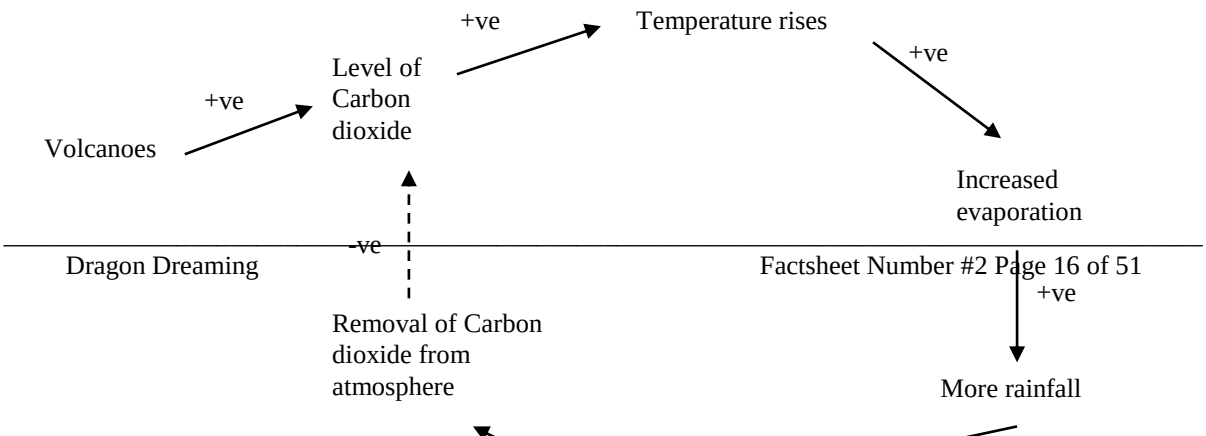
Parallel developments in the climatic science of global warming was also showing that the Earth-atmosphere-ocean system was far more complex than anyone had thought, and that a new trans-disciplinary Gaian method of biogeophysiological "Earth Systems Science" was required to deal with these complexities. Conventional Geologists argued that Gaia theory was not needed to explain the observed reduction in carbon dioxide in the atmosphere. They argued that the fact that volcanoes continue to belch out Carbon Dioxide (CO_2) into the atmosphere is a problem for Gaia theory. Carbon Dioxide, as we know, is a greenhouse gas, and as the sun gets hotter with increasing CO_2 the earth should also get hotter, with the result that the Earth should fry.

Conventional geochemists argue that Carbon Dioxide dissolved into water, creating a dilute acid, through the weathering of Silicate rocks should be sufficient. They argue that the following process would occur.

(3) $CaSiO_3 + 2CO_2 + H_2O \rightarrow Ca^{2+} + 2HCO_3^- + SiO_2$

(4) $Ca^{2+} + 2HCO_3 \rightarrow CaCO_3 + 2CO_2 + H_2O$

In this way the calcium ion (Ca^{2+}), washed down to the sea to form super saturated solutions which should precipitate as chalk. This, so some conventional geophysicists claim is enough to provide a thermostatic regulation of the Earth's temperature. Thus



This gives us a negative feedback loop in which temperature regulation occurs and it seems that life is not required. But when the calculations for this process are done, it turns out to be far too little for what is observationally required, it is less than 1/8th as powerful as that needed to account for what has in fact happened. And there is the further difficulty that super-saturated oceans of calcium would be extremely difficult to generate life, and such oceans don't appear to have ever existed on Earth, as such a situation would wipe out all life on the planet. Life is clearly required as a regulator in the process. When life processes were included it was suddenly found that bacterial action of coccolithophorids and humic acids of living soils were more than 1,000 times more efficient, and needed to be included in the feedback processes.

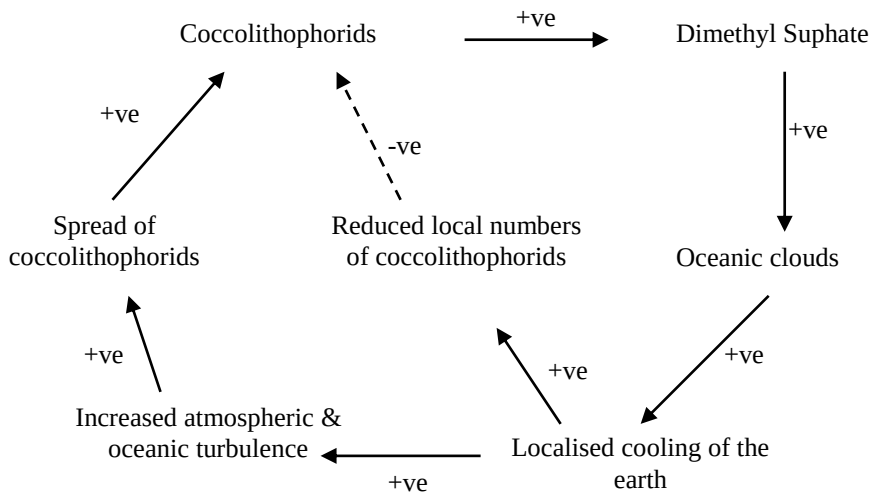
In fact it is the smallest components of life that play the major role in the removal of both calcium and Carbon Dioxide. In fact the small bacteria, Aemiliana huxleyi, which is about 1/4000th of a millimetre seems to be central. Its tiny skeleton is made of chalk, CaCO3. Although tiny it produces huge "blooms" in the ocean, causing the surface layers to go white and milky over areas nearly as large as the whole of Scotland. Accumulation of such coccolithophorids over the time of the Cretaceous, the era of the Dinosaurs, has been enough to build the huge chalk cliffs of the White Cliffs of Dover, cooling temperatures. The famous "white cliffs" are solid atmosphere, created by a process to keep the Earth habitable.

Thus one of the main ways in which Gaia has achieved such climatic regulation is by taking carbon out of the atmosphere through the burial of carbon. Gaia thus is a huge planetary entity, and yet it is not us humans that are its most important constituents. It is the bacteria that have kept life going for 4 billion years, and these bacteria regulate all of the important planetary cycles. How efficient this has been can be shown in the following table.

Source of Carbon	Amounts of Carbon Present (gigtonnes)
Methane (in atmosphere)	10 Gt
Life	610 Gt
Atmospheric CO_2	760 Gt
Oceans CO_2	740 Gt
Oceans CO_3^{2-}	1300 Gt
Carbon in soils and sediments	1600 Gt
Carbon in fossil fuels	4200 Gt
Oceanic HCO_3^-	37,000 Gt
Sedimentary rocks (eg shales)	10,000,000 Gt
Limestone rocks	40,000,000 Gt

Without such burial of carbon dioxide, the earth would have an atmospheric pressure of over 60 times that now found in the atmosphere, and would be a run-away greenhouse world like Venus, with temperatures over 600 degrees. A closer picture of Hell on Earth would be hard to imagine.

Thus Coccolithophorids thus seem involved in a second feedback loop necessary for this rain and thus necessary for life. From the effects of oceanic and atmospheric turbulence it has recently been confirmed that coccolithophorids are producing turbulence in order to get themselves more widely dispersed. Thus when we look at clouds we may really be seeing the dispersal buses necessary to spread themselves around the Earth. This use of clouds as agents for dispersal may explain why these bacteria seem to have a genetic antifreeze that prevents crystallisation of their internal water.



The coccolithophorids have thus been able to precipitate the Calcium ion at concentrations much less than that required by conventional geochemistry, and has in this way maintained the world as a fit environment for life (and for itself). These coccolithophorids, like Aemiliana huxleyi, as we shall see, also seem to play a more direct major role in temperature regulation too.

Coocolithophorids also take up calcium from the water and precipitate it as chalk at concentrations far below that which natural processes would require. This is important because if the calcium build up were allowed to proceed to the levels required for spontaneous precipitation to occur it would make the oceans poisonous to life. The white cliffs of Dover in this way can be seen to be “solid atmosphere”, the atmosphere made solid.

The soluble silicon ions (from SiO_2) washed down into the oceans are in a similar way also used by diatoms in their exquisite cases and shells.

Over 90% of the thermal equilibrium on Earth is maintained instead by the regular escape of heat along the margins of tectonic plates, processes not found on either Venus or Mars. The difference seems to be due to the presence of water on Earth when compared to these bone dry worlds. Water, when built into the crystaline latices of rocks, effecectively lowers their melting point, with the result that the thick insulating Venusian crust does not form on Earth. Instead an oceanic crust of between 3 and 20 kilometres carries embedded continents on one of about 12 tectonic plates. Water is essential in this process as it is in all life, as it is water of crystallisation built into the rocks at the mid ocean ridges that lowers the melting point of the rocks sufficiently so that the solid tectonic plates can slide over the mantle and so that at the subduction zones one plate can slide beneath the other. Water is here functioning as a lubricant. Because of these plate movements, life has to keep colonising new habitats if it is to survive. It also recycles the needed phosphates from the deep

oceans pushing them high into mountain ranges, making them once again available and recycling them in a way necessary for life on Earth to continue. It is a little like Life as a whole having to keep walking backward so that it can stay still on an upward moving escalator.

The collisions between these plates are interesting, as not only do they allow continuous cooling of the deeper Earth, thus preventing catastrophic resurfacing events, but they also scrape the floor of the oceans when one plate is subducted beneath another, elevating young mountains in an orogenic mountain building phase, and thus returning phosphorus and other minerals, essential to life, to the tops of mountains, where through weathering and erosion it can begin, once again, its long trip to the sea. Without such recycling of phosphorus, life would have long ago come to an end. But ironically it is life itself which seems to have indirectly organised this recycling, through an indirect geological feedback.

But why do we have water on the Earth when Mars and Venus have lost any water they once possessed? Water has disappeared from Mars and Venus long ago as a result of the ultraviolet light of the sun, splitting the water molecule into oxygen and hydrogen, with the latter, being lighter than air, escaping the planet's gravity into outer space. No doubt this did happen to some degree, but the Earth prevents this from this happening by the Ozone screen, which prevents ultraviolet light penetrating the troposphere, the lowest layer of our atmosphere, and splitting the water molecule into Hydrogen and Oxygen, with the hydrogen, unable to be held by the Earth's atmosphere, ultimately escaping (it is for this reason Mars and Venus are waterless – they have never had an atmosphere of Oxygen – again a biological product, this time of blue-green cyanobacteria). The only reason why this did not happen on Earth would appear to have been the presence of life itself. The evolution of methane producing bacteria, nearly 3.8 billion years ago, effectively screened the oceans from ultraviolet light, a task which was overtaken by ozone when the atmosphere became 1% oxygen, some 1.8-2.0 billion years ago. Thus life, by screening the oceans and lower atmosphere from ultraviolet light, enabled water to survive. This water, built into crystal structures of rocks, enables tectonic plates to form, which gradually cool the Earth and returns mineral phosphate to the mountains, where erosion makes it available as one of the 6 elements most essential to life. Above the troposphere the Stratospheric atmosphere is kept dry and almost completely waterless. Water is here confined to the lower atmosphere through the water cycle of evaporation, crystallisation and precipitation as rainfall or snowfall, which only works at lower heights.

But there is more. As one plate is subducted beneath the other, it is forced down into the asthenosphere where it partially melts, losing in the process its crystalline water, which moves upwards as molten magmatic streams to form granitised plutons beneath the surface, and volcanoes when and if they break through. In this way the continents were built. The descending plate, now denser and cooler than the surrounding mantle, slowly sinks towards the core, effectively blanketing part of the core until temperatures rise beneath, heating it and forcing it to rise as a mantle plume, which punctures the crust as a hot-spot. Mantle plumes are also thought to force the mid ocean margins of plates to rise as a ridge, driving the plates apart, and reinitiating the whole cycle of sea-floor spreading. Through maintaining water on the Earth, Gaian life has had the indirect effect on shaping this planet all the way down to its core. Even there, it is thought these geophysical effects may have some impact on producing the self-exciting dynamo effect which generates the Earths' magnetic field, a field which helps to screen life from cosmic radiation. Thus through Gaia, geological effects have biological causes, which in turn are maintained by geophysical factors, which again aid life on the planet. The system is not only more complex than we imagine, it is probably more complex than we can imagine.

Seen from this perspective Gaia is thus a creation of the edge, in two senses of the word. Not only does Gaia exist scientifically on the edge of the Enlightenment reductionist scientific paradigm, as a

reality it also exists on another edge. This “edge” is shown by the complexity of its systems of positive and negative feedback, a complexity that exists at critical states of spontaneous self-emerging behaviour. Gaia is created at a frontier between order and chaos. At this “edge” as a result of what has been called “autopoiesis” or the “self-organization” property, life itself initially emerged.

Lovelock has shown that there is possibly an even more profound reason as to why conventional scientists have difficulty with the Gaia hypothesis. The Gaia hypothesis rejects as hubris, the “myth of control”, the attempt too achieve “power over” the Earth. Gaia in fact allows us to achieve a greater sense of participation, partnership and belonging to the living world of which we are a small, but increasingly a now important part. In the Gaian paradigm, we are not the separate Newtonian or Cartesian observers outside the systems we observe, but like has been shown with early Quantum theories of physics, we are intimately involved as active participants, and our projects and our behaviours can and do have potentially huge effects. This new sensibility and curiosity, closer to the original meaning of “scientia” as true “knowledge” is within those working within the Gaian paradigm becoming once again a real reason why we are doing science.

GAIA THEORY AND THE ORIGIN OF LIFE

For example, in the case of the newly formed ancient Earth, about 4.404 billion years ago[25] the possibility of complexity was probably originally maximized in the newly formed deep oceans, at the volcanic margins of numerous small tectonic plates produced wherever the fires of the centre of the earth poured forth their heat. This heat had two sources, firstly it was produced from the gravitational in-fall and collisions with the planetismals of the protoplanetary accretion disk of the new solar system that formed the Earth[26], and secondly it was the result of the natural radioactivity of the rocks from which the Earth was formed, left over from the supernova explosion of the star, about 4594 million years ago, which formed most of the matter from which our bodies are made, and which detonated the shockwave in the HII clouds of interstellar dust and gas that over the following 2 million years[27] were squeezed to form the sun and its family of planets. These sources of heat and gravity together[28] promoted the subsequent differential sorting of core, mantle and crust. The edge from which life developed was probably where new molten and solidifying rock met the cold water of the original world-covering ocean. In these heated waters, chemically rich iron sulphide environments were created in which the volcanic degassing of ammonia, methane and water vapour in the early earth created a range of biological chemicals including amino acids and polypetides in a proto-biotic ecological environment in which highly complex bacterial cells could quickly evolve.[29]

For example, just as adding grains of sand into a pile creates a situation where it eventually reaches criticality, and one additional grain ultimately is enough to set off an avalanche, something similar seems to have catalysed the evolution of life. In the sand pile it is completely unpredictable which additional grain will set of an avalanche, but as one approaches the critical edge, each additional sand grain has an increased chance of being “the one”[30]. Complex systems that tend to states of higher fitness in the respective fitness landscapes have better chances of survival. So it was with life itself.

