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Evolution and alienation of Homo sapiens

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Abstract

Living systems are "multi-verses." They show at the same time apparently contradictory features, such as continuity and discreteness, chance and determinism, selection by the environment and according to internal rules. Rather unfortunately, life sciences students often tend to think in terms of antinomies and are therefore liable to build theories on one of the two choices of the dilemmas. For this reason, conflicting theories have sometimes been developed on the ground of the same experimental data. Since the early years of the twentieth century, and, in other terms also before, two opposite visions have been fighting in life science, namely: A mechanistic one, prevailing in the modern era, and the holistic approach, that is, the materialist version of the spiritualist paradigms of the nineteenth century, based on theories dealing with the so-called complex systems.

1. The dynamics of the discussion between opposite conceptions of life: the problem of the "pair of glasses"

The choice of the preferred paradigm has often been influenced by the cultural environment of the times, due to the close interaction between biological data and the self-conceptions of humans, scientists included. It is not by chance that the mechanistic conception and its paradigms have been flourishing in an era when, as we shall see later, the goal of human societies was to optimize the world as if it were a machine. Complex systems theories, however, although anticipated in physics by the work of Poincaré, became new disciplines only after the pioneering data by Lorenz (1963), a meteorologist who found that climate dynamics is not deterministic but intrinsically partially unpredictable, thus challenging the vision of the planet as a machine. It should be mentioned here that the new conception born within physics was introduced only later in the life sciences, S.J.Gould and N. Eldredge being the first to openly apply it to evolutionary processes in the seventies, challenging the mechanicist, neo-darwinist "modern synthesis," and particularly its population genetics version. This "delay" has been probably caused by the diffused resistance of human societies to change from the "Prometean paradigm" developed during the period of industrial revolution. It is however worth noticing that the deep roots in human cultures of this optimistic conception were not universal in the twentieth century, and "heretic" scientists have always been present and offering different "pairs of glasses," often derived from their personal cultures and human experiences – and not necessarily coherent with the prevailing way of looking at living systems.

An interesting example of the influence of cultural traditions and, within them, of religion on the scientific approach is offered by the behaviour of three scientists of different cultural backgrounds who, in 1965, received the Nobel prize for the discovery of the dynamics of the first gene regulatory system in bacteria, namely, the famous *lac-operon,* studied in the laboratory of André Lwoff by himself, François Jacob and Jacques Monod. Rather amazingly, although they had been working together on the discovery of the *lac-operon* and were good friends as far as we know, the general conceptions they extracted from their experimental data were strikingly different. Jacques Monod, in his famous book *Le hazard et la nécessité* [1] gave a very clear picture of his conception of life. In his opinion, every organism was built following an invariant project (he could easily have called it "a program") without any interaction with the environment and the context in general:

> *One of the most relevant features of all living systems is to be objects endowed with a project. We should also say that living beings differ from the structure of whatever other system in the Universe because of this feature which we may call teleonomy[...] The structure of a living being is the result of a totally different process as it does not owe anything to the action of external forces, owing everything to morphogenetic interactions internal to itself[...] The structure [...] can be therefore autonomously and spontaneously realized without external contributions, without new information: its epigenetic construction therefore is not a creation but a revelation.*

Moreover, Jacques Monod built something very similar to an ideology when he stated that the organisation of living beings was rendered possible by the transmission from one generation to another of invariant information, devoid of possible mistakes, contained in DNA according to the "central dogma of molecular DNA" proposed by Francis Crick in 1958 [2] – to be transcribed into RNA and translated into proteins (the tools of lives):

> *A third relevant feature of these objects [is] to be able to reproduce and transfer –- ne varietur -– the information needed for their structure[...] wholly conserved from one generation to another. We shall call this property "invariant reproduction," or simply invariance. [...] We can today deduce its general law, [which is] that of chance [...] Chance is tapped, conserved and reproduced through the mechanism of invariance and transformed in order, rule, necessity. [...] The whole system is therefore wholly conservative, closed in itself, and absolutely unable to receive instructions from the outer world. As we can see, because of its properties and its microscopic behaviour establishing an one-way relationship between DNA and proteins, it defies any "dialectical" explanation. It is fundamentally Cartesian and not Hegelian: the cell is really a machine.*

