Klaus Illum, June 2014

An essay on the anthropogenetic mutations in Gaia

> I consider the Earth to be a super-organism and that its proper study should be by physiology.
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> James Hutton, 1789

> During his visit to the UNU, James Lovelock spoke of the evolution of the Earth and of the living organisms that inhabit it, and how these led to the Gaia theory. He also recounted the current scientific problems of biodiversity and climate change from the perspective of the Gaian view.
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> Re: *The Evolving Gaia Theory*, paper presented by James Lovelock at the United Nations University, Tokyo, 1992.

The process of the biological evolution of plants, insects and animals in the course of billions of years from the original organic soup of bacteria and algae is incomprehensible. It is unimaginable how the original organic cells organized themselves into genes which controlled the construction of extremely complicated organic structures such as, for example, dinosaurs: Animals equipped with muscles attached to the spine and the other bones of the skeleton and controlled by the nervous systems of their brains. Superb pieces of engineering powered through blood vessels by the even more complex digestive system, in which chemical conversion and transmission takes place in the stomach, the guts, the kidneys and the liver. Hundreds of millions of years after such vertebrates appeared on Earth our species came into being: the upright walking and running naked Homo Sapiens with hands and a brain capable of making artefacts and creating art, of communication of thoughts, ideas and feelings vocally, and of reflecting on our being in our Earthly environment.

The history of humanity - i.e. the history of the ephemeral anthropogenic era of life on earth - is a history of changes in the conditions of life brought about by the human brain at an exponentially increasing rate, relatively slowly in the first fifty millennia or so after the exodus of our species from Africa, then at an explosive rate in the last few centuries.

This evolution is not biological. It is the unprecedented technological evolution of artefacts invented by human brains. In the same way as in biological evolution, each step in this evolution of human thoughts and ideas, manifested in technological inventions, had its specific preconditions in the previous successful 'mutations', which created the necessary intellectual and technological environment for possible successive inventions. However, unlike biological mutations, which are assumed to be entirely accidental, intellectual and technological 'mutations' are teleological. They have intent and purpose. Yet, the development of life on Earth brought about by human thoughts and inventions was unforeseeable whatever the intents and purposes.

Conceptual and technological achievements of the human brain

Reading history and the archaeology of prehistory backwards, one may observe the intellectual and technological preconditions for the changes of the human condition over the last 50 millennia or so and view the technical inventions which have changed the conditions of life on our planet as technological mutations in Gaia brought about by the human brain.

For example, the preconditions for the invention in the late 19th century of the most advanced abstractions ever created in the human brain, namely the concepts of 'energy' and 'entropy' as thermodynamic functions of the state of any simple system or composite system of any complexity, are found in the works of Joule, Carnot and Clapeyron in the first half of that century. The ideas of these ground-breaking scientists were inseparable from the technological development of the steam engine in the 18th century when James Watt improved the original Newcomen engine. This technological breakthrough depended in turn on the concept of pressure, in particular the atmospheric pressure demonstrated by Pascal's experiments in the 17th century, inspired by Toricelli's experiments and Galileo's discovery of gravity in the early 17th century, which gave rise to the idea of a finite atmosphere kept in place by gravity as against Descartes' idea of an 'ether' filling the universe.

Likewise, Newton could not have accomplished his breakthrough in mechanical physics in the late 17th century had he not mastered the arithmetic of the positional number system, which had as its precondition the invention of zero in India in the 10th century, and the new algebraic language invented by Vieta in the 16th century and further developed by Descartes together with its graphical representations in coordinate systems.

Already in the late Middle Ages the newly invented clockwork mechanisms divided days and nights into hours and minutes and became an essential precondition for the development of astronomy. Not only the clocks but also a multitude of other machines and instruments had cogwheels, big and small in their various forms, all invented in Europe in the early Middle Ages, as their basic rotating elements. In nature only the planets rotate. The invention of the wheel was an offspring of human imagination beyond imitation of a natural phenomenon. It brought about a technological revolution in the means of transportation. However, the invention of the cogwheel brought about a technological revolution with ramifications into all branches of technology, science and industry.

Modern man's music and literature also had their specific preconditions. Bach's and Handel's epoch-making music depends on the organ and wind instruments and Mozart and many other great composers could not have unfolded their geniuses without having all the instruments of the symphony orchestra at their disposal. And without the formal language of music - the notes written on the preprinted sheets of music - their works would have been lost to future generations. Thus, a host of different techniques invented and developed in previous centuries - many of them making use of cogwheels - enabled the great composers of the 17th, 18th and 19th

centuries to create music hitherto unheard of. And, of course, the prerequisite of the widespread ability to read and write learned papers, novels, poetry and music was Gutenberg's invention of the printing machine in the 15th century and -notably - the invention of paper in China around the first century BCE. By the 8th century the paper technology had spread to the Arab-Muslim world but it took another five centuries before it reached Europe. Without it the revolution in written communication brought about by Gutenberg's invention would not have taken place.