The world of four billion years ago, it has been shown, was a very different world than that which we have today. With an atmosphere with no oxygen, no humans could long exist. Our young sun, having gone through a short hot bright blue phase of a T Tauri star, would have settled in for the long haul in its current yellow colour, though significantly cooler than it is today. The Earth would have been covered with moon-like craters, the results of millions of years of astronomical bombardment by left-overs from the creation of the Solar System. The young moon, newly formed after a collision of Theia[31], a Mars sized planet, 4,533 million years ago, with the Earth, hung low and over 20 times closer to the Earth, creating huge tides. Days were much shorter than the current 24 hours, as with tidal forces between the Earth-Moon system, not only has the moon receded to its present position, but the spinning of the Earth upon its daily axis has also slowed. It had not been long before that the planet had been a hot-cloud covered world, like today's Venus. The radiation of the heat of its formation to space, and the cooling of the sun, however, had allowed liquid water to form, first, only as droplets in the upper atmosphere, then as rains into the basins that filled to become lakes, seas and oceans. Hot radioactive elements deep within the Earth's mantle, split the crust into many small ridges and faults, deep beneath the primeval oceans. Ever at the risk of another aerial bombardment from space, volcanic vents of hydrogen sulphide, water, carbon dioxide and other gases had rebuilt an atmosphere, and were in the process of building the first living organisms. Despite the continued bombardment of Earth from space during the Late Heavy Bombardment of the Lunar Basin and Nectarian phases, caused perhaps by movements of the outer planets of the solar system, eventually a little self-replication machine was created. It is today called the bacterial cell.

The frontier between order and chaos is precisely where what is known as complexity exists – and it is a twilight zone in which Nature is most prolific and creative. Complexity here is characterized by three criteria, first of all by its structure, as illustrated by flows of information within the system. The second is by entropy of the second law of thermodynamics, which is a measure of disorder produced through the energy flows required for the maintenance of that structure. The third criteria is determined by its "granularity" or the graininess of the scale at which analysis occurs. This last criteria is illustrated by the nature at the lowest scale of the recently discovered "nanobes"; the minute bacteria that may exist in the deep, hot biosphere, and which may be a survival of creatures that are perhaps direct descendents of the "Last Universal Common Ancestor" (or the LUCA) of all life on Earth. At its upper extremity, the "graininess" of complexity is illustrated by the one inclusive and emergent incorporation of all living things, into the structure of Gaia, the living Earth System itself. This holarchic organization, from the many to the one is an example of a "fitness landscape" which represents all of the characteristics that can be used to describe a particular point in a mathematical matrix, and can be considered as the way in which physical conditions of elevation, slope, roughness, sunlight and shade, temperature and rainfall vary for each and every particular point as we move across a particular geographic region. At very small scales, this graininess is maximized, at large scales we have to work with averages. This creates an enormous number of environmental niches, or in complexity terms what may be called "attractors", at small scales there is a huge number, but at higher levels there are fewer and fewer at these greater scales. This is why life on earth resembles a skewed graph; there are many millions of different types of bacteria at a simple level of holarchic granularity, but at a lower degree of resolution only one large species we know about that has a fully reflexive consciousness – namely us. Similarly, there are tens of millions of individual living species, but as we move up through increased levels of complexity – through organisms, to communities, societies, and ecosystems to Gaia, the number of ecological niches declines through a power-law until we at the limiting margin we are left with just one example – the living planet itself.

Given that there is a maximum complexity given for any complex system, as it moves towards its edge of chaos, so its fragility is increased. When a system is fragile – i.e. close to its critical

complexity – a very small perturbation can bring the system crashing down. In this chapter we will see how, in many parts of the world today, complexity has reached levels where our socio-economical systems have now become critically fragile and will, if additional complexity is added, undergo a general systems collapse. Our complex industrial growth societies are fast evolving to very fragile states, states in which ultimately social unrest or conflict becomes the only mechanism of entropy removal. At such situations, like with the end of communism, a sudden general systems collapse occurs. When systems collapse, either partially or totally, the event is accompanied by a sudden loss of complexity. Fragility, therefore, is inversely proportional to the distance that separates the complexity of system from its level of critical complexity.

The resilience or robustness of any system is determined by its ability to handle this fragility and refers to the system's ability to maintain intact its fitness landscape and the functionality of its structure in the presence of uncertainties. In the case of the Earth, this fragility is minimised through biodiversity. At the point of general systems collapse, however, a bifurcation is reached, where the system will either spontaneously collapse into a new state of lesser complexity, or else the system will quickly evolve to a more entropic state far from equilibrium. At such bifurcation points what will happen is either the remove entropy from the system through a reduced complexity or through evolution move to a new form through the addition of a new structure.

Evolution on earth is an inventive phenomenon. When life first appeared it was highly dependent upon a pre-biotic environment rich in organic molecules. These molecules had been produced en-masse in the hot oceanic environment rich in hydrogen. The exploitation of available chemical free energy also led to the environmental build-up of large, stable molecules like Carbon Dioxide, diatomic Nitrogen, and water, which accumulated in the environment as life exploited the available free energy generated by the process of planet accumulation.

But there was a more immediate problem. Life, as it incorporated these pre-biotic molecules within the membranes of living cells, gradually oxidised its environment and depleted the source of abiogenetically synthesised organic molecules upon which it originally depended. The crisis was met through mutations in the pathways of chemical synthesis, leading to life finding new ways of synthesising the chemicals it needed. But such a trend resulted in the reduction in the availability of required precursor molecules. This depletion in turn opened up the niche for the evolution of a new biological pathway which synthesised needed precursors from still more simple elements. Eventually a form of bacteriological life appeared that was capable of using the photochemical energy captured from sunlight to split the water molecule. With the hydrogen and oxygen thus liberated, it gained access to sufficient energy to split carbon dioxide and diatomic nitrogen sufficient to permit the synthesis of the full suite of necessary organic molecules. With this breakthrough life gained all that was necessary for establishing a sustainable living system on the surface of the planet. Gaia was born.

Gaia therefore is the whole of the living Earth, both biological and geophysical, born as life took hold on the third planet of the sun's family, nearly 4 thousand million[32] years ago. Gaia is a system based upon the deep coupling of geological and biological cycles involved four principle chemical elements essential in maintaining the earth as a home for life, carbon (30.37% of atoms, 39.04% of the weight), hydrogen (51.58% of atoms, but only 5.12 of the weight), oxygen (13.18% of atoms, 22.59% of weight), nitrogen (4.58%, 6.88%). These, together with sulphur and iodine, are all recycled by the air and oceans, which act as Gaia's principle circulation mechanism. But phosphorus (0.29% of atoms, 0.95% by weight, and a number of other minerals (for example iron, calcium and magnesium) which are up to 25% by weight, require another recycling mechanism determined by the coupling of biology and geology.

To illustrate the nature of this coupling requires us to look temporarily again at Mars and Venus. Thermal equilibrium in any planet occurs when the rate of internal heat production (a production of its volume, measured in cubic kilometres) is equal to the heat radiated through its surface (measured in square kilometres). In small planets, like Mercury, Mars and the moon, with a high surface to volume ratio, they cool quickly. Larger planets, like Venus and the Earth, with how surface to volume ratios, take much longer to cool, with the result that they have a molten core to this day. But the growth of a thick crust, like that on Venus, effectively insulates the planet, causing it to heat up inside, eventually thinning the crust to the degree that it is broken down through a total resurfacing event every 800 million years. The old crust is largely subducted and a new crust forms as the surface cools, initiating the cycle yet again. It is thought that such a scenario may be responsible for the peculiar volcanic features found on Venus. Complex life on Earth could not survive such repetitive planetary cataclysms.

The success of photosynthesis in the Archean system, generated a further problem – what to do with the accumulating amounts of free oxygen? Various solutions were tried. In Gabon, bacteria succeeded in locking the oxygen up as insoluble uranite, precipitating enough enriched uranium 238 by this means to build the world's first nuclear reactor. Elsewhere, iron was used as an oxygen receptor, leading to bands of rusty precipitate (Banded Iron Formations) in ancient marine sediments. Depletion of the available ferrous ion caused oxygen to accumulate to toxic levels, eliminating the life that produced the problem, and allowing grey, black ferrous iron to be deposited. This oscillation between life rich and ferric iron precipitate, and life poor ferrous iron accumulation created the famous banded iron deposits of the Western Australian Pilbara, or the edges of the Canadian Laurentian shield, shallow iron rich oceans of these times.

Free oxygen, however, provided an immense store of energy. As the second most reactive of the chemical elements, oxygen as an electron acceptor tended to prove damaging to the early structures of life that had evolved in an anoxic environment. Wild, cancer-causing molecules were generated that required the evolution of chemical anti-oxidants to eliminate and remove. Bacteria evolving the appropriate skill of eliminating oxygen from the microbial mats became an important part of the growing complexity of the ecosystems that were appearing with the successful resolution of each crisis. This successful resolution was in itself the cause of the next problem.

The success of the ecosystem of blue green algal mats began the process of converting our atmosphere away from the stable state of Carbon Dioxide and Nitrogen, similar to that found on the inner "telluric" planets of Mars and Venus. Our atmosphere henceforth was characterised by Oxygen and Nitrogen, and this generated a huge problem. Firstly those bacteria that had previously evolved have to find anoxic environments in oxygen poor soils, within the bodies of oxygen breathers or in stagnant pools, in order to survive. Even greater problem was the depletion of carbon dioxide, the greenhouse gas which had warmed the atmosphere of the early earth. Life almost ended in a run-away ice-house world that resulted as we have seen, with glaciers approaching the equator in the Huronian, Maranoan and Sturtian "snowball Earth" episodes.

Fortunately for us, the reduced photosynthesis allowed the accumulation of volcanic carbon dioxide that eventually began the melting of the planet-sized glaciers, temporarily generating extremely hot conditions. Marine blue green algae proliferated again, allowing the depletion of carbon dioxide a second and perhaps even a third time. With such huge oscillations between hot and cold extremes harmful to life, a new solution was required. It was found in the evolution of more complex animals that could graze on the algal mats, respiring the oxygen and converting it to carbon dioxide and returning this gas to the atmosphere. Through trial and error life evolved more sophisticated means of modulating temperature, stabilising the situation sufficiently to allow the flourishing of the new types of animals. New ecological niches were created which adapted those herbivorous filter

feeders grazing upon microbial mats to become carnivores, preying upon the sessile herbivores. To avoid being eaten, early worm-like animals evolved systems of motility, evolving eyes and adapting segmented systems of muscles and nerves to sense the environment in new ways. A series of multiple "arms races" evolved in the co-evolution of herbivore and carnivore. Skeletal systems provided greater possibilities for the anchoring of muscles and internal organs, and exoskeletons of calcium phosphate, calcium carbonate, chitin or keratin scales helped protect soft tissues from the attack of predators. In turn teeth, eyes, and other sense organs evolved to detect internal and external changes

Another example of the way system complexity leads to increased systems fragility was the way in which by 230 million years ago, the evolution of land plants created new ways for Gaia to remove carbon dioxide from the atmosphere, drawing it down to such a degree as to change the greenhouse balance that had been established for the Earth, and producing yet another Ice Age. The amount of carbon locked up this time in cellulose and the lignin of trees was indigestible to life at the time, and has resulted in the huge coal deposits which humans have discovered lie beneath our feet, and used in our industrial processes. It was the evolution of insects, particularly of wood-borers and termites which rebalanced the system by returning this carbon to the atmosphere, but this increased the complexity of the system and moved it closer towards criticality. Eventually the perturbations of the end of the Permian period produced a General Systems Collapse and over 95% of all species became extinct in the largest mass extinction event of the last 530 million years. The eventual extinction of life was in this case only averted through the co-evolution of insects and flowering plants, which allowed the addition of new structure of greater complexity to be added to the biosphere. By the Cretaceous period, Gaia had regained the levels of complexity it had achieved previously at the end of the Permian, and so was now better placed to survive intact as a result of the perturbation events that forced the Dinosaurs into extinction. In the following Cenozoic period flowering plants continued to populate available niches in the fitness landscape, creating a degree of complexity sufficient to allow human life to emerge. And so in the 1970s, we arrived at another bifurcation point.

Just as organic molecules are assembled into ecological systems called cells, so cells are combined into tissues, tissues into organs, organs into bodies, bodies into ecosystems and the biosphere. Evolution of any one part in this process had impacts on all the others. The ecological age into which we were moving, showed us that in a real way, it was the integrity and continued geophysical functioning of the biosphere which kept the whole of life working. It was the geo-biogenic cycling of the components of life, carbon, nitrogen, water, phosphorus and sulphur, which allowed the ecosystems to flourish. A "healthy" diverse ecosystem created niches in which a wide variety of different species could flourish.

GAIA AND INDUSTRIAL CULTURE

And so we arrive at the Industrial Revolution, based upon the unceasing "exploitation of Nature's resources" for human purposes, and as dumping ground for our wastes, saw the elimination of the last vestiges of these earlier peasant sensibilities. The first act of this drama came with the enclosure of the villager's common land, and the driving of the landless poor to the cities to work in the new industrial factories. With the disappearance of the reciprocal gift subsistence economy, land was totally reduced to being a resource, owned and exploited like any other, as industrial, economic and technological "progress" sought to extend this exploitation to "virgin wilderness", taken from native peoples in the "New World". The growth of private corporations, increased markets and new technologies were all part of "progress" or "development", which was seen as

desirable and inevitable. Despite the shadow cast by two world wars when technology had been used mainly to find new ways of killing each other in ever-larger numbers, it was hoped that soon the whole world could achieve such a market-led prosperity. Today it is believed by many that the process of "globalisation" is equally inevitable, despite the evidence of a widespread economic collapse that it is increasing the gaps between rich and poor, destroying biodiversity and causing climate change and global warming at an alarming rate. Lovelock has suggested that at present the Earth has a cancer-like disease of "disseminated primateaemia" a form of "homosapientitis".