This conception was fully coherent with that emerging from the data obtained by Mendel, a physicist near to the so-called "medical materialists," who wrote in 1847 a manifesto stating the total equivalence of living and non-living systems. Mendel's conclusions from his experiments with peas were that characters were fully determined by factors (*anlagen*) independent from one another, not influenced by the environment and randomly assorted at every generation. At the very beginning of the twentieth century, Hardy and Weinberg extrapolated this conception to populations, thus founding the new discipline of "population genetics," the background of the "modern synthesis." The main principles of this new theory of evolution, in its orthodox version proposed by R.A Fisher, were: (a) continuous change in time of the relative frequencies of discrete alternative events (*alleles*); (b) random mutations and recombination events; (c) random drift; (d) natural selection; (e) genotypes as additions of independent genes and alleles as units of evolution; and (f) full determination of the phenotype by the genotype. Therefore, in spite of the title of the book, "The modern synthesis", by Julian Huxley [3], this is not really a synthesis, but rather an explanation of evolution as the result of the addition of alternative processes (total randomness/total determinism, and continuity/discreteness) – a conception challenged by several authors including the writer of this review [4] and the other two discoverers of the *lac operon*.

It should be recalled that in 1970, when Jacques Monod wrote his book on "Chance and necessity," the structure of DNA and the "Central Dogma of molecular Biology" had been published in 1953 [1] opening the way to the *informational metaphor*. At this point, the mechanistic vision of life seemed to have been winning, the introduction of the word "dogma" excluding any further change in the key concepts of life, thus fully confirming the Cartesian view of equivalence of living systems to machines. That was not the opinion however of the other two winners of the 1965 Nobel prize. André Lwoff, in 1963, for instance wrote [5]:

> *An organism is an integrated system of interdependent structures and functions. An organism is constituted of cells, and a cell consists of molecules which must work in harmony. Each molecule must know what the others are doing. Each one must be capable of receiving messages and must be sufficiently disciplined to obey them. You are familiar with the laws which control regulation. You know how our ideas have developed and how the most harmonious and sound of them have been fused into a conceptual whole which is the very foundation of biology and confers its unity [...] It is clear, on the other hand, that the expression of the genetic material is subject to external influences. Ten years ago it still seemed possible that in certain processes such as the induced biosynthesis of enzymes or of antibodies, the presence of specific compounds could modify the synthesis of proteins, mold their configurations, and hence alter their properties. What the study of regulatory circuits has shown is that the compounds in question serve only as simple stimuli: they act as signals to initiate a synthesis whose mechanism and final product remain entirely determined by the nucleotide sequence of the DNA. If the nucleic message may be compared with the text of a book, the regulatory network determines which pages are to be read at any given time.*

And, still A. Lwoff, in 1960 [6]:

The living organism is an integrated system of macromolecular structures and functions able to reproduce its kind. Waves and particles are the complementary aspects of the atom. Structures and functions are the complementary aspects of the organism. Separated from its context – that is, extracted from the cell – any structure, either a nucleic acid or a protein, is just an organic molecule. Such a thing as living substance or living matter does not exist. Life can only be the apanage of the organism as a whole. Only organisms are alive.

François Jacob had a very similar position and wrote a book as famous as that by Monod, whose title was, certainly not by chance, "The logic of life," showing a completely different way of thinking from that of his Cartesian friend. Just to give an example of it, we quote the following passage [7]:

Every living being, says Goethe, has in itself the reason of its existence: all the parts react one with another [...] therefore, every animal is physiologically perfect. Living organisms are subject to different influences by non-living objects and other living beings [...] To cope with those actions an equal and opposite action is needed [...] In comparative anatomy, a fragment is not anymore an isolated element: it is a sign of the organization of the whole [...] the relative relevance of an organ is measured through the constraints that it imposes on the others [...] and everything is allowed as far as variation is concerned: only combinations satisfying functional needs of life are allowed. Life is the product of an always unstable equilibrium between living beings; it is a play of interactions of organisms and environment, the dialectic of the same and the different within a unitary history of nature [...] Transformism is a causal theory of the origin of species, of their variation and parenthood.