The most decisive precondition of the all-embracing changes in the human condition which took place in feudal Europe against a backdrop of decimating epidemics and wars is perhaps the invention of gunpowder for military use. Besides the immense increase in destructive power, the gunpowder technology changed the European environment and the course of technological development. Not only the mining and melting of iron ore for guns, canons and canon balls but also the construction of defence works against them and the building of the bigger, heavier ships needed to carry the heavy canons required huge amounts of wood and charcoal. As the ships were sunk in sea battles and storms at the same rate as they were built, the forests of Europe were felled at a faster rate than they grew. However, the environmental deterioration that followed was accompanied by scientific observations and experiments which laid the ground for the scientific revolution in the 17th century. In particular, Toricelli's discovery of vacuum in his search for an answer to the question why suction pumps in iron ore mines failed when the depth exceeded about 10 metres and Galileo's discovery of gravity as he studied the path of an iron canon ball were - as mentioned above - essential prerequisites of the idea of the atmosphere and atmospheric pressure, which together with the need to replace wood by coal created the environment of physical concepts and material needs in which the idea of the steam engine could be conceived.

The generic properties of the human brain

It is common knowledge and indicated by the name of the era that the intellectual roots of the Renaissance originate in the classical Greek tradition as recorded in the writings of the founding fathers of European literature, philosophy and science. These recordings were made possible by an awesome achievement of the human brain, namely the invention of the alphabetic writing system, based on the breakdown of the spoken language into a manageable number phonemes represented by written characters. This written Greek language was in place in the 5th century BCE, when Herodotos wrote his *Histories* and Homer's *Iliad* and *Odyssey* were recorded in writing. Its precursor was Sumerian Cuneiform, which dates back about 35 centuries to the Sumerian city states with their fortified cities, which depended for their food supplies on agriculture, invented some 4,000 years earlier.

Presumably, the anatomy of the human brain has not changed significantly since the emigration of our species from Africa about 50,000 years ago and its migration into Europe, Asia, Australia and the Americas in the following millennia. Otherwise there would have been significant differences in the brains of the various peoples who lived apart from one another for thousands of years under dramatically shifting climatic

conditions in the different regions of the world. However, the mental capacities - the faculties of language, imagination, memory and emotions - of the aborigines of Australia, who travelled along their songlines, are not inferior to those of the American Indians, the Europeans, the Eskimoes, the Japanese - whoever. It was not superior brains but the military superiority of their gunpowder powered weaponry that enabled the Europeans to conquer the world.

This is not to say that the differences in the cultural, behavioural, ethical and religious concepts among the peoples of the world are insignificant. In his book *The Master and his Emissary - The Divided Brain and the Making of the Western World* (2009), the psychiatrist Ian McGilchrist presents his thesis that while there are no signs of a significant evolution of the human brain since our species emigrated from Africa, our usage of these faculties, in particular the manner in which we develop faculties dominated by the left and the right cerebral hemisphere respectively, is strongly influenced by the cultural environment in which we grew up. The faculties of the human brain can be developed and used in may different ways.

Evolution as conceived by Darwin rules out the success of mutations which do not serve useful purposes under the actual circumstances but might prove useful in other future social and technological environments. Evolution is not teleological. Therefore, assuming that the anatomy and the functioning of the brain has not changed significantly since cave painting artists decorated European cave walls about 35,000 years ago, the complex functions of the Homo Sapiens brain must have been useful to individuals and tribal societies all over the Earth in these distant ages.

Communication in spoken language was undoubtedly useful. The languages of our distant forefathers were probably less advanced than the ancient Greek language of Homer and Herodotus but could easily have been more elaborate than the languages used in the social media of the present time. However, the generic properties of the brain required to communicate in a relatively primitive language (expressed in Chomsky's *transformational grammar theory* as the *deep structure* common to any language) appear to facilitate the communication in any language of any complexity also. Like the structure of a loom, which can be used for the making of simple uni-colour sheets of cloth as well as fanciful, artistic compositions of patterns drawn in many colours, the structures of the human brain required for communication in primitive languages also enable communication in any advanced language.

Obviously, not only the spoken language but all the intellectual faculties of the brain depend on memory and, especially before the invention of writing, the ability to remember experiences from the past, tactical plans for the immediate future and long-term strategies was of crucial importance for the survival of human beings. Cave paintings exhibit the artists' advanced ability to memorize the appearances of horses, rhinoceroses, mammoths and other animals. Surely, these people also memorized the configurations and movements of the stars on the firmament and the paths of the sun and the moon at the different times of the year. The conscious concept of time as against the unconscious instincts of migrating birds must have been one of the first

fundamental abstractions of the human brain.

It is not surprising that the mutations which fostered these mental abilities, essential in practice for the survival of our species, in turn made other mutations successful, mutations which created other cerebral faculties such as phantasy, aspiration, imitation, curiosity, empathy, logic, humour, metaphorical representation etc. which constitute humanity. In the same way - metaphorically speaking - as the invention of the basic structure of the loom gave rise to the fabrication of sails for boats, tents for portable shelter, as well as carpets and tapestries woven in coloured patterns.