We can say there are six pillars of sustainable complex life on the planet. But in each case the Industrial Growth Civilisation in which we live seems to be having a damaging effect.

Pillar 1. Burial of Carbon (temperature regulation – a fit habitat for life)
By burying as calcium carbonate and fossil fuels most of the carbon dioxide of the primitive atmosphere, it has prevented the Earth from heating too much, simultaneously liberating oxygen and maintaining the temperatures which make complex life possible.

There also appears to have been a similar long term regulation of planetary temperature so as to permit the survival of all three states of water (soil ice, liquid water, and gaseous vapour) on the planet simultaneously. As K.C. Condle and R.E. Sloan show, the long term temperature and humidity of the atmosphere have oscillated backwards and forwards across both recent and long term geological time, but unlike the extraterrestrial conditions, it has never exceeded the values under which liquid water survives. This pattern of temperature maintenance has occurred despite the known heating of the atmosphere by the sun as shown above by a value of between one third and half of its current value. Despite the sun getting hotter, the temperature of the Earth has remained remarkably constant. For at least as long as the last 800 million years, the earth seems never to have been much hotter than about 30 ^{o}C and never much cooler than about 7 or 8 ^{o}C. Any colder and the planet risked a run-away ice-box effect, where temperatures would fall, larger glaciers would form, more heat would be reflected, more carbon dioxide (CO_2) would be dissolved in the oceans, and temperatures would fall still further. Alternatively above 45 ^{o}C, less CO_2 would be absorbed in the oceans, and they would become a source rather than a sink of the gas. Temperatures would rise higher. Rainforests would burn, and permafrost would melt pushing huge amounts of carbon into the atmosphere. A runaway greenhouse of this kind risks converting the Earth to a Venus situation. What we see is a tight coupling of atmospheric composition, temperature and wetness of our climates.

Human activity is intent on digging up the fossil fuels and returning carbon dioxide into the air as quickly as possible in such amounts as to make our climates increasingly unpredictable, threatening all life on the planet. Rapidly rising Carbon Dioxide levels and the consequent rise in global temperatures suggested a planetary fever which could end our stable agricultural systems and drown our cities. Already human activity is responsible since the Industrial Revolution for 30% of the total carbon dioxide levels present in the atmosphere. Greenhouse gases are forcing global warming. Through human activity we have returned the carbon dioxide levels to that last seen in the Eocene period, 50 million years ago, when there was no icefields at all in Antarctica, and sea levels were up to 70 metres higher than present. We also now risk releasing tundra methane or hydrates in the deep ocean making the climatic situation much much worse. In fact the Paeleocene Eocene Thermal Maxum saw massive releases of methane which caused major extinctions in many species and disrupted the climate for over 100,000 years. Rainfall patterns around the world are changing rapidly as evaporation is increasing fast, drying out the soils and limiting soils abilities to shed water in runoff throughout the year. At the same time, with more energy in the climatic system, increased evaporation is causing excessive snowfalls or floods in areas where water is not normally a problem. Extreme climatic events increase as greater amounts of energy are now being

"processed" through the cycles of weather and climate, with the result that "extreme weather events" that numbered 24 per year in the US, in 1950-1959, in the period from 2000-2004 numbered over 350. The Arctic Council's has recently reported on the effects of global warming in the far north which shows global floods, extinction of polar bears and other marine mammals, and fisheries collapse.

Pillar 2. Maintenance of the Ozone shield (opening of terrestrial habitats)
The oxygen has created an ozone shield, which prevented the photochemical breakdown of water, preventing the Earth from drying out like Mars and Venus. By protecting the land from harmful ultraviolet light, life was able to leave the protective oceans and spread to every habitat on the planet.

Human activity, through the release of ozone destroying chemicals has created huge ozone holes over the poles, and has reduced global ozone worldwide, seriously threatening all life by increasing cancer rates for all living things. Ozone was declining by 3-4% each year, but stabilised from about 1997, and is estimnated to return to 1980 levels by 2050. Through increased surface ultraviolet – we have focussed upon skin cancers but have not addressed the rise of cataract blindness to natural fauna caused by ultraviolet light, perpetuating our own anthropocentricism, as though the 10-15% of Australia's kangaroos that have been blinded don't matter[33]. Ultraviolet too puts increased pressure upon already stressed immune systems, not just of humans but all animals. For example it seems implicated in the disappearance of Australian frogs. The effects of ultraviolet on marine zooplankton is also rarely considered. Resarch in July 2006 has shown that Ultrviolet B light has a negative effect upon phytoplankton[34], at the base of the Antarctic foodchain, and already since 1970, 80% of krill in these waters have disappeared. It was thought to be due to global warming, but Australian research also shows krill are killed by Ultraviolet light. This is the major food source for all Antarctic species. As these impacts deepen the ecological systems will be damaged in ways similar to the changes being created by the Greenhouse effect. The species most susceptible to the changes will be the first to go and as they go the ecosystems will progressively deteriorate. Also not considered is the fact that it is ozone which has preserved our planet as a water world, as Ultraviolet light dissociates water into oxygen and hydrogen, which subsequently escapes the planet's gravitational field.

Pillar 3. Natural purification of fresh water (natural irrigation)
Waterways and wetlands, created by the interaction of the previous pillars of life, have created sources of fresh, unpolluted waters that recharge aquifers and ground water systems, and through interaction with plants maintain a hydrological cycle that, as we have seen, sustains and nurtures all life.

Globally, humanity now uses more than half of the runoff water that is fresh and reasonably accessible, with about 70% of this use in agriculture. Major rivers, including the Colorado, the Nile, and the Ganges, are used so extensively that little water reaches the sea. Massive inland water bodies, including the Aral Sea and Lake Chad, have been greatly reduced in extent by water diversions for agriculture. Acidification and algal blooms caused by fertiliser produced eutrophication of waterways and overfishing accelerated the death of marine corals, previously thought to be the largest living structures on Earth. Reduction in the volume of the Aral Sea resulted in the demise of native fishes and the loss of other biota; the loss of a major fishery; exposure of the salt-laden sea bottom, thereby providing a major source of windblown dust; the production of a drier and more continental local climate and a decrease in water quality in the general region; and an increase in human diseases Human activity discharges over 70,000 new chemicals previously unknown to life. These are pumped, through sewerage and through the use of excessive amounts of agro and other chemicals in the soils. Huge amounts of fresh water have become polluted, creating algal blooms and eutrophication at the same time as releasing exo-oestrogen and other hormone

disruptors which undermine the living pillar of our waterways and wetlands. In Western Australia the average Perth household consumes approximately 920 litres of water per day, with 70% being used for irrigation of the garden. Deforestation and climate change have meant that since 1976 Perth's average rainfall has been 12-15% lower than in the preceding 75 years. This has contributed to a much more significant decline in runoff in our surface water catchments and recharge to our groundwater resources., and our demand for water is still increasing. Currently our dams hold only 32.1% of their full capacity. At the same time in rivers and waterways eutrophication problems increase, and elsewhere other pollutants, industrial wastes and human faecal matter pollutes what waterways there are. Similar problems are found worldwide. In Hanoi, tens of thousands of cubic metres of dirty, untreated water containing inorganic and organic toxins, bacteria and parasites are drained into lakes, ponds and canals within the city and its outskirts. The Thames River, on Britain's East Coast, contributes an annual load of 150 pounds of the pesticide Lindane, 225 pounds of DDT, plus about five million tons of partially treated sewage.

Pillar 4. Creation of Soils (maintaining fertility)
Interlocking nutrient cycles amongst soil microflora, fungi, bacteria and non vertebrates have created thick fertile soils which retain moisture, hold nutrients, limit erosion, stimulate plant growth and recycle all plant and animal wastes.

For instance, there are an infinite range of possible states between the ultimate acidic state (pH1), and the ultimate basic state (pH14). There are also a vast number of bacterially regulatory cycles that shows how the pH of soils is regulated by humic acids that seem designed exactly to provide for simultaneously the release of needed minerals from rocks, and at the same time, to prevent their too rapid leeching into the water table and transport to the oceans, thus maintaining life as a whole. In fact it was the creation of this ability that allowed the accumulation of calcium and phosphate ions in the soils and muds in the soils of the early Cambrian period and may have led to the explosion of complex multicellular life on the planet at that time.

Human activity, through over-use of our soils and excessive dependence upon agro-chemicals for fertiliser and pest control, increases erosion, and reduces soil viability. The Global Assesment of Soil Degredation, published for the UN in the late 1980s show nearly one third of the agricultural soils of the world are affected. Through the resulting desertification, increase in soil salinity and reduced soil structure, all life is threatening by removing this pillar. Studies show that of the 56 million square kilometres vulnerable to desertification, they have nearly six times the global average rates of erositon.[35] Nearly 430 million hectares of land have been lost since farming began and the current rate of loss is nearly 3 million hectares per year. Continuing soil erosion and salinization (1 tonne of wheat loses four tonnes of topsoil) is everywhere a problem. But the principle remains that if the humans cannot maintain the soil of the planet, their civilisation collapses and they cannot live here. In 1988, the annual soil loss due to erosion was twenty-five billion tons and rising rapidly. If chemical fertilizers were eliminated, due to loss of soil fertility and erosion damage world agricultural production would drop by at least one-third.

Pillar 5. Creation of Forests (maintaining rainfall)
Forest ecosystems, hundreds of millions of years old, have evolved to maximize biodiversity of life, providing many millions of ecological niches which help generate biological resilience which dampens the destructive effects of climatic and other environmental fluctuations and changes.

Human activity through deforestation, clearfelling old growth forests around the world, is contributing to habitat destruction at hundreds of thousands of square kilometres per year. This is producing a huge reduction in biodiversity, pushing nearly sixty three thousand plant and animal species per annum, most of them unknown to science, into extinction, so undermining this major

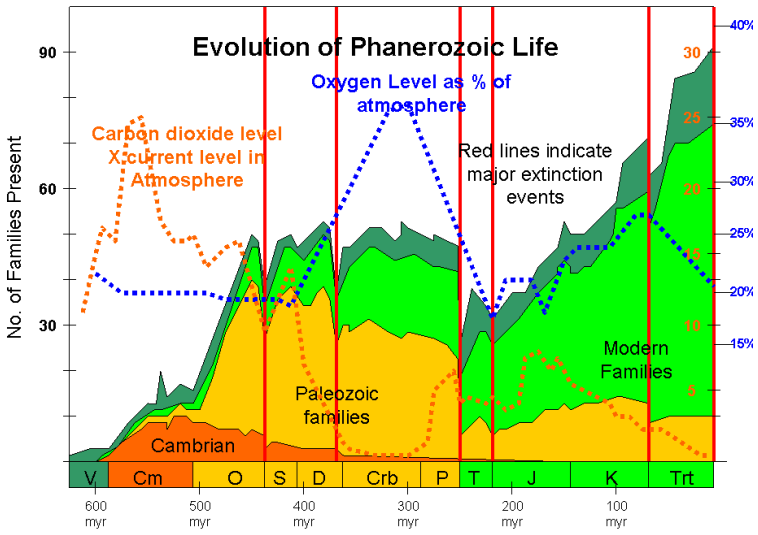
pillar of all life. Forests are the greatest generators of topsoil, and covered roughly one-third of the earth prior to the advent of civilization. Spreading desertification and clear-felled ancient forests were causing massive "skin lesions" on the face of the Earth, as once fertile and diverse ecosystems have collapsed, dragging many tens of thousands of species into extinction, most of them never even named and recorded by science. By 1975 the forest cover was one-fourth and by 1980 the forest had shrunk to one-fifth and the rapidity of forest elimination continues to *increase*. Indeed, World Wildlife Fund study released in 1998 states that between 1970 and 1995 the world's forests declined ten percent. This is a loss of forest cover the size of England and Wales- each year. If the present trends continue without interruption eighty percent of the *vegetation* of the planet will be gone by 2040.

Pillar 6. Maintenance of biodiversity (creation of ecological stability) *As the Daisyworld and more sophisticated examples show, adding diversity to the Gaia system increases its resilience and enables it better to recover rapidly from either internal or external disruption.*

South Western West Australia is considered amongst the top 6 spots for marine biodiversity in the world and amongst the top 9 for terrestrial biodiversity. There is nowhere else on earth that ranks so highly for both terrestrial and marine diversity, yet there are few spots where such diversity is so pressured with extinction. As the seed banks in the Vavilov centres are privatised and eliminated and the heirloom seeds eliminated from seed companies' inventories worldwide, the control of the seeds remaining is centralized and patented with the elite multinational corporations like Monsanto. Overfishing is also killing the oceans. Since 1984, the world fish catch has begun to shrink, even though investment in fishing equipment has risen substantially. In the northwest Atlantic, catches of cod, haddock, halibut, herring and other major human food species peaked in the late sixties. The catch of these species has dropped sharply since then. In such ways we are participating in the sixth extinction of life on the planet, the greatest loss of life since the extinction of the Dinosaurs. The cause of this planet-wide "illness" was the selfish, cancer-like behaviour of just one species; our own.

Our life as human beings is maintained through each cell being part of a massive and complex system of communication, linking the DNA of our cells, the neuro-transmitters of the brain, the endocrine hormone system and the chemical transmitters involved in the immune system. Disease is caused when this communication system is in some way disrupted. Cancer cells develop when living tissue loses its connection with the whole body, reproducing wildly, re-routing circulation systems and treating the body as mere resources to support the growth of new cancerous tissue. In the worst cases, eventually the toxic by-products and disruptions to vital organs produced by the cancerous tissue grows to the extent that it becomes harder and harder for the body to maintain itself in balance. In this way too, humans, out of touch with the living body of Gaia, are equally behaving selfishly, undermining the pillars upon which life depends.