It is not the matter which evolves but rather the organization, the unit of emergence always capable to unite with other similar unities to become integrated in a system. The position of François Jacob was very similar to that of Steven Jay Gould, also him jewish – a paleontologist who was probably the first student of life sciences to openly join the discussion on complex systems, first introduced, as already mentioned, by physicists. He wrote [7]:

Complexity theory can help us understand why prediction is so difficult. For one thing, management is not a science like physics or astronomy, where you have complete predictability. I can tell you to the minute when the next eclipse is going to occur, because it's a simple system with limited interactions. I can't tell you where human evolution is going. Also, the mathematical analysis of complex systems – systems composed of multiple, independent parts – shows that a small perturbation can produce profound effects, because of the way it cascades through the nonlinear interactions of the system. If you then add a little bit of randomness you get profound and unpredictable effects. The world is too complex to be in continuous flux in all its parts. If you have continuous flux in every part of a system, how are you ever going to get integrated, complex systems? [...] With the Darwinian theory, there's no notion of general advance. There is adaptation to a changing environment. Darwinian theory is about constant local improvement, and since environments are always changing, especially given technological progress, there always has to be flexibility for adaptation.

The principles of the new way of approaching the study of the life sciences proposed by Gould opened the way to the construction of a theory of evolution based on most of the main concepts present in the original work by Charles Darwin, with the exception of the continuous character of evolutionary change. Such a theory was indeed developed by S.J. Gould and N. Eldredge and is called the theory of "punctuated equilibria," suggesting the alternation during evolution of periods of "stasis" with others of fast accelerations of change determined by the abrupt modification of living networks caused by mutations in key components ("hubs") of the systems. This concept was partially derived from the experiments by an earlier "heretic," again of jewish origins, Richard Goldschmidt, quoted here by Gould [8]:

> *Goldschmidt raised no objection to the standard accounts of microevolution; he devoted the first half of his major work, "The Material Basis of Evolution" [9], to gradual and continuous change within species. He broke sharply with the synthetic theory, however, in arguing that new species arise abruptly by discontinuous variation, or macro-mutation. He admitted that the vast majority of macro-mutations could only be viewed as disastrous – these he called "monsters." But, Goldschmidt continued, every once in a while a macro-mutation might, by sheer good fortune, adapt an organism to a new mode of life, a "hopeful monster" in his terminology. Macroevolution proceeds by the rare success of these hopeful monsters, not by an accumulation of small changes within populations [...]*

As a Darwinian, I wish to defend Goldschmidt's postulate that macroevolution is not simply microevolution extrapolated, and that major structural transitions can occur rapidly without a smooth series of intermediate stages. I shall proceed by discussing three questions: (1) Can a reasonable story of continuous change be constructed for all macro-evolutionary events? My answer shall be no; (2) Are theories of abrupt change inherently anti-Darwinian? I shall argue that some are and some aren't; and finally, (3) Do Goldschmidt's hopeful monsters represent the archetype of apostasy from Darwinism, as his critics have long maintained?

Though he cited examples drawn from work on mutable genes in Drosophila and other organisms, prominent among Goldschmidt's remarks are several glowing mentions of McClintock's description of the Ac/Ds system in maize. For Goldschmidt, transposable elements provided a shining example of position effects and a dynamic genome. He referred to transposable elements as "invisible" (i.e., submicroscopic) rearrangements and position effects. To his full satisfaction, McClintock had proved that in zea, "mutable loci are actually position effects produced by genetically controlled and repeating transpositions and translocations" [10] and wrote: "The author agrees with Goldschmidt that it is not possible to arrive at any clear understanding of the nature of a gene, or the nature of a change in a gene, from mutational evidence alone" [11].

McClintock also invoked Goldschmidt in her conclusion: "Evidence, derived from Drosophila experimentation, of the influences of various known modifiers on expression of phenotypic characters has led Goldschmidt [9, 10] to conclusions that are essentially similar to those given here" [11]. Nowadays the basic concepts of punctuated equilibria in the evolution of complex living systems have been confirmed by a large amount of data on the acceleration of genome changes [12]. We know now that internal stresses induced by abrupt changes in one or few components of one level of the hierarchical organization of living systems, as well as external ones, may cause "butterfly" effects liable to be transmitted from molecules to the biosphere and back. This dynamic process of change may lead either to the destruction of the systems or to genome shuffling processes and an acceleration of the evolution of the affected networks. These concepts are now fully supported by the genetic and molecular studies of the last decade and are part of a new vision of life, based also on new disciplines such as epigenetics and mathematical/computational methods for the study of complex biological system.