Thus, it seems reasonable to assume that the complex structures of the Homo Sapiens brain were fully developed all over the Earth 35,000 years ago, perhaps even earlier, even though our distant forefathers' vocabularies probably did not comprise the naming of the faculties of the brain - words introduced much later by philosophers using the properties of their brains to reflect on the properties of our brains.

If that is the case, then several Mozarts must have turned up in the course of the many millennia, each of them having to make do with the human voice and primitive flutes and drums to unfold their unique geniuses; several Leonardo da Vincis must have performed their arts as cave-painters and inventors of various devices such as bow-and-arrow and the boomerang; and among a few Einsteins, short of paper and pencil and the algebraic language, one could have been the inventor of the crucible for copper, tin and bronze moulding techniques - no minor achievement.

Indeed, the evolution of Gaia during the last 35 millennia or so - Gaia meaning the entire body of human societies and their biological and physical environments as conceived by Lovelock - appears to be progressively influenced by technological mutations brought about by the human brain, mutations turning up as inventions which changed the human condition: the wheel, the taming of horses and oxen, canoes and boats, enhanced weaponry, and, well after the end of the last ice age, the invention and spreading of agriculture, the precondition for city states with magnificent castles and temples and other arts.

Prometheus unbound by the human brain

Thus, reading history forwards, we witness the evolution of Gaia in the anthropocene era. It is not a biological evolution brought about by advantageous mutations of our species' brains but rather an anthropogenic, technological evolution brought about by the unfolding of latent intellectual abilities embedded in the human brain as new intellectual and technological inventions facilitated hitherto restrained human capabilities. For example the restraints on the abilities of the great Greek geometers and mathematicians - Euclid, Archimedes, Erathostenes and others - to proceed into the realm of mathematical analysis because this progress had to await the invention of zero and thereupon the positional number system and the formal algebraic language. They paved the way but only after almost two millennia did the journey into modern mathematics gain momentum.

However, many historians do not acknowledge the invention of the steam engine and its symbiosis with coal as a technological mutation which in all respects determined the way ahead for human societies and their physical and biological environment. Coal was needed by the steam engine and the steam engine was needed for the mining of coal. Railways and steamships revolutionized the transport of people and goods. Without the coal-fired steam engine there would have been no Suez canal and no Panama canal. Moreover, the steam engine-powered industrial revolution created the technologies needed for the construction of diesel and petrol engines as soon as petroleum began to flow from the oil fields in Pennsylvania, Romania and Baku. The discovery of electromagnetism through the experiments of Galvani, Volta, Romagnosi and Örsted (late 18th and early 19th century) resulted in the concurrent technological mutation determining the development of human societies: the electrical transmission of power from coal-fired power stations.

Also the development of telecommunications by means of electrically transmitted signals in the 19th century and the early 20th century depended on the steam engine for the manufacturing and laying out of wires and cables. Notably, there would have been no transatlantic cables without steam engines in the cable factories and the steamships deployed to lay the cables out on the seabed. And the telegraph lines followed the railway lines.

The exponential coal-powered growth in all the fields of human activities, which began in the late 18th century - in agriculture, manufacturing, transportation, science and the arts - gave rise to the concurrent growth in the global population, firstly in Europe and America. In the oil-based economy of the 20th century the growth rate of the global population reached frightening heights.

The symbiosis of the oil industry and the motorcar and aeroplane industries together with the chemical and biochemical industries has profoundly changed and is still changing the physical environments of human societies. Concurrently, the inventions of wireless global telecommunication networks, computers, satellite-based global positioning systems, and robots have created an entirely new conceptual environment for the functioning of the human brain: the anthropogenic Gaia with the chrematistic global system of electronic money tranfers as its central nervous system.

It thus appears that the mental abilities embedded in the immensely complex neural structures of the human brain, originally serving the survival of tribes of hunters in challenging environments, turned out to be so powerful that the human intellect gave rise to technological mutations of Gaia, the entire body of life on earth; technological mutations which profoundly changed not only the human condition but the conditions of life for all the species of our planet's flora and fauna.

The human brain is not endowed with a divine ability to foresee the consequences of its ideas and inventions beyond the immediate advantages they yield under the current circumstances. Toricelli could not imagine that his demonstration of vacuum would have the invention of the steam engine as a result and Newcomen, the inventor of the

steam engine, and his contemporaries could not foresee that climate change would occur as a consequence of his invention. Today we are unable to envisage a future Gaia transformed by the rapidly ongoing transfer of the faculties of the human brain to computer networks and robots with huge electronic memories and extremely fast search machines.

We now believe that the evolution of our species has finally equipped us with brains which make us capable of understanding this evolution. Yet, the evolution of our brains may not have provided us with the divine capability of understanding ourselves - whatever understanding may mean in this context.