Gaia as a living system, however, has suffered planetary assault before. She has survived Ice Ages that came close to freezing all the Earth's oceans, and other catastrophes that have at times wiped out 98% of all species. Even the extinction of the dinosaurs from a massive Meteoric impact was not enough to sterilise the Earth and wipe out all life. Over 99% of all species who have ever existed are extinct today, and Gaia can survive, albeit in a less complex form, by the simple extinction of humanity. This is the ultimate lesson in humility that Gaia science has been showing us. Not only are we totally dispensable, but unless we mend our cancerous ways, as we shall see, the continued future health and survival of our planet may require our extinction.



Civilization is out of balance with the flow of planetary energy and is doing damage to each of these pillars. In each case, however, Corporations of the Industrial Growth Civilisation and their government spokespersons have fought a continuous campaign against each of these findings. The tactics they use include

- Launching public relations campaigns that dispute the evidence.
- Finding "dummy" citizen action groups that campaign against the issue
- Predict dire economic consequences, and ignore the cost benefits.
- Find and pay a respected scientist to argue persuasively against the threat.
- Use non-peer reviewed scientific publications or industry-funded scientists who don't publish original peer-reviewed scientific work to support your point of view.
- Trumpet discredited scientific studies and myths supporting your point of view as scientific fact.
- Point to the substantial scientific uncertainty, and the certainty of economic loss if immediate action is taken.

In every case these short-sighted tactics have delayed action on every one of these environmental difficulties. But life on the earth is sustained by a single reversible reaction held in dynamic balance.

Like all such reversible reactions in chemistry generally, one can say that Gaia ultimately abides by Le Chetalier's principle which states "When a stress is applied to a system in equilibrium, the system tries to remove the stress by changing the equilibrium". Through our attacks on the 6 pillars that together support complex life on the planet, we are such a stress. And Gaia can and will respond, and this response will be to remove the stress. The stress is the seemingly irresistible force of Industrial Growth Civilisation. It has at last met the final immovable object; the fundamental reality of the life support systems of Gaia herself. But how is the removal of the stress going to happen?

On the 16th January 2006, James Lovelock, in the Sunday Independent feature article wrote

"The climate centres around the world, which are the equivalent of the pathology lab of a hospital, have reported the Earth's physical condition, and the climate specialists see it as seriously ill, and soon to pass into a morbid fever that may last as long as 100,000 years. I have to tell you, as members of the Earth's family and an intimate part of it, that you and especially civilisation are in grave danger.

Our planet has kept itself healthy and fit for life, just like an animal does, for most of the more than three billion years of its existence. It was ill luck that we started polluting at a time when the sun is too hot for comfort. We have given Gaia a fever and soon her condition will worsen to a state like a coma. She has been there before and recovered, but it took more than 100,000 years. We are responsible and will suffer the consequences: as the century progresses, the temperature will rise 8 degrees centigrade in temperate regions and 5 degrees in the tropics.

Much of the tropical land mass will become scrub and desert, and will no longer serve for regulation; this adds to the 40 per cent of the Earth's surface we have depleted to feed ourselves.

Curiously, aerosol pollution of the northern hemisphere reduces global warming by reflecting sunlight back to space. This 'global dimming' is transient and could disappear in a few days like the smoke that it is, leaving us fully exposed to the heat of the global greenhouse. We are in a fool's climate, accidentally kept cool by smoke, and before this century is over billions of us will die and the few breeding pairs of people that survive will be in the Arctic where the climate remains tolerable.

By failing to see that the Earth regulates its climate and composition, we have blundered into trying to do it ourselves, acting as if we were in charge. By doing this, we condemn ourselves to the worst form of slavery. If we chose to be the stewards of the Earth, then we are responsible for keeping the atmosphere, the ocean and the land surface right for life. A task we would soon find impossible - and something before we treated Gaia so badly, she had freely done for us.

To understand how impossible it is, think about how you would regulate your own temperature or the composition of your blood. Those with failing kidneys know the never-ending daily difficulty of adjusting water, salt and protein intake. The technological fix of dialysis helps, but is no replacement for living healthy kidneys."

He concluded

"Perhaps the saddest thing is that Gaia will lose as much or more than we do. Not only will wildlife and whole ecosystems go extinct, but in human civilisation the planet has a precious resource. We are not merely a disease; we are, through our intelligence and communication, the nervous system of the planet. Through us, Gaia has seen herself from space, and begins to know her place in the universe.

We should be the heart and mind of the Earth, not its malady. So let us be brave and cease thinking of human needs and rights alone, and see that we have harmed the living Earth and need to make our peace with Gaia. We must do it while we are still strong enough to negotiate, and not a broken rabble led by brutal war lords. Most of all, we should remember that we are a part of it, and it is indeed our home."

Our levels of stress are a cause of this dis-ease, and this imbalance will always interfere with the chemical language circulating within our bodies. It is not surprising that the two great illnesses of our age – of cancer and auto-immune disease – are diseases signalling the breakdown of the chemical communication that stitches our bodies together. As we unravel the external planetary ecosystem, through biochemical poisons, pesticides and other toxins, it is not surprising that our internal ecosystems are unravelling too[36].

But it doesn't have to be this way. There is an alternative. Robert Constanza, President of the International Society for Ecological Economics has calculated that the environment provides the following ecological services, that would cost the following amounts if humans had to provide them

Environment	Value (trillion $ US)	Biosphere Area (Mkm^2)	Net Primary Production Dry Carbon Gm/m^2	by weight total (Gigatonne)	Biomass total Gigatonne
Coastal	14.568	2	1,800	3.60	2.6
Open Sea	6.381	359	147	53.08	1.28
Total Marine	20.949	361	1,947	56.68	3.87
Wetlands	4.899	2	2,000	4.0	30.0
Forests	4.706	57	1,405	80.09	1700.9
Lakes/Rivers	1.700	2	250	0.5	0.04
Grasslands	0.906	42	515	21.64	128.48
Crops (all kinds)	0.128	14	650	9.10	14.0
Total Terrestrial	12.319	149	775	115.40	1873.42
Grand Total	33.268	510	926	170.28	1877.29

This figure is equivalent to the "interest" of the Net Primary Production of 170.28 billion tonnes of Dry Carbon by weight, produced by the photosynthesis of a biosphere of 1877.29 billion tonnes, giving a "return on investment" of living tissue of about 9.07%, bigger and better than all but the fastest growing exploitative economies.

But this economistic type of calculation is a little like trying to fit an elephant of the living planet into a VW beetle automobile of human economics. The world of course does not "own" such things nor sell them, it is the generous fecundity of life that maintains the gift of such a living biosphere and us. Nevertheless as Costanza showed, the economic value of the environment is much larger than the total Gross Domestic Product of all the nations of the world, and its destruction is even economically, therefore, at our own peril. And even then it is easily arguable that Constanza has left much out of his calculation. For example, what is the cost of the natural pollination of all of our flowering plants on earth by insects? The disappearance of the bees is demonstrating this in a graphic way. And how does one place a value on the gift of life itself? Destroying the life sustaining capacity of the planet will obviously destroy us and the economy, yet that is what is currently happening.
In this fact sheet we looked in detail at the growth of the Gaian model and suggested that it provided us with a new scientific paradigm, still being incorporated within more conventional scientific frameworks. We also showed how the Industrial Growth Civilisation, of which we are a part, through anthropocentric ignorance, stupidity and blindness is selectively attacking and destroying each of the "pillars" upon which Gaian stability is maintained, increasing the fragility and reducing the resilience of the living systems of which we are a part. But how do we undermine and remove this anthropocentric blindness? There are many ways, but science is itself showing us that rather than being the crown of creation, we are in fact just part of a much more ancient wisdom of blood-music.

The brain is the most complexly organised organ yet known to humankind. While exceeded in size by the brains of elephants and whales, when considered in proportion to the size of the body as a whole, humans are clearly the brainiest creature on the planet. With an average size per adult of 1,500 cubic centimetres, this represents a staggering figure of over 100 billion nerve cells, nearly one for every human who has ever lived, a figure equal to the number of stars in the Milky Way galaxy. The superlatives multiply when we consider that the numbers of interconnections made possible by these cells in a single brain, through nerve fibres, axons and synapses, exceeds the number of atoms in the entire universe.

This astonishing organ is an incredibly recent inhabitant of the Earth. Just 2 million years ago, the brains of our ancestors, already one of the "brainiest" on Earth, had a brain size of just 480 cubic centimetres, comparable to that of chimpanzees, gorillas and the orangutans of today. Whilst the rate of increase is almost imperceptible from generation to generation, an increase in the order of one two-thousandth of a cubic centimetre, per year, if it were a constant increase, it would mean that each generation of humans, for 2 million years, would have had 640,000 additional brain cells than their parents. There is still much debate about the cause of this increase in human brain size. Less well known is the fact that our brains have ceased increasing in size about 150,000 years ago. Indeed, if size is the measure of intelligence, then we are less "brainy" than the Neanderthal "cave men" that modern human beings replaced, between 45 and 28,000 years ago.

Our brains are not organised hierarchically. There is no "central controlling circuit" in the brain, no "I" located inside who pulls the strings, no apparent "seat of the soul" such as Descartes sought to find in the pineal gland. Instead the brain is organised by networks. Each brain cell appears similar to every other brain cell – there are not "greater" or "lesser" cells in the brain. Cells are equal, it is in the networked organisation of the whole, as it engages with the environment through which consciousness works. This is contrary to our hierarchical cultural common sense, everyday view of the world, discussed in earlier chapters. This common view perceives the brain as the seat of the mind, and sees the mind as more "Godlike", and superior to the body. Vital organs, like the heart, in language and metaphor, are also seen as superior to the "guts". We use bodily metaphors in our hierarchical organisations. The "head" directs the operations, hired "hands" do the work they are told to do. But this view is false, as shown by modern scientific breakthroughs.

The neurotransmitters, those chemicals that transmit messages from one nerve axon to another are tiny neuropeptide chemicals that previously were thought to be confined to the brain. More recent research shows that they pass easily between the brain and the blood. Chemically they are very similar, in many cases identical, to the hormones that are produced by the endocrine glands of the body. Thus male testosterone, produced by the gonads, is also produced by the brain, and the brain cannot distinguish the one from the other. Adrenaline, produced by the adrenal glands near the kidneys, associated with the "fight" or "flight" response when confronted with fear, is a precursor to the noradrenaline of the brain, one of the stimulators of nerve synapses when messages are passed. Recent medical research is also showing that these same chemicals are involved in preparing or hindering the cells of the immune system to do their work. It appears that this is the mechanism by which mental stress can have an adverse effect upon our resistance to disease. The work of Candace Pert and others, has demonstrated that there are in fact neurotransmitter receptor sites on most if not all major organs of the body, and the concentrations of these neuroreceptors in our blood, is determined by differences in the way we think. In the emerging science of psycho-neuro-endocrino-immunology, the blood in our veins is literally an important part of our thinking process, part of our mind. Despite science fiction stories about brain transplants transferring one consciousness into another body, this is an old survival of the "body-mind" dualism problem confronted in earlier chapters. Our self-consciousness, itself, does not reside in our brains alone, but in every organ in our body, in our whole being.

In fact, the chemical language of the neurotransmitters does not even stop with my body. These little chemicals, and their neuropeptide cousins, extend far further into all ecosystems. They are found in trees, in the soil, in the deep waters of the ocean and in the very air we breathe. As units of information, they carry multiple meanings through the sap of the tree, through the creation of soil, through the wetlands into ocean currents, in the regulation of global temperatures by the winds of the earth, in the perfume of our hair, and in our own internal blood-music. When looking at the intricacies of the biochemical pathways that links our body into the larger body of the Earth, one

finds amazing harmonies. The daily and seasonal rhythms add a counterpoint, and the organisation of each chemical instrument to create a larger melody, complete with chaos and discordances, climax and resolution, it is positively symphonic.

Circulating through and between the "six pillars" of the living Earth discussed in Chapter 6, these messages of information they collectively partake in an intelligence much older, and much more complex than our own. It is ultimately this blood-music that creates the intricate order of life, and structures the symphonic mechanisms of communication within the living planet, the Earth, of Gaia itself. Blood-music determines the nature of the air we breathe and of the waters that flow through our veins.

Throughout the forests across the surface of the earth, the trees pepper the soil with a fall of leaves. Having already sucked as much of the sugars and moisture out of the leaves in advance as possible, all that remains is cellulose and minerals. As the leaf on the tree ages, the neuropeptide cytokinin[37] chemicals, sent as a continuous messenger from the tip of its roots, is blocked. This liberates abscisic acid[38] (ABA), which creates an abscission layer of special cells filled with a jelly-like substance that grows at the base of each aging leaf stalk. With the slightest breeze, or even with the weight of the leaf itself, these gelatinous cells rupture and break. Devoid of a covering, the cells suddenly release the cytokinins which chemically tells the stem to secrete a waterproof layer to heal the sudden wound[39]. Such trees comprise a major "organ" of the planet, as they "eat the sunlight" and are in this way responsible for capturing the vast bulk of the energy that maintains the living body of the Earth. Forests may cover only 32.55% of the land surface of the Earth, but they collectively have 88.21% of the biomass of living tissue.

Once it falls, digested by fungi and soil bacteria, the fallen leaves change the chemical structure of the soil to increase its moisture retention and limit evaporation. The increased soil moisture provides a damp home for numerous invertebrates feeding on pollen spores and fungal hyphae. Earthworms, feeding on the fungus, churn the soil, adding their casts as faeces to the developing blood-music system. These invertebrates in turn are the food for other predators; the ants being the ultimate top-predator. A fine spray of humus percolates along fine root hairs, connected, in the most fertile soils by a mass of mycorrhiza which access soil chemicals and moisture to make them available for the fine root hairs of trees. Even if the soil has been severely damaged, humus performs damage control; for example, it helps prevent rotting of the roots after floods. The meristem on the tip of the root hairs produces signalling neuropeptide auxins[40], plant growth neuropeptide hormones that stimulate rapid growth. It is not accidental that these auxins are also found in animal urine, for they too are part of this system of blood-music. The speed by which this happens is mind-boggling. A mature rye plant, for instance, will extend its root systems by 5 kilometres each day, and its root hairs increase by 90 kilometres over the same period. This is far from the vegetative passivity described by Aristotle. Plants may appear passive in the way we see them above the ground, but at these microscopic levels below ground there is a ceaseless activity. At maturity the roots of the rye plant, if laid end to end, would extend over 622 kilometres, and the root hairs an unbelievable 10,620 kilometres[41]. Charles Darwin was so impressed by these abilities that he wrote, "it is hardly an exaggeration to say that the tip of the [root] thus endowered, and having the power of directing the movement of adjoining parts, acts like the brain of one of the lower animals." If the root tip acts so intelligently, what about the whole network of roots taken together? This churning activity beneath the ground belies the slow vegetative growth and stability of the plants above the ground. Little do we realise that the lacy network of branches and leaves above ground is vastly exceeded by the complexity of the networks of roots penetrating every nook and cranny beneath the surface of the soil, a complexity which can only be compared with that of the wiring pattern of nerve cells within the human brain.