We know now that the first consequence of the stress induced by the modification of the system is a burst of genetic variability in bacteria and complex genome shuffling processes in eukaryotes. Therefore, several different events can accelerate evolution, such as for instance: (a) mutations in pleiotropic genes; (b) horizontal transfer; (c) interspecific hybridization; (d) response to external stress; (d) dragging mutations, meaning by this the acceleration of change due to positive selection of a single or few genes highly connected with others leading to a positive re-arrangement of a large part of the genome.

Obviously, the change from a fully mechanistic theory prevalent in life sciences until the last decade of the twentieth century to a new, complex vision present also in other disciplines such as the pioneering physics, certainly modified also our vision of humanity itself and of human evolution. As I shall discuss later, the change of the "pair of glasses" has been due in the first place to the failure of the modern project of construction of a world totally humanized through an everlasting production of tools and machines and to the breakthrough of science in the field of complex systems. But certainly, students of life sciences have been influenced by the changing spirit of the times and in general by their cultures at all levels of the human hierarchical organisation, from families to communities, ethnic groups and therefore by ideologies and religions. For instance, as mentioned before, an example of the effects of cultural and religious traditions may be considered in what happened in Paris to the three winners of the same Nobel Prize obtained through joint experimental studies, but very different in the conceptions of life extracted from the data obtained. I already mentioned that two out of the three winners in 1963 were jewish and so were most of the scientists, mathematicians, physicists, and philosophers who built the theories of biological complex systems. Within them, geneticists like Goldschmidt [13], Lerner, Lewontin, palaeontologists like Gould, mathematicians like Mandelbrot, general biologists like S. Kauffmann, S. Rose, students of developmental biology such as S. Gilbert, M. Kirschner, neuroscientists like G. Edelmann, D. Amit, and phylosophers like Ben Jacob, E. Jablonka, E. Fox-Keller, H. Atlan [14], E. Morin, H. Jonas, all worked on a new vision of humanity perfectly coherent with the new current of thought and also with that of physicists like Prigogine and Stengers, M. Gell-Mann and many others.

But then, why jews? Can we develop the hypothesis of a specificity of the jewish religion and its practices liable to be transmitted generation to generation? Although, of course, such an hypothesis cannot be fully proven, there are specific concepts present in the jewish religion and, more than that, specific ways of looking at the living and not living matter, which may be at least worthy of a discussion. First of all, the jewish religion, although it has 613 *mitzvoth* (commandments), far from being dogmatic encourages the discussion, not only allowed but requested as a religious practice. The "pilpul", a method of disputation among rabbinical scholars aimed at the discussion and interpretation of the Talmudic rules and principles, involves the development of careful and often very subtle distinctions, the background of the living Torah, which according for instance to many scholars like Ephraim from Sedlikov, should be discussed and changed at every generation, thus discovering more and more of its infinite hidden meanings.

The jewish tradition, being living power, needs therefore study and decisions, and at the same time is always growing and developing from inside, as described by Gershon Scholem in his book on the fundamentals of Judaism [15, 16]. In that same book, Scholem also said that power and weakness of the tradition are interwoven, everything depending from the point of view of the observer. Investigating the Torah's "multiversity" and the practice of continuous discussions on its infinite "hidden truths," is in a sense analogous (although not homologous) to the methods used to study living systems, always "multiversed" and endowed at the same time with a wide number of only apparently conflicting features. In both cases single truths are not universal but change continuously, widening the knowledge and extracting from it previously hidden rules and concepts. This is exactly the opposite of the description of a machine completely determined by a simple and everlasting human project.

It is not by chance then that, although it has always been a matter of discussion, in the jewish tradition, science has often been considered one of the possible ways of the glorification of the creation and therefore of the Creator. Consequently, although the discussion on the interactions between science and faith is still open, in many cases in the jewish tradition the study of the sciences and particularly medicine has not only been approved but also suggested to the scholars, as did Rabbi Moshe ben Maimonides (Rambam; 1135-1204), who wrote several essays on medicine, many of which are included in the *Mishneh Torah,* coherently with the principle of the supreme value of life [17]. Indeed, the distinction between living ad non-living matter has always been very clear within the jewish tradition starting from *Bereshit* (Genesis) according to which the creation of plants has been in the third day, the animals appearing in the fifth and humans the sixth. The supremacy of humans has always been so relevant to allow the infringement of 610 out of the 613 commandments contained in the *Mishneh Torah*, when human life is in danger.