As we have seen in previous chapters, geology is a part of this Gaian system. Rain falling upon this soil dissolves small amounts of Carbon Dioxide, becoming a weak solution of Carbolic Acid. Percolating down the channels made by the roots of trees and by burrowing invertebrates, it dissolves a cocktail of stronger humic and folic acids. This slowly percolating liquid of blood-music[42] eats into the deeper rocks below, followed closely by root hairs, and liberates the minerals needed for life. This binds them into forms that can be absorbed quickly via the mycorrhyzal fungi and root hairs. As seen already the living soil of the Earth constitutes a second, even older great "organ" of the living Earth than the trees themselves.

A stand of trees of the same species helps feed the coral-like mycorrhyzal fungi that attach to the tips of their roots. It uses its excess of sugars that have been manufactured in leaves growing high above the forest floor, receiving in exchange a variety of these minerals, other chemicals and moisture necessary for growth and maintenance. A secret underground commerce is underway, with each side benefiting from the transaction. Both sides gain, performing tasks that neither could achieve alone. The felty tip of the mycorrhizal sheaths surrounding roots are the most amazing water pumps. Root mycorrhyzae pump water at a rate of up to 3 times the pressure of the atmosphere. Other chemicals too get exchanged in the process. One tree, suffering an attack of leaf-eating insects, will pass a chemical message through its roots, accepted and disseminated by the mycorrhiza to other trees, warning them to start producing greater quantities of terpenes[43], tannins and other alkaloid neuropeptides to make their leaves less tasty and less digestible. Leaves may also produce chemicals that mimic the moulting hormones of caterpillars, preventing them from maturing into breeding adults[44], and laying eggs elsewhere.

This system of mutual interconnections between soils and trees has had more than 300 million years to evolve. The trying to map the biochemical complexity in its entirety is almost impossible. It can really only be appreciated as a whole and if scored in musical notation could only be compared to a vast choral symphony. Scientists working with just one square metre of soil in Norway, for instance, have found that soils can act as living sponges. They can accumulate heavy metals that are toxic to other life-forms, and using these chemical processes extract the energy contained through gathering, concentrating and precipitating dissolved harmful substances as inert harmless compounds. In case of over-fertilisation of soils the humus actively forms a reservoir for the excess nutrients and releases them gradually in doses that the plant can easily absorb when required. Plants that cooperate in the interconnections of bacteria, fungus and plant are rewarded with faster plant growth whilst those that do not are progressively poisoned as their growth is stunted.[45] Humic acids also activate plant roots. In particular they promote longitudinal growth of the roots and protect them from many harmful influence. This speeds up and optimises the rooting process. Soils thus provide a strange series of interlocking edge worlds where solid, liquid and gas can be brought together in strange new combinations. Bacteria absorb manganese from water; the ingested manganese being oxidised to form manganite, an insoluble mineral which can be deposited to act as a site for other bacteria. Clay molecules with a lining of chelated biochemicals and exposed to local concentrations of carbon dioxide, methane, nitrous oxides and other gases, can act as little chemical synthesis laboratories. They continuously pass other chemical messages out into the environment, to be picked up and relayed onwards by a host of different bacteria and fungal species. Polyphenol chelates[46] for instance prevents trace elements from reacting inappropriately with other substances in the soil or in plants. This prevents them from reacting together and so allows plants to absorb these elements as needed for healthy growth. Inorganic fertilisers are bound by these chelates, becoming more readily activated for absorption by plant roots. The binding also helps limit the leaching of these important chemicals out of the soil, maintaining them in a state ready for plant growth. It is as if underground there is a cabling of a large telephone exchange, carrying the messages of thousands of individual subscribers switching back and forth.

It is in this strange world of the living soils is echoed along the shoreline where we find an older organ of the Earth's body. In the eerie pungent-smelling world of tidal estuaries, sea grass and mudflats, held together by the roots of mangroves, nutrient rich lagoons and backwaters develop, providing protected spawning grounds for hundreds of species of shrimps, crayfish and various types of fish. The mangroves also help stabilise the shore habitat from destructive wave erosion. Aerial roots growing vertically out of the water provides the oxygen missing in the roots. Algal blooms growing on the nutrients filtered through river deltas provide the growing fingerling fish with sustenance before they take to the open seas. Nibbling off special growths on the exposed roots of the trees encourages plant growth and fruiting, and helps eliminate harmful salts and other tree pathogens that are in this way kept at bay, recycling them through other bodies that need them. Different species are found in zones depending upon their proximity to eroding soils from the shore or the depth or salinity of the water. Their shape and abilities to capture and hold sediments actually sculpts the water flow into eddies and rills that keep the habitat working as an interrelated communication system of incredible complexity.[47] These in turn sorts sediments by size to deposit them in patterns that reclaim shorelines for the more productive ecosystems found in swamps. Once again we see evidence of the vast and ancient intelligence of Gaia busily at work.

In deeper waters at first it seems a different blood-music intelligence is at work. On the eighth night following the August full moon, in the Gulf of Mexico:

> "Suddenly and silently, three different species of massive brain and star corals begin releasing their colourful globules, which soar toward the sea surface like tiny balloons. Before long, the water fills with millions of these packets of eggs or sperm, the sum total of this year's reproductive output for these colonies. Aboard the research boat, scientists notice a faint, sweet odour as the water's surface becomes strewn with floating gametes.
>
> The show's first act continues for two hours before other species of corals take over. Mountainous star corals measuring 15 feet across emit their vast quantities of egg-and-sperm bundles. Nearby, another species of star coral releases its delicate eggs and sperm separately like champagne bubbles. At the ocean surface, the slick formed by the gametes transforms from pink to orange with the new arrivals.
>
> Invisible to the scientists but crucial to this annual reproductive bonanza, microscopic sperm wriggle throughout the water in a blind quest for eggs. Each fertilised egg may develop into a tiny larva that spends weeks drifting with the ocean currents, possibly travelling great distances. Eventually, if it escapes fish and other predators and encounters a suitable clean spot on the seafloor, the offspring will attach itself to a hard surface and metamorphose into a single, immobile coral polyp--the beginnings of a new coral colony."[48]

Exactly the same symphony of breeding can be observed on the first full moon after the spring equinox on the Australian Great Barrier Reef, a night that was in ancient Babylon celebrated as the Akitu, the night of the sacred marriage between Ishtar, Queen of heaven and earth, and Tammuz. Nine-months later, close to the December solstice, if a child was conceived from this union, it was known as "the Son (or Daughter) of God". Yes we find the same synchrony operating at the level of nature itself. What is not known is the nature of the communication system that operates through the waters to synchronise this amazing coordination of behaviour? Scientists studying the behaviour have found a female neuropeptide hormone, oestradiol[49], released into the water in large amounts a few days before the event, which may assist the coral reefs synchronise their spawning. This is only part of the chemical complex language and intelligence that is at work. Nevertheless, the reefs house the most complex ecosystems of the ocean, sculpting refuges and hiding places for predators and prey alike, harvesting the largess of sunlight and warm nutritious waters of the external walls of

growing reef lagoons. These aquatic systems, of wetlands and lagoons, mangroves and reefs, constitute a most important organ of the living Earth, dating back at least 530 million years if not longer. Comprising less than 1.64% of the total aquatic environment, it produces a staggering 96.25% of its biomass.

Just as water is the major component of our blood, so water is also the basis of this chemical intelligence of the earth[50]. Both contain a small percentage of dissolved salts (oceans 3.6%, blood approximately 2%), that has a huge importance upon its structure and function. William Harvey (1578-1657 CE) demonstrated the circulation of the blood. As we have seen, in a similar way the water cycle comprising evaporation and rainfall, winds and ocean currents, rivers, lakes and oceans, comprise the circulation system that drives the Carbon, Nitrogen, Oxygen, Sulphur, Phosphorus and mineral metabolic cycles on which continued life of the Earth depends. In this way it is this water cycle that ultimately drives the system of blood-music. In the H_2O of the water molecule, the oxygen is strongly electronegative, leaving the hydrogen ends with a slight positive charge. Water can thus dissolve both positive metal ions and negative non-metal compounds, and the weak hydrogen bonds assists in the transport and solution of many more chemicals than any other solvent. Many of the chemical compounds are hydrophilic, easily dissolved, whilst others are hydrophobic repelling water from them to form greasy or oily coverings and semi-permeable membranes[51]. By combining hydrophilic and hydrophobic properties the chemical messengers can bend and shape others to fit into the templates created, achieving tasks not possible otherwise.

Mark and Dianna McMenamin (1994) show that in addition to all the oceans of the world, there is another huge body of water, the “hypersea” comprised of all the waters that travel through the bodies of life in the course of a year. This hypersea is rich and fecund, the source and solvent of the chemicals of the blood-music, which exploits the strange properties that make water unique and the medium of exchange of the chemical languages of which we are a part. As we bathe ourselves or consume our next drink, we are participating in the most personal way in this continuous cycling of nutrients. The rich broth of waters in our intestines are home to a bewildering variety of creatures. Indeed, the human body is home to more bacteria than there are human beings alive today on the earth[52], and bacterial cells, being so small, may in fact outnumber the cells officially recognised as genetically part of our own bodies.

As shown above the airs above the open oceans are also invaded by the water-borne communications system of the chemical intelligence. Blossoming coccolithophorids, vacuuming calcium bicarbonate washed down from the rivers systems into their solid bodies, create a ceaseless rain of calcium carbonate along the deep ocean floors. The burying of the atmospheric carbon dioxide in this manner has been vitally important for the continuity of life on Earth, and has also been modulated by neuropeptide blood-music. This rocky precipitate of limestone is scraped up against continental margins as cliffs of chalk, or thrust deep beneath volcanic island arcs, to emerge again through volcanic degassing as atmospheric carbon dioxide. As vast milky lakes, formed when the conditions are right[53], the coccolithophorids seed the air with high concentrations of dimethyl sulphide, which react with the oxygen of the air to make droplets of sulphuric acid, upon which water vapour condenses[54]. The heat contained in the vapours is suddenly pumped into the air fuelling rapidly rising updraughts. Swept aloft the droplets repeatedly freeze and thaw, growing in bulk. In vast clouds they reflect incoming sunlight, cooling the oceans below and with winds and waves becoming choppy. The bacterial engines themselves are carried aloft to seed oceans elsewhere not so depleted of the needed calcium bicarbonate. Here we see again a vast and ancient intelligence at work. These tiny rainmakers create the white veils of cloud that wreath the planet to cool it from the heating fires of the sun[55], by increasing its reflectivity.

A similar air-and-water-borne chemical language is found in the air above the forests. Not only does each tree act as a huge water pump, passing water from the ground straight back into the air[56], but accompanying the vapour droplets are scents of a different kind. Water may rise through a hardwood tree at a rate of 50 metres per hour, with a maple tree, on a warm sunny day pushing 200 litres per hour out into the atmosphere. Dissolved in this water is a whole family of light-weight sulphurised phenols and other oils that are carried aloft to stimulate the formation of rain-clouds. There, they too set free the latent heat carried by water vapour into the air, heating it and causing huge thunderhead updraughts to form once again. Perpetually wreathing the rainforests of the world, the seasonal cycles created by these processes create the living lungs of the planet. Inhaling and exhaling carbon dioxide and oxygen the yearly swing of the whole planet has been measured as an annual pulse[57], in which the various parts are coordinated to work together by the chemical language of the system as a whole. Forests can be said to have been the way in which the living oceans perpetually came upon dry land, to colonise the desert-like surfaces of the ancient Earth. Working in harmony with the oceans, they have added to the oxygen atmosphere. This in turn has reinforced the ozone shield, and so has prevented ultraviolet light decomposing the water molecules, which would have robbed this planet of its moisture over a two billion years ago[58]. In this way the chemical language of the earth has achieved its greatest victory, creating Gaia, the living planet Earth. As we have seen, the Earth alone, of the inner family of the sun, has maintained itself as a water world.

Much of this blood-music language occurs close to or even inside the body. It is a language of intimacy, ultimately a language of communicative touch. To gain a faint understanding of the power of such a language we humans need to get down on our hands and knees and put our noses to the fertile ground. The rich aroma forms a heady brew, but our noses, compared to others, are colour-blind. Dogs smell in technicolour[59]. A single skin flake of a human that they know, shed whilst walking, gives bloodhounds their amazing ability to follow a trail even days after you have passed by. But even dog's noses are not as sensitive as some on the planet. E.O.Wilson is an ant specialist. He has found the ant is "a walking battery of endocrine glands", with over 17 sites to its body[60], each capable of producing a range of specific neuropeptide scents. Meeting another ant, the first message given is one of recognition – this is one of "us". Other messages are carried. These include "follow me", "danger nearby", "food here" and many others that scientists have not yet managed to learn. "Alarm" pheromones will bring soldier ants running. The distinctive formic acid smell of a crushed ant also carries a message to others of the colony "danger, proceed with care"! Multiplied in the millions, this ancient chemical language creates the intricate complex behaviours of the ant colony. Here in the world's oldest cities, vastly more ancient than ours, continuously rebuilt for hundreds of millions of years, the world's first farmers, the ants, have learned to cultivate fungus from fresh harvested leaves, cut through their especially genetically engineered jaws[61]. The intelligence of the ant colony, like that of the bee hive, or indeed, our brains, is assembled from simple components, but as in all cases when communication is involved, the whole is greater than the sum of the parts. On a hot day in the breeding chamber, bees fetch water mixed with evaporative alcohols from their tiny bodies. Acting as little air-conditioners, rows of bees with beating wings cause this water to evaporate cooling the breeding chamber to exactly the needed temperature. As Lewis Thomas has suggested, these examples of social insects are not in any way separate from each other, they are parts of a single individual, a colonial superorganism[62].