Also in the Talmud, human lives are considered to be by far the most important ones, although other living beings and particularly the animals were of utter relevance. It is said that "all the creatures constructed by the Earth derive both their soul and their body from the Earth with the exception of man whose soul derives from the sky, his body from the Earth" (Salm 82,6). And, "as the animals, man eats and drinks, procreates and dies, but as the angels hold himself upright, speaks, is intelligent and sees" (Gen., VIII,11). Although the animals are at a lower level than man, they should be therefore helped and nourished: "It is not allowed to buy an animal [...] without nourishing it" (Jeb, 14d). A man should not eat before nourishing the beast: "I shall give grass in your field for your animal and then you will eat" (Deut. XI,15).

2. The unique adaptation strategy of human hopeful monsters

As thoroughly discussed, the birth of Homo sapiens is not old at all in paleontological terms, and our ancestors left Africa probably not much more than 100.000 years ago. These data suggest a sudden acceleration of hominization and are supported by recent findings showing an accelerated change of less than a hundred genes whose expression has been found to be localized in the cortex of human brains. Nowadays our cortex contains 100 billion neurons liable to be connected in one million billions potential different combinations by synapses, quasi-random at birth, organized according to the reception of human signals but not of animal ones. The species-specific social role of human communication is supported by the fact that humans reared by wolves or other mammals are handicapped, probably deriving from the biased reception of non-human signals. It is reasonable to think that the first genes to be involved in the acceleration of change were sequences like microcephalin and ASPM involved in the growth of the cortex. Now the ratio between the size of the encephalus and the rest of the brain in humans is 7.4-7.8, the second and third species being the bottlenose dolphin (5.3) and the white-fronted capuchin (4.8).

The enlargement of the encephalus allowed an escalation of neuron numbers in the cortex, the differentiation of cortex areas, the spreading of the neuron-mirror system, and the configuration of comprehensive neurocognitive nets. It is worth noting that along with the aforementioned genes others have also accelerated their change [18]. Among them, the genes of the Fox P group, necessary for the construction of language and the consequent improvement of communication, and others allowing for fast neural connection plasticity, perception, high conductivity of cortical fibers, etc. It is worth noticing that, while the subdivision of our brains in relatively large different areas, each devoted to specific actions, can be considered as a part of embryo development and is controlled by a small number of genes; The fine network of synapses is largely directed by human signals received during pregnancy and in the first years after birth. Just to give an example of the relevance of the connection between mother and child during pregnancy, it is known that already at its beginning, the zygote sends messages to the hypothalamus of the mother receiving then the information needed for the organization of the hypothalamus in the embryo. Then, when this organ is formed, it will induce changes in the hormonal system of the mother leading to milk production. Moreover, after birth and during the whole life, the ever-changing organization of our neural networks, quasi-random at birth, mainly depends from human signals. These processes never end during our lives, although they are less and less effective with age. The reception of human signals organizing and changing continuously our brains not only during the first 2-4 years but throughout our lives, mainly through epigenetic processes is certainly not determined by our genes. All this evidence seems to suggest that at least a large part of our "humanity" is due to the "invention" of a very specific brain with a very high capacity to receive information from other members of our, but not other, species – to conserve and use it for the configuration of up to a million billions different neuronal combinations.

The exchange of human signals was also shown to be relevant for our species by a study where physical and social performances of 2.5 year old human children have been compared to those of chimpanzees of equivalent age. In this experiment, all kinds of performances were comparable between the two species with the exception of the capacity of receiving information from members of the same species, much higher in humans than in the primate counterparts. The exchange of information is probably the main reason for the "invention" by our species of a specific and original adaptation strategy, based not on the passive selection by the environment of the "best-adapted" individuals, but rather on the active production of projects of change of the environment aimed at rendering it adapted to our needs. This is why, although we are now more than seven billions, our genetic variability (measured as the number of gene variants present in our species) is much lower than that of the closest primates, and differences between human populations are so low that the term "race" has no biological meaning in our case.

Chimpanzees on the other hand are endowed with a much higher genetic variability, as their communities, living in different environments, have been exposed to differential selection, and the same happened with all living beings both under natural and human selection. Probably the best and clearer description of the differences between animals and humans is offered by the jewish philosopher Hans Jonas, who summarized and described with three metaphors the main features of humans, absent in all other living beings: images, tools, and graves.

Images are, for instance, those painted on the rocks by our ancestors, not photographic but "aesthetic," deriving from non-material projects constructed in the brain of the painter and projected onto the external matter of rocks, thus producing "humanized" versions of the objects observed. Moreover, our ancestors were already able to mould the external matter according to images (the projects) thus constructing "tools" to be used for the adaptation to our needs of the environment in which humans moved and settled. This allowed the construction of villages and towns but also the development of agricultures through the selection of plants and animals and the modification of ecosystems. The last but certainly not least capacity has been described by Jonas as "the grave," meaning by that the capacity to develop thoughts independent from the information coming from the exterior in terms of transcendence, philosophy and, in general, human culture and language. It is worth noticing here that all these capacities have been for a long time shared by four species of the genus *Homo*, namely ours, the *Neanderthalensis*, *Denisovianus* and the *Floresensis*, all capable of modelling caves, burying their dead in graves along with tools for a possible future life, and constructing aesthetic ornaments. Jonas developed this conception of humans in *"Organismus und Freiheit"* , from 1973 [19], a very important text on the differences between non-living and living systems, humans included, and certainly to be considered one of the best discussions ever of living complex systems, published only one year later to Gould and Eldredge's work on punctuated equilibria [8].

3. The two levels of alienation of Homo sapiens

The human-specific adaptation strategy just described has certainly allowed our species to become by far the most "generalised" in our planet, but also led to the development of the *"Prometean Utopia"* of modelling the whole planet according to human needs without any possible unintended interactions with the non-human living and non-living matter. Hans Jonas was fully aware of this problem and of the dangers deriving from the spirit of the Modern Era, and introduced his "imperative of responsibility" [20] – *Das Prinzip Verantwortung. Versuch einer Ethik für die technologische Zivilisation*, published in german in 1979 and in English in 1984 – where he asked the actors of change to try to predict not only the direct effects of their planned modifications but their interactions with the dynamical complex network in general, where they were going to be introduced. H. Jonas wrote:

> *Modern technology and its products spread all over the globe, their cumulative effects putatively reaching an unlimited number of future generations. What we do here and now, mostly only thinking about ourselves, affects in a massive way the lives of millions elsewhere and in the future, millions that did not have any say about our doings [...] We mortgage the future life for present short-term gains and needs (indeed needs we have mostly created ourselves). Perhaps we could not entirely avoid behaving like this or in a similar manner, but in that case we have to use extreme caution so that we operate in all fairness towards our descendants, namely, so that their capacity to pay back the mortgage is not compromised from the start[...] The crucial point here is the penetration of distant, future and global dimensions into our every-day worldly practical decisions in an ethical novum which technology has foisted upon us. The ethical category that above all is called into play is responsibility [...] This extended global view point connects the human good with the cause of life as a whole, instead of confronting it with hostility, and guarantees non-human life rights on its own.*

Unfortunately, this principle, by far stronger and more precise than the "precautionary principle," has not been followed by Homo sapiens, who on the contrary keeps acting according to the suggestions of the Modern era without even perceiving the possible dangers deriving from this behaviour. In other words, although contemporary life sciences changed the basic models and paradigms of living matter, the main goal to be reached by humans still seems to be the mechanical "humanization" of the whole world. One of the first examples of the application of the mechanistic view to living systems certainly has been the "green revolution," a world-wide project supported by The Food and Agriculture Organisation (F.A.O), whose aim was to obtain optimal plants and animals to be cultivated and bred throughout the whole world irrespective of the different environmental, social and economic conditions of the different contexts. Breeders were therefore taught to develop ideal projects of optimal plants and animals where the best features of every crop and breed were described one by one as if they were independent (the so-called Donald's ideo-type) and then to use cross-breeding and selection accordingly for the production of optimal future varieties and breeds.