But these examples are only recent products of the flowering of the chemical intelligence. Insects comprise the largest and most important animal contribution to the biodiverse world of blood-music. Butterflies can scent a mate from a distance of kilometres, and flowers call insects whose tiny bodies have been genetically sculpted over millions of years to specifically meet their needs for pollination[63]. Beetles smell ripening fruit or new leaves. We humans are like a blind bull in a shop

of tiny glass ornaments, but even we can detect the changing pollens and odours of spring, in a great flowering of scents that resembles the spawning of the corals mentioned earlier.

Although we are usually unconscious of this chemical intelligence, blood-music completely rules our bodies. Its almost miraculous achievements are stunning. In the developing embryo, chemical signals cause the skin to fold and wrinkle, bulging inwards and changing shape and function to form the first nerve cells. Gathering in great ganglia the tips of the nerve cells become little root-hairs. Their tips, like little noses are busy, seeking specific scents produced from targeted muscles. Growing rapidly in the direction from which the scent emanates, finally they reach the target that they seek. A chemo-electric message is sent along the nerve axon, back to the developing brain, shaping cell division into new organic architecture. Nerve cells that fail to make the appropriate connection, wither and die a pre-programmed death, switched on by ancient chemical pathways in the internal language of the cell. More complex than all the telephone exchanges and computer networks of the planet, the self-organising structure of each individual human brain, complete with its miraculous abilities to process information, is only one of the most recent products of the chemical blood-music intelligence of the Earth. Beneath consciousness, the chemical scents travel the synapses of the brain, carrying specific messages to be broadcast widely or whispered secretly to neighbouring cells. These neurotransmitters are swept up into the blood stream, to travel to other parts of the body. The complex endocrine system of specialised organs modulates everything from our sexuality to our digestion, releasing our energy for strenuous activity, or shutting down peripheral systems not currently required.

The same chemical agents appear again in the lymph of the vast communication immune system, where signals recognise, like the ant colony between "us" from "not us", self and other. For too long our scientists have used military metaphors describing the "defences" created by our "anti-bodies", but some now suspect that a "communication system" would be a better way of describing it. "Infection" here resembles a "communication breakdown", which can be exploited for its own purposes by the bacterial or viral agent. But the learning capability of the blood music orchestra seem miraculous, and in most cases, internal harmony can be re-established. If not, the phenols and steroids secreted by the skin pass unseen to the noses of our neighbours in ways that we are just beginning to discover, carrying messages of the vaster intelligence of which we are a part.

An unpleasant body odour or bad breath signals that the bearer's physical and mental condition is under stress, and all is not well. Unpleasant body odours are repulsive, and, in the natural world, warn those detecting them that all is not as it should be for the unfortunate bearer of such chemical bad news. But there are far more chemical signals passing between us all the time of which we are totally unaware. For example, research has shown that humans can consciously distinguish between 10,000 and 100,000 specific odours, but recent work suggests that our olfactory discrimination is far vaster than we think, as the nerves from the nose travel to the deepest, most sub-conscious parts of our brain, and we may not even be aware that we are receiving chemical signals for much of the time. The male androsterones [64] are hardly consciously detectable, yet when sprayed on a specific chair in a dentist's waiting room will attract women patients to sit as close as possible, like butterflies around a candle flame. Female equivalents cause men to find women most attractive around the time of ovulation. Similar neuropeptide chemical messengers correlate the menstrual cycles of women living in close proximity in dormitories, and in natural circumstances, with the phases of the moon. These pheromone chemicals, spreading from the hairline, the corners of the eyes, nose and mouth, from behind the ears, along the base of the neck, around the arm-pits, the breasts, from the groin and behind the knees, are closely associated with the lymph nodes. They thus form part of the external system that ties us socially into the Earth's body and manipulates us psychologically, linking the lymph, endocrine, immune system and neurotransmitters into one vast ceaseless chemical web of interacting messages[65]. By comparison, the subtleties of our spoken

language are crude and coarse when compared to the precision and accuracy of the chemical syntax and grammar that surrounds us.

Blood-music is a good name for this chemical music that surrounds us. With vastly more instruments than any symphony orchestra, or more voices than even the largest choir, our bodies continually "sing", if only we had ears to hear. The song begins before birth, in the signalling between sperm and egg, and the song continues after death, with the continued growth of hair and fingernails. But our song is not a solitary melody. As we have seen above, our chemical symphony is only a most minute part of a much larger multi-voice chorus, spreading all around us throughout the world. In death, new chemical words signal to the bacteria that live upon and within us that the host has let go of holding the internal structure intact, and they change into new forms, rapidly reproducing themselves preparatory to spreading elsewhere. Once aiding in the digestion process of the food provided by their host, they now discover that their host is a last source of food, and so the chemical components of our bodies are recycled once more into the older intelligence of the living planet. Enriching soils, feeding vast hosts beyond number, our death is not an ending but is indeed a new beginning, an opening of possibility and a creation of space for others yet to come. The song adapts, evolves and thus continues, only the singers have changed.

These communication channels forms part of a web of language that stretches out and between us all, creating, disseminating and passing new information. The flow of information, energy and material ties us into this vast living web of life. Some of this information is encoded, intended for the chemical ears of one specific listener. Other information is widely broadcast, intended to be heard by all within chemical earshot. Some information degrades rapidly once heard, as though a secret message on a piece of paper that once read will spontaneously burst into flame. Other messages can travel right around the planet, passing needed melodies to singers in other continents. In addition to aiding the spread of messages, some chemicals also act to block or distort the signal of others. Local disharmonies find resolution within the larger body of the Earth. The complexity of the interlocking chemicals, though filtered through some membranes of the various living "organs" of Gaia we have discussed, are rejected or destroyed by others in a complex seamless web that acknowledges only the boundary of the top of the atmosphere and the deepest rocks beneath the surface. The recent finding of nanobes[66] in rock samples that had been retrieved from 3 to 5 kilometres below the ocean bed suggest that this intelligent chemical language may even be capable of geological as well as biological effects. At these depths pressure is around 2000 times that of the atmosphere, and temperatures range between 115 to 170 degrees Centigrade.

Unfortunately the international industrial growth society is blind to the reality of blood-music. One by one, the spread of mass consumer culture and its hierarchical anthropocentric ethical system has been dismantling the "living organs" of the Earth on which the blood-music depends. Our task, if we are not to perish, is to rebuild and learn to live within these natural systems of the Earth.

We of the west are only now beginning to recover the awareness that we are only a tiny part of something far larger, and far wiser than we, part of this Gaian planetary intelligence that makes our own puny understandings minuscule when compared to its vast knowings. We are slowly, and painfully, recovering the wisdom of the blood-music, a wisdom that began singing with life over four billion years ago, with the reproduction of the first living cell. The song continues all around and through us.

It was the Australian aboriginal hunter-gatherers who first viewed nature as a series of intersecting "song-lines"[67]. For them, the process of maturity came with a greater awareness, an increased ability, to recognise melody and words of the song that was theirs, the melody and phrases emanating from the country that owned them, over which they were just temporary custodians. We

of the west are only now beginning to recover the awareness that we are only a tiny part of something far larger, and far wiser than we, part of a planetary intelligence that makes our own puny understandings minuscule when compared to its vast knowings. We are slowly, and painfully, recovering the wisdom of the blood-music, a wisdom that began singing with life over four billion years ago, with the reproduction of the first living cell. The song continues all around and through us. Despite the best efforts of reductionist science to hierarchically separate ourselves from it, of neo-conservative economics to deafen ourselves to its tunes, of technology to subdue it to our wills; we must and will fail. We will fail because we are only a very recent part of the bloodmusic, and it in turn is an ancient part of us. Hopefully our blindness to its beauty will be only a temporary blindness. As we rush about on our daily tasks, we in the west continue to deny this reality. We encase our bodies in clothing, soaps and alien scents, and our minds in our mental armour, to prevent the messages of our fear, loneliness or daily grief straying out into the larger social systems of which we are a part.

Blood-music cannot be denied. Our levels of stress are a cause of dis-ease, and this imbalance will always interfere with the chemical language circulating within our bodies. It is not surprising that the two great illnesses of our age – of cancer and auto-immune disease – are diseases signalling the breakdown of the chemical communication that stitches our bodies together. As we unravel the external planetary ecosystem, through biochemical poisons, pesticides and other toxins, it is not surprising that our internal ecosystems are unravelling too[68].

The song must continue, and if we block its path, if we seek blindness over sight and deafness over the ability to hear, we too are signalling that we are an impediment. The song of the planet's blood-music has rejected singers before, in fact scientists estimate that over 99% of all species that have existed are today extinct[69]. Extinction in natural circumstances is just the song's way of recycling some of the components and of putting their bodies to other uses. Through blood-music, the life of our bodies does not stop at our skin, but seeps, and oozes, and signals all the time. Just as ants in a colony are both individuals, and parts of a super-organism, so it is with us humans. For at least 100 million years we have not stored information individually, but socially[70]. We primates have long been social creatures. Belonging to a group larger than ourselves, it is the knowledge of this larger group that enables us to survive. It is strange that the modern industrial culture that prides itself on placing individualism above and beyond any collectivism is the same culture in which the individuals are most dependent upon the smooth workings of the largest collectivity that the planet has yet seen. It is a pity that this collectivity has sought hierarchically to control and master nature, rather than trying to learn nature's ways to live in greater harmony within it. Such ignorance will always ultimately prove fatal, as it has with past cultures and civilisations who have prided themselves upon their ecological ignorance rather than their ecological wisdom. They too have died and disappeared[71], as we shall too, unless we urgently learn the non hierarchical wisdom of the blood-music and start to sing in harmony once again.

Here at last, in the lessons of the ecology of the living planet Earth, we have found an antidote to the hierarchical anthropocentric systems that have been with us since the Greeks. Seen from the perspective of blood-music, human life is not superior to that of the dog, the tree, the soil or even of the wind or water. The hierarchical Aristotelian ascent of the Great Chain of Being can now be finally set to rest. We have the possibility of an ethical system based, not on a system of superior and subordinate, but upon mutuality, respect and interdependence. Health, in such a reality, cannot be reduced to the separation of its parts but involves the health of the whole system. An attempt at maintaining individual health that damages the whole system cannot continue for long. Building an ethics in such a system is much more dependent upon context and consequence. It has to be field dependent. It cannot be about adherence to timeless abstractions, because they too evolve. Flexibility and adaptability thus are more important as they cope with change better than attempts

at uniformitarian control. Rather than exclusivity, conformity and obedience it is a system that is intimate, participatory and inclusive. Value is determined not by some external measure or standard, but by the quality of communication and relationship. But in the intertwining biology of the blood-music we have at long last found the basis for an ethic that promotes a mutual equality in our ceaselessly unfolding uniqueness. As the Samyutta Nikaya Vina (Lute) Sutta of the Buddhist Pali Canon states -

> "we who look at the whole and not just the part, know that we too are systems of interdependence, of feelings, perceptions, thoughts, and consciousness all interconnected. Investigating in this way, we come to realise that there is no me or mine in any one part, just as a sound does not belong to any one part of the lute."[72]

Blood-music gives us an alternative way of viewing the world, a means by which to recognise the way the planet self-organises as a living entity, organised not as a hierarchy of authority, but as networks of communication and responsiveness, networks which link vast and ceaseless flows of information. If it is true that our much vaunted human intelligence is really only a very recent part of a much larger and much more ancient intelligence, and if, as I have asserted, we tend to model our human organisations on the way we view ourselves and the world, then the cooperative non-hierarchical systems of blood-music provide us with better conceptual models upon which to build human organisations that are in harmony with the ecological realities of which we are a part. The way forward for humanity clearly must be to work in harmony with the blood-music of which we, our minds and bodies, are a part. But how do we work in greater harmony with Gaian processes? It is to this we now must turn, but before we do, is there a better way of examining the nature of human consciousness than we have considered so far? It may be that there is, but first we need to examine a little more about the nature of human nature.

GAIA AS A MOVEMENT

Given the current ignorance of Gaian wisdom, and the fact that the corporate consumerism equates progress with turning the life of the planet into money, ignoring both the finite sources of its wealth and the limited capacity to detoxify wastes, this is a culture which Lovelock has recently reckoned on the basis of its current trends, has not long to survive. If we are to survive its demise, we need to engage in a planet-wide Transition Project, creating a Great Turning, away from the consumer Industrial Growth Civilisation towards the Life Sustaining Culture of the future. In this way, Gaia Theory, or rather more accurately, Gaia Science is now recognised as an important part of what has been called the "Deep Ecology Movement".

It was Arne Naess[73], the Norwegian philosopher and environmental activist, who was the first to speak of Deep Ecology in 1973. He also spoke of the transpersonal "wide identification with the more than human world". It was Aldo Leopold[74], the forester and wild-life expert, who began to speak of an "ethics of the land" in the 1940s also spoke of the need to start "Thinking like a Mountain" when he saw the great living spark that linked the light in the eyes of a dying wolf with the world in which it lived. David Thoreau had made similar suggestions when he was living by Walden Pond in the 19th century. Humans too, Thoreau, Leopold and Naess suggested, need to respect the larger systems of which Lovelock and Margulis have shown of which we are all indissolubly a part. As we cannot separate ourselves from the metabolistic processes which keep our air breathable, our waters drinkable and our soils fertile. What we do to the Earth, we ultimately do to ourselves. We are not separate "things", we are in fact just temporary nodes in this planetary process of flow.

Doing science in the absence of such identification and participation within the Anima Mundi, the soul of the Earth, it would seem makes science into a soulless, dry and lifeless mechanism, and possibly results ultimately is us becoming the ecologically suicidal subject which extinguishes and sucks the soul out of that living body which is being studied. Like vivisection, dissection of living tissue first kills that which it is trying to study. But looking at the true nature of scientific creativity shows this has never been the only, nor indeed the best way deep science has ever been done. Truly great science has always been in touch with the ultimate mysteries of existence, the awareness as Newton said that we are "on an infinite seashore exploring a few small shells of interest, while all around us the mighty unknown ocean rolls". To reclaim a living and not a suicidal science, we need to reanimate science with this ancient soul, a planetary project with poetry, animation, and the joy of our full participation in and with life. All the work that the world does to maintain life is not done on the basis of the sterile economic motives of narrow and limited cost-benefit calculations that seem to have become the dominant way of describing "rational economic behaviour" for us humans. Each human life we share in this way is gift which needs to be celebrated, it is the ultimate "free lunch". Life is not a market economy, but a gift economy, in which we never fully can understand the richness of what we have been given.