The conception behind all this was that the ideal optimal plant or animal thus obtained, controlled by genes considered as non-interacting pieces of a living machine and putatively not subjected to environmental changes, could be sold and utilised everywhere in the world. Optimization meant therefore homogenization and destruction of extant "non-optimal" genetic variability and, contrary to Jonas's principle, no attention was given to possible negative unintended interactions between the genes of the plant and the different contexts, namely the agro-ecosystems, social systems included. The possible problems deriving from poor adaptation of the putative optimal *cultivars* were then tackled according to the same mechanistic ideology, through the usage of machines for the modification of soils together with chemical (fertilisers, pesticides, etc.) and energy inputs. These concepts have been applied particularly in developing countries, a number of centres of plant breeding have been installed in several of them under the direction of the F.A.O. and a very large number of new cultivars were introduced into the market. At the beginning, global food production in Asia and Latin America, Africa being left behind, increased. The number of undernourished people slowly decreased from 1980 until 1995, but increased again later on to more than one billion. Soon production costs started rising because of the need to counteract with hydraulic tools, chemistry and machines, the loss of natural resources in terms of fertile soil, ecosystems and genetic variability of the cultivars selected *in loco* by small farmers and substituted by the new ones selected in environments different from those where they had to be cultivated.

The overall result of the change from subsistence agricultures to industrial ones led to the loss, according to F.A.O., of 75% of domesticated plant and animal biodiversity, a treasure critical for human survival to be used to counteract environmental changes; and cultivated soils were as well reduced by desertification and the incredibly fast increase of towns, roads and other human constructions. All these problems derive from the total oblivion of the responsibility principle or, in other words, from the absence of evaluation of the effects of the green revolution on the complex networks of the agro-ecological systems stemming from the decision to reduce plant and animal variability to obtain single, optimal, homogeneous cultivars, and in general, of the conversion of traditional agricultures to industrial ones.

It is not by chance then that, one year after the beginning of the new increase of famine after the first positive performance of the "revolution", in 1996, the first *genetically modified plants* entered into the market after a long period of discussion, promote and advertised as putative "miracle plants," liable to fight famine again with a new mechanical tool, obtained through the translation of the optimization paradigm into molecular terms. Genes were again seen as independent entities liable to be transferred from one species to another without any unintended effect. Rather unfortunately, the new Promethean hope of winning the battle against famine with "wonderful living machines," led, since 1996, to the entrance into the market of only four GM species (soybean, maize, canola, cotton) modified only for two characters (resistance to insects or to herbicides) – many others being total failures because of a series of negative interactions between components of the hierarchy of networks of the agricultural systems from the plants to the ecosystems (see [12] for a recent review).

This unprecedented failure is the result of the unintended effects of highly unpredictable plant transformations due to the non-additive interactions of the sequences engineered with the host plant genome, those of the gene products and the plant metabolism, of the GM plant and the agro-ecosystem, the social traditions, and finally the market itself. Moreover, genetic engineers did not develop techniques allowing for the control of the number of copies of the DNA fragment inserted in the plant genome, nor for the position of the insertion putatively changing the activity of the pre-existing sequences, the possible synthesis of "fusion RNA" transcribed both from the insert and the sequences where insertion has occurred. An unitendended effect deriving from the lack of this knowledge has been shown by [21] in engineered MON810 maize plants where at least four unintended mRNAs were found, likely leading to the synthesis of brand new fusion polypeptides of unknown effects.

Moreover, the lack of control of the direct and indirect effects of the transformation led in many instances to unintended levels of productivity of transgenic cultivars and in general to features not accepted by the market. Even worst results have been obtained (unfortunately) also in the field of genetic engineering of human cells, where the goal was the development of gene therapy protocols, aimed at the substitution of a dangerous gene variant with a healthy one. In this case the reason of the failure was the unintended presence of DNA fragments introduced in tested animals in the blood circulation system and in all organs, inducing a high incidence of unwanted effects – see for instance [22].

Unfortunately, the negative effects of a mechanistic ideology on living beings in the case of genetic engineering is only the top of the iceberg if compared with damages influencing the whole planet such as the acceleration of the climate change in the last century and the beginning of the third millennium, although already forecasted by the *Club of Rome* and a number of far-sighted scientists and economists. It is rather sad that already seven years from the Millennium Climate Change assessment describing the dynamics and effects of the human-induced acceleration of greenhouse gases, no real world-wide agreement on the Kyoto protocol has been reached in spite of many meetings and discussions. Even sadder is the persistence of doubts on the climate change itself and the fact that anti-climate actions almost only concern mitigation (reduction of greenhouse gas) through the production of green machines while adaptation, that is, conservation of the resources, is almost forgotten, the reason being that in the first case industries and money exchange are more relevant than in the second.