This is the challenge we face, a challenge to engage in what has been called the Great Work, the Great Turning, the Great Re-linking, or the Work that Reconnects. We humans need to curb our consumption, to find ways of living once again in fully harmony within the living body of which we are an indivisible part, for our own survival. It is no longer enough to save a local Amazon forest from logging, or a single species from extinction, or to prevent the poisoning of the water and air of some Third World city. These piecemeal actions, while important, only buy a little time. A time for the work of building us a cultural bridge to enter what has been called the Solar or Ecozoic age.

How can this occur? To some degree it is happening already. The Gaia Trust, operating out of Denmark, the work of Ross and Hildur Jackson, has been instrumental in assisting the formation of a Global Ecovillage Network, with branches in the Americas, Asia and Oceania, Europe and now Africa and the Middle East. It has also been instrumental in establishing the world-wide Gaia University, with its headquarters in the USA but operating worldwide. The Gaia Foundation, with a headquarters in London, has been part of many projects, particularly in association with groups like the African Greenbelt Movement led by the recently deceased Nobel Prize winner Wangari Matthai. Gaia Foundations are now found around the world, prominent organisations in Brazil and Chile. Gaia Education, championing the spread of the Transition Movement is assisting its spread through Ecovillage Design Education, which is spreading fast throughout Africa and now India.

Such movements show us that paradoxically the answer is quite simple. If for example, as a result of Dragon Dreaming, if you are inspired and empowered to change your lifestyle to live in harmony with the Earth, that is a huge start. If you can, with a friend, work colleague or relative, over the course of one week, get them too to understand the nature of Gaia and make the change, that is the next step. If, over the course of that week, that person too, develops the skill to share what they have learned with one other, working with one person a day, we have the third and final step in place. That is all we require to build a socially just, peaceful, sustainable and democratic world for all of us, and for our no-legged, four-legged, six-legged, winged and swimming cousins, those "more than human" beings with whom we share this world. Because, if we manage to achieve this spread of a sustainable lifestyle today there could be two of you, tomorrow, when your co-conspirator works with one other person and you repeat what you have learned with one other, there will be four of you. The next week there can be eight, then sixteen, thirty two, sixty four. If the power of doubling continues, so within just 33 weeks you will have changed the lives of every single man,

woman and child on the planet. By the first person just working with 33 people, in a little over eight months could change and heal the world forever.

This is the power and the promise of the international deep-long range Gaia ecological movement on which Dragon Dreaming is based. It is a movement that is already leaping international boundaries, halting destructive practices, building new green sustainable technologies, economic systems and social structures, and re-programming the Human consciousness to resume its responsibilities to live in harmony with all that is alive. It would seem that not only does the healing of the planetary predicament of our present cancerous-like existence require such a personal and collective mobilisation, but paradoxically, new technologies, new movements and the proliferation of community organisations and projects is making such a mobilisation increasingly possible. Unlike other earlier revolutionary changes in human history, this Gaian movement requires all of us, working together to make the shift. It also requires us to liberate our buried human potential on a scale never before attempted. It cannot occur only in one part of the world, as the disruptions it could produce would be almost as catastrophic as the extinction of human life itself. We are all part of this single living being. This has to become the source of our true globalisation, not the shallow parody occurring in the name of planetary corporatism or free market economics. Not only is this shift going to take all of us, it is also going to require us using all of our potential skills and abilities, including those skills and abilities which we have not yet adequately developed. It will take All^2. Confronting the inspiring and empowering challenge of the Great Work is thus going to take all of us, and all of each one of us.

CONCLUSION

Gaia was a ***myth*** of ancient and indigenous people in which the Earth was alive, and this non-human and human existence were profoundly interconnected. Gaia then became a ***metaphor***, replacing that of a "chain of being" with humans in "the web of life", with us humans being just one strand. . Many people are also increasingly aware of Gaia, the scientific ***model*** of James Lovelock and Lynn Margulis of the Earth as a self-organising, sun energised system. But today Gaia is also an international ***movement*** of people working to eliminate the cancerous characteristics of Industrial Growth society, and to facilitate a Great Turning towards a Sustainable Life Sustaining civilisation on Earth. It is important for us, those people engaged in this great work, to become familiar with the intricacies of the myth, metaphor, model and movement. We can then draw strength from the fact that we are not powerless, separate individuals, but part of the world's own attempt to heal the damaged relationship with its human part.

Since the beginning of history the "idea of Gaia" has given us one important way of combating civilisation's inherent tendency to destroy the important connection between human beings and the natural world of which they are a part. To cultures that are ecologically sustainable, the reality of Gaia is all encompassing, but equally she, or it, is as invisible as water is to a fish. For example, as the Lakota Sioux, Black Elk has said

"Then I was standing on the highest mountain of them all, and round about beneath me was the whole hoop of the world. And while I stood there I saw more than I can tell and understood more than I saw; for I was seeing in a sacred manner the shapes of all things in the spirit, and the shape of all shapes as they must live together like one being. And I say the sacred hoop of my people was one of many hoops that made one circle, wide as daylight and as starlight, and in the centre grew one

mighty flowering tree to shelter all the children of one mother and one father. And I saw that it was holy…

But anywhere is the centre of the world."

Ultimately the idea of Gaia is an attempt to recapture this sense of wholeness shared by Black Elk, of which we are always and in reality connected. It has the power to heal our sense of brokenness; our sense of being all apart and separate from the natural world, a separation that seems to be an automatic result of the "nature" of our rapacious civilisation.

So why is the Gaian view so important to the "Deep Long Range Ecological Movement"?

Gaia seeks, quite simply, to save us from ourselves by expanding our identification -- our sense of "egotistical separated self", beyond community and nation-state, beyond even humanity -- to the whole biosphere -- to a sense of "interconnected eco-self" of Gaia. What it shows is that we are not alone in the changes we seek to make. As we heal ourselves, so we are working in harmony with over 4 billion years of biological evolution. We can draw immense strength from these connections.

This healing is urgently required. Peter Vitousek in 1986 showed how nearly 40% of the present net primary organic material produced each year is being co-opted by human beings. After only a single doubling of the world's population (say, in 40 years) we will use 80%, and 100% shortly thereafter, leading to a truly massive planetary extinction thereafter. The Ecological Footprint analysis by Drs. W. Rees and M.Wackernagel shows that it takes 1.8 hectares of land to maintain the current average world levels of consumption (8-9 hectares in Australia), which, when multiplied by current world population comes to a land surface equal to 1.3 planets! As a result it has been estimated about 104 species become extinct per day, 37,500 per year, a loss that will take 10 million years to repair. These studies indicate that today's 6.6 billion humans at present levels of consumption are nearly double that needed to maintain Gaia as a fit environment for complex lifeforms. The Living Planet Index, of the International Union of the Conservation of Nature has today fallen to 70% of the values it had in the 1960s.

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[1] Caroline Merchant, (1990) "The Death of Nature: Women, Ecology and the Scientific Revolution"

[2] Ken Wilbur (2001) "A Brief History of Everything" (Shambhala Press)

[3] Diane Skafte "When Oracles Speak: Opening Yourself to Messages found in Dreams, Signs and the Voices of Nature" Thorsons Harper 1997

[4] Leick, Gwendolyn (1993), ""Sex and Eroticism in Mesopotamian Literature" (Routledge)

[5] The language of George W. Bush is especially informative of this ancient pattern. "Anyone not with us is against us" is a key strategy of dualism through exclusion of the possibility of any middle ground compromise. The biblical origins of this language have been discussed above.

[6] This second name she had is the origin of the classical Greek god (later considered Gaia's "husband") Uranus. Uranus was the name given later to the 7th planet of our Solar System by the English Astronomer Royal William Herschell on 13 March 1781. Ania, as a name of the mother goddess is found in the names of such divinities as Inanna, Anahita, Anath, Athene, Hannahannah, and in the Christian Saint Anne. It seems to have meant simply "mother" in the substrate language of the first farmers of the ancient Middle East.

[7] Verdansky, Vladimir
[8] Bertalanffy, Ludwig

[9] Von Neumann, John
[10] http://palaeo-electronica.org/2000_1/editor/westbroe.htm

[11] "Snowball Earth"
[12] Smil, Vaclav "Energies:an illustrated guide to the biosphere and civilisation" (MIT Press, Boston) p.42
[13] See Sterelny, Kim "Dawkins Versus Gould" (Icon Books) ISBN 184846-249-3 for a discsson of the similarities and differences between these two leading evolutionary scientists/

[14] Pope John Paul II has strengthened the Catholic Church's views on evolution in an address he gave to the Pontifical Academy of Sciences meeting on evolution and the origin of life (October 1996) in which he stated "Today, almost half a century after the publication of the [papal] encyclical [of Pope Pius XII which had "already stated that there was no opposition between evolution and the doctrine of the faith about man and his vocation"], new knowledge has led to the recognition of the theory of evolution as more than a hypothesis. It is indeed remarkable that this theory has been progressively accepted by researchers, following a series of discoveries in various fields of knowledge. The convergence, neither sought nor fabricated, of the results of work that was conducted independently is in itself a significant argument in favor of this theory." (Inserted square brackets are mine, see http://www.newadvent.org/library/docs_jp02tc.htm for the full text of the speech). This is in marked contradiction with the position of the Fundamentalist Moral Majority that supports the Republican Presidency of George W. Bush.

[15] But in his discussions on the nature of the noosphere as a thinking web that he saw surrounding the planet, linking minds technologically, Teilhard seems to have predicted the nature of the internet and cyberspace, long before they developed. Fueled by Moore's Law, which demonstrates the doubling of computational complexity every eighteen months, a number of modern thinkers suggest that Teilhard's Omega point, is in our near future, as our computers achieve and then surpass the complexity of the Human Brain. At that point, the Transhumance theory states, history as we understand it comes to an end, as we will have created a collective entity far greater than ourselves. Rather than fearing the extinction of what we currently understand by humankind, the transhuman thinkers welcome the rush towards a culmination of our evolution in a post human world. Wedded to technological determinism, the extinction of conventional life does not fill them at all with dread.
[16] Bateson, Gregory
[17] Haldane, J.B.S.

[18] Lovelock, James "At the Service of the Earth" Researgence 2006 May/June 2001 see http://www.resurgence.org/resurgence/issues/lovelock206.htm

[19] Such "thought experiements" or "gedanken experimenten" were an important scientific tool, one of the favourites of Albert Einstein, who used them in a number of his major discoveries. For example, his theory of relativity had its orgins when he was 16, on holiday to Padua. Riding his bicycle through the streets led him to wonder what he could see if he was traveling at the same speed as light.

[20] For a recent examination of the differences between evolution and the formation of Daisyworld, see Downing, Keith & Peter Zvirinsky "The Simulated Evolution of Biochemical Guilds: Reconciling Gaia Theory and Natural Selection" (Dept. of Computer and Information Sciences, The Norwegian University of Science and Technology)
which shows in "simulations of Gaian emergence based on an artificial-life model involving genetic algorithms and guilds of simple metabolizing agents (producers, herbivores, carnivores and decomposers), … resource competition leads to guild diversity; the ensemble of guilds then manifests life-sustaining nutrient recycling and exerts distributed control over environmental nutrient ratios. These results illustrate that standard individual-based natural selection is sufficient to explain Gaian self-organization, and they help clarify the relationships between two key metrics of Gaian activity: recycling and regulation."
http://www.idi.ntnu.no/grupper/ai/eval/guild/guild.html

[21] A useful powerpoint presentation explaining "Snowball Earth" theory is at
shadow.eas.gatech.edu/~jean/paleo/discussions/**snowball**.ppt

[22] The original case of altruism proposed that the altruistic individual may sacrifice himself for the sake of relatives which share the same gene. HGT suggests that non-relatives may also share the same gene by virtue of geographic proximity. With prokaryotes, therefore, cooperating with near neighbours may be a strategy that favours genes passed through HGT.

[23] Lovelock, James (2002) "What is Gaia?" "Resurgence" Issue 211 March/April 2002 see http://www.resurgence.org/resurgence/issues/lovelock211.htm

[24] See http://tracer.env.uea.ac.uk/esmg/papers/SporaandGaia.pdf.

[25] According to the detritus zircons of that age found in the rocks of the Jack Hills of Western Australia, the Earth already had a water ocean at this age. Mars possibly did too.

[26] Rates of meteoric impact have been graphed based upon the age of lunar craters. The show that significant impact events continued down to the end of the Nectarian epoch, which could have effectively repeatedly sterilized the Earth of life. Thereafter their frequency declines rapidly. The fact that there is evidence that life was on earth shortly thereafter suggests that inn the right conditions, life evolves comparatively rapidly.

[27] The Calcium-Aluminium Inclusions were 2 million years earlier than the remainder of the carbonaceous chondrule meteorites, the oldest part of the protoplanetary disc still surviving today. This would seem to be a way of accurately dating the time of the supernova explosion that formed the sun. Once the HII region started to contract started to contract, it would take approximately 100,000 years for the sun and the protoplanetary accretion disc to form, and the sun to light up as a T Tauri star. It would appear to have taken 25 million years for the Earth to form from the protoplanetary disc, an event which has been dated to approximately 4567.17 million years ago.

[28] Research shows that the earth is radiating energy at the rate of 6.18×10^{-12} Watts per kilogram. Given the huge size of the Earth, 5.97×10^{24} kilograms, this meas that the total energy produced by the Earth is about 36.92×10^{12} Watts. Recently, the total radioactivity of Earth from all sources has been estimated from various neutrino counts as about 24 Terawatts (i.e. 10^{12} Watts). This leaves a further 12.96 Terawatts as a result of the ongoing gravitational sorting between mantle and core – a result of its early formation from accretion by impacting planetismals. The radioactivity comes from a number of sources as follows.

Element	Half life	Half life unit	Comparative composition parts per million
Uranium 235	740.00	million yrs	0.10
Uranium 238	4.47	billion years	1.40
Thorium 232	14.10	billion years	6.00
Potasium 40	1.27	billion years	360.00

As potassium 40 predominates, the half-life of the radioactive Earth is about 1.25 billion years, with the result that the present radioactivity represents less than 6% of the original amount at the time the Earth was formed. If the Earth was in thermal equilibrium, and given that plate tectonics is currently responsible for 90% of the Earth's cooling, then in the Archean age there would have been many more tectonic plates than the 12 or so we now observe on Earth. The plate margins would have been important sources of life at this stage. This is confirmed by the rates of contental growth. Some 3 billion years ago, continents had grown to 20% of their current size. By 1.5 billion years ago they were 80% their current size, creating new ecological niches for Gaian life to occupy.

[29] This is the "iron-sulphur world" theory of Gunter Wächterhäuser, where hydrothermal black-smokers establish the conditions necessary for the synthesis of acetic acid, which seems to be the central core of all biological processes. Each black smoker would act like a single cell, with the evolution of bacterial membranes being a means for chemical communication between them. This is similar to the origins of the "blood-music" approach to neuropeptides being the chemical basis for Gaian functioning developed below.

[30] This "edge of criticality" was also discovered by the ancient architects of the first civilised state. In ancient Egypt, the building of pyramids without mortar, essentially big piles of sand, meant that in the case of the

Pyramid of Maidun, built for Pharaoh Snofru, the angle of criticality was exceeded and the pyramid collapsed. The second pyramid of the Pharaoh at Darshur was immediately modified and the angle of its construction was reduced to below a sub-critical angle. What was learned was then incorporated into what is still the largest construction of humankind, the Great Pyramid of Snofru's son, Khufu, who was known to the Greeks as Cheops. And as a result, this represents the only one of the seven wonders of the ancient world that still stands today. These facts demonstrate another characteristic of complexity.

[31] Theia was the mother of Selene, Greek Goddess of the moon. The name has been given to an early protoplanet that is thought to have developed at the L4 or L5 Lagrange points of the Earth's orbit with the sun. As it grew larger, gravitational perturbations between Theia and the proto-Earth would have swung Theia towards the Earth like a pendulum, eventually striking a glancing blow at a fairly low velocity. The blow was enough to destroy Theia, whose core fused with that of the Earth, Theia's and some of the Earth's mantle was flung into space, eventually coalescing about 4.533 billion years ago, just outside the Roche limit as our moon.

[32] i.e. the Earth is estimated to be about 4.56717 "billion", or 4.567×10^9 years old. The oldest minerals yet found on the surface of the Earth are single zircon crystals that are found in younger sedimentary rocks from Western Australia. They have been dated by radioactive methods to have an age of as much as 4.404 billion years. Zircons are grown under water and water is essential to life so the Earth must have had this pre-requisite for life by this early stage.

[33] http://www.eco-action.org/dt/krill.html

[34] http://www.newscientist.com/channel/earth/mg19125614.600-ozone-hole-alters-antarctic-sea-life.html

[35] Reich, Paul; Hari Eswaran and Fred Beinroth "Global Dimensions of Vulnerability to Wind and Water Erosion" (Natural Resources Conservation Service)
http://soils.usda.gov/use/worldsoils/landdeg/papers/ersnpaper.html

[36] *The Poisoned Womb: human reproduction in a polluted world* by John Elkington (1985, Viking, UK) *and Our Stolen Future* by Theo Colborn, Dianne Dumanoski and John Peterson Myers (1995, Abacus, London) provide a good explanation of the dangers involved.

[37] Cytokinins have been found in regulating cell division in both insects (Drosophila) and in mammals. They appear everywhere in the regulation of growth.

[38] Abcissic Acid is "a key signal compound that regulates stomatal aperture and, in concert with other plant signaling compounds, is implicated in mediating responses to pathogens and wounding. In seeds, ABA promotes seed development, embryo maturation, synthesis of storage products (proteins and lipids), desiccation tolerance, is involved in maintenance of dormancy (inhibition of germination), and apoptosis (*Zeevaart and Creelman, 1988; Davies and Jones, 1991; Thomas, 1993; Bethke et al 1999*)." from http://www.abscisicacid.com/whatis_aba.htm 22 June 2002

[39] Anthony Huxley (1974) p76.

[40] A good explanation of the biochemical function of auxins is found at http://www.plant-hormones.bbsrc.ac.uk/education/Kena.htm 22 June 2002. Auxins are also regulators of growth in animals too, and excreted in urine.

[41] John King (1997) *Reaching for the Sun, How Plants Work* (p.3) has an excellent illustration of this process

[42] For research into the importance of the way the "biosphere is a fundamental component in the weathering of framework silicates. Plants, bacteria, fungi, even mammals, excrete organic waste products that can react with the components of their surrounding geologic materials.Organic acids from the biosphere have been implicated as important reactants in a number of weathering environments. Organic acids may accelerate silicate dissolution, increase silicate solubility, mobilize aluminum and silica, and alter the equilibrium between the solution and the precipitated secondary phases" see *Research in Sillicate Dissolution Kinetics* by Wan-Joo Choi and Phil Bennett, at http://www.geo.utexas.edu/chemhydro/dissolution_kinetics/ 24 June 2002

[43] Built from isoprene, terpenes include phytol (Vitamin A1) and carotene (Provitamin A1) essential in human and animal life too.

[44] John King (1997) op cit p.169

[45] "Mycorrhiza-bacteria biofilms associated with tree roots: genomic diversity, cellular structure and role in soil nutrient cycling and plant growth" by Robin Sen http://www.biocenter.helsinki.fi/groups/sen/sen.html 17 June 2002

[46] Polyphenyl chelates also appear to be involved in accessing iron (ferric) ions and making them biologically active. In this way the chelates of humus are the source, ultimately of the iron we find in our blood. Bloodmusic once again, as soil humus literally here gives rise to the humours of our body, and thus preserves our capacity for a sense of humour.

[47] *"Modelling Eddy Formations In Coastal Waters: A Comparison Between Model Capabilities"* by Duncan Galloway, Eric Wolanski and Brian King http://www.aims.gov.au/ibm/reports/asce/asce95dg.html 17 June 2002

[48] *"Spectacular Conception"* by Peter Taylor, for National Wildlife. http://www.nwf.org/nationalwildlife/2000/specon00.html 17 June 2002

[49] High levels of oestradiol have been found amongst women with a high risk of breast cancer. It seems to be linked with a chemical message in humans that encourages cell growth and division. See T. J. Kay *Serum oestradiol and breast cancer risk* http://journals.endocrinology.org/erc/006/erc0060175.htm 21 June 2002

[50] A good beginning for an understanding of the special nature of water in bloodmusic is Philip Ball (1999) H20: a biography of water Weidenfield and Nicholson.

[51] The dilipid mycele coascervates formed from these processes seem to have created the first cell membranes. The Russian biochemist A.I. Oparin, used the early creation of bloodmusic coascervates to explain the origins of life on earth.

[52] Michael Andrews 1976 *The Life that Lives on Man* Arrow Books UK

[53] Coccolithophorids seem concentrated in areas where warm and cold saltwater currents meet, bringing bicarbonates from root weathering of granitic soils into contact with upwelling currents of deep ocean nutrients. It seems that these areas, in the North Atlantic and Pacific, and in the Southern Oceans near South America and South Africa, are the locations for the genesis of frontal rain systems in both the northern and southern hemispheres. Bloodmusic in this way is here driving the weather systems of the world.

[54] *"DMS production in a coccolithophorid bloom: evidence for the importance of dinoflagellate DMSP lyases"* byMichael Steinke, Gill Malin, Stephen D. Archer, Peter H. Burkill, Peter S. Liss http://www.int-res.com/abstracts/ame/v26/n3/p259-270.html 17 June 2002

[55] There are 5,500,000 Ekajoules (1 EJ = 10^{18} J) of energy received by the earth yearly from the sun (equivalent to one Hiroshima per day per square mile), and over the course of geological history this figure has grown by over 40%. Of this some 2,000 Ekajoules (0.16%) are captured by photosynthesis and used to power the bloodmusic. However with 50% of the rainfall of rainforests being biologically modulated, and all the oceanic rainfail due to the coccolithophorids, the systems of energy transport of the weather itself seems also due to bloodmusic. It is no accident that the Intertropical convergence and the genesis of frontal weather systems, responsible for 90% of the world's rainfall comes from these areas. Clouds reflect over 22% of the sun's heat (342 Watts per square metre), keeping the earth at this critical temperature for the maintenance of liquid water.

[56] Up to half of the rain in rainforests is arbrogenic – produced by the trees through evapotranspiration of the trees leaves. This is why clearing forests always produces a drop in rainfall. See http://www.enfo.ie/Library/bs/bs26.htm 20 June 2002 for further information.

[57] Called the Keeting curve, after the scientist who since 1950 has been studying the phenomenon, the curve measures the world-wide build up in carbon dioxide every northern winter, and its reduction with the northern spring, as trees in the northern forests start reducing the carbon dioxide to sugars and starches. For a good

understanding of the Greenhouse effect throughout history check out *The Greenhouse Effect, Global Warming, and Pittsburgh* by F. Michael Read at http://www.chatham.edu/pti/Pgh_Env_History/Real01.htm 20 June 2002

[58] Life should have come to an end on the earth with the ultimate photodissociation of water into gaseous hydrogen and oxygen, by solar ultraviolet light billions of years ago, as was the fate of the water molecules originally part of Martian and Venusian atmospheres. If life did not become extinct from this mechanism, it should have ended with the burial of all dissolved phosphates in the deep oceans, dissolved out of rocks and carried from the soils by the process of erosion. Bloodmusic found answers to both problems. Photosynthesis created an oxygen atmosphere, which from 2.2 billion years ago accumulated an ozone screen which prevented the dissociation of water. Evaporated from the oceans, the water condenses on the supluric acid droplets of coccolithophorid dimethyl sulphides and suphurated molecules of rainforests to condense and fall as rain, beneath the stratospheric shield of ozone. This water, combined in olivine basalts at the mid ocean ridges, lowers the melting point of the rocks and lubricates the plate tectonic movements, which through mountain-building orogeny returns phosphates to the tops of mountains and allows life to continue. Bloodmusic in this way drives the planetary processes that make continued life possible.

[59] Based upon the size of the area of the brain devoted to scent, the dog's ability to detect differences in odour is about ten million times better than ours. Humans are largely "odour blind" by comparison.

[60] For an excellent introduction to the complexities of the ant's world see Erich Hoyt's *The Earth Dwellers: adventures in the land of the ants* 1998, Mainstream Publishing, Edinburgh UK Erich Hoyt (1998) *The Earth Dwellers: adventures in the land of the Ants* Mainstream Publishing

[61] Erich Hoyt (1998) op cit p 62

[62] Erich Hoyt (1998) op cit p.65

[63] An introduction to pheromones in insects, other animals and humans is contained at http://www.ultranet.com/~jkimball/BiologyPages/P/Pheromones.html 20 June 2002

[64] Neeraja Sankaran *The Science Of Sex: What Is It And Who's Doing It?* in "The Scientist" Volume 8, No 6, 1994 speaks of the chemical signals and the ability to detect them for humans. Male androsterones are currently being marketed as a natural aphrodisiac! Such is the ability of the modern industrial system to abuse the natural chemical language we are born with!

[65] For an understanding of the basics of the developing field of socio-psycho-neuro-endochrino-immunology see Black PH: *Psychoneuroimmunology: Brain and Immunity*. Scientific American (Science & Medicine) Nov.Dec. 1995, 16-25, *Psychoneuroimmunology* by Ader R, Felten DL, Cohen N Eds. Academic Press CA, 1991, pp 1-1218

[66] Nanobes in Australia have been reported by Philippa Unwins, Richard Webb and Anthony Taylor of the University of Queensland in *Novel Nano-Organisms from Australian Sandstones* in American Minerologist (1990) Vol 83 pp. 1541-1550

[67] Bruce Chatwin (1988) *Songlines*, Penguin Books, Harmondsworth UK

[68] *The Poisoned Womb: human reproduction in a polluted world* by John Elkington (1985, Viking, UK) *and Our Stolen Future* by Theo Colborn, Dianne Dumanoski and John Peterson Myers (1995, Abacus, London) provide a good explanation of the dangers involved.

[69] The International Union for the Conservation of Nature has reported that "recent calculations by leading scientists put it at between 1,000 and 10,000 times greater than it would naturally be. The rate of extinction also appears to be increasing." http://www.iucn.org/info_and_news/press/species2000.html 19 June 2002. Given that the rate of extinction in 1900 has been estimated by Norman Myers (1987) to have been 1 species per year (*Gaia Atlas of Planet Management*, Gaia Books London), it appears that the rate of extinction over the course of the 20th century was doubling every 6-10 years. It is clear, as Richard Leakey has shown, that we are creating the "sixth extinction" of life on the planet (Richard Leakey and Roger Lewin, (1995) *The Sixth Extinction:*

biodiversity and its survival Pheonix, Weidenfield and Nicholson, London). Ultimately, at such a rate, it is questionable whether we ourselves can survive.

[70] The evolution of social behaviour, part of the emotionality of McLean's "triune mind", seems to have been associated with the evolutionary appearance of the earliest mammals. Mammalian infant's dependence upon "mothers" created the possibility of emotional bonds of larger social groups. The signalling systems of Macaque monkeys for eagles, snakes and leopards suggests that environmental information of advantage to a social group can be shared in such a way as to increase the chances of survival of each member.

[71] Arnold Toynbee in his monumental *Study of History* considered there to have been 26 separate civilisations since the building of the first cities on the plains of Sumer in southern Iraq. Of these most today have passed away, as the hierarchically stratified systems of civilisations historically have proven to be unsustainable for longer than about 1-2,000 years.

[72] The Vina Sutta of the Pali Canon Samyutta Nikaya speaks about a king who has never before heard the sound of the Lute and "is delighted, so tantalized, so intoxicated, so ravished, so enthralled" by the sound that he asks his chief minister to fetch him the sound. When the lute is produced, the monarch "would say, 'Enough of your lute. Fetch me just the sound.' Then they would say, 'This lute, sire, is made of numerous components, a great many components. It's through the activity of numerous components that it sounds: that is, in dependence on the body, the skin, the neck, the frame, the strings, the bridge, and the appropriate human effort. Thus it is that this lute -- made of numerous components, a great many components -- sounds through the activity of numerous components.'" so it is with any of us in the realm of bloodmusic. See http://www.sacred-texts.com/bud/sam/sn35-205.htm 22 June 2002.

[73] Naess, Arne

[74] Leopold, Aldo