Still, the official prevalent dogma keeps being that of the infinite growth of the industrial economy aiming at the total mechanization of the planet according to the concept of the substantial equivalence of living and non-living systems, or better still, machines, introduced by J.Monod and not by chance also used in the European GMOs risk-assessment protocols. All this in spite of the failure of the application to living beings of the mechanistic theory in plant and animal breeding, genetic engineering of animals, plants and humans, and also of the deadly transformation of the planet with man-made artifacts due to the unpredictable and unintended effects of the interactions of human/non-human components of the planet, as foreseen by physicists and biologists, particularly in the last ten years of the twentieth Century and in the first decade of the third millennium. As Jonas wrote [20]:

> *We have to admit that the problem of how the immense responsibility should be met, which the irresistible scientific technological progress places on the shoulders of both its practitioners and the public which enjoys or suffers from its gifts, is still completely unsolved, and the ways of solving it are hidden in darkness. Only the beginnings of a new consciousness, recently awakened from the euphoria of the big victories to the harsh daylight of the dangers, learning again to know fear and trembling, give us hope that we shall voluntarily impose on us the barriers of responsibility and not allow our power, which has grown so large, to finally overwhelm ourselves or those who will follow us.*

Not only Hans Jonas, but also many other philosophers like Edgar Morin [23], Gregory Bateson [24] and many others, warned that the infinite growth of production was a deadly dogma. Unfortunately, out of the three distinctive features of human beings proposed by Hans Jonas, Homo sapiens has been forgetting his capacity of transcendence and philosophy, and kept using imagination and construction of tools without considering the possible negative effects of their over-dosages. For this reason, far from abandoning the mechanistic equivalence of living and non-living matter, and accepting the concepts of complexity, the humans of the third millennium entered into a new phase of alienation, abandoning the human adaptation strategy based on the construction of useful tools and inventing a new virtual economy, or better, a metaphor of it, substituting the exchange of matter with the exchange of money and the dogma of infinite growth of human-made machines with that of infinite growth of money.

A paradigmatic example of the dynamics of this process is the behavior of the "three sisters" (Monsanto, Dupont and Syngenta), world-wide controllers of the GMO market and of a large part of agriculture, who almost stopped investments in research maintaining their leading position in the markets through incomes deriving from royalties and stock exchange operations. In spite of the lack of new genetically engineered plants, stock exchange quotations are increasing due to a series of scoops on the putative future production of wonder-GMOs capable to alleviate famine and lower cancer incidence in human populations, and on the widening of the market through agreements with formerly anti-GMO nations.

The behavior of the three GM sisters is only an example of the new virtual economy based on advertising agencies of all products, from cars to food and from stock exchange policies, instead of competition in the real markets. So, while in 1980 the amounts of nominal GDP and financial assets where respectively ten and twelve trillion dollars, in 2002 the ratio became 33/96 and since then the difference kept accelerating with an almost exponential speed leading, in 2007, to an incredible 56/196 and reducing nowadays the circulating money coming from exchange of matter to only 1/12th of the whole.

As everybody now knows, for this reason we are confronted with several contemporary crises, such as the climate crisis, the financial crisis and the crisis of production of real goods, as well as the destruction of "common goods" (air, water, soil, energy, food, communication and knowledge), and the market based on the equilibrium of classical economy between offer and demand is not acting anymore, competition being less and less on the value for life of goods and more and more on advertising of products.

Even what makes human adaptation strategy valuable, i.e. exchange of information, is being reduced by the substitution with two-dimensional gadgets of our four dimensional communication tools, including speech with its modulation capacity, the ever-changing movements of the body and the modification of our visages, etc. Substituting friends and enemies with tablets drastically reduces human connections and exchanges of information, thus modifying brain networks in an unprecedented way with yet unknown effects on the behaviour of human communities and their choices.

In Jonas's terms we are losing the capacity of creating "images," – painting, music, literature – all essential areas of communication between humans and happiness, because of their low virtual money output. We are at the same time forgetting that we should go on producing new and adaptive tools, badly needed also because of the human-induced climate change and the destruction of the environment.

Finally, we are also losing the "grave," that is the capacity of individual and collective introspection, and with this Jonas's responsibility imperative, completely useless in a world where only money as such is worth increasing. Inevitably this brings us to lose democracy itself, the result of living and communicating societies of humans and not only of stock exchange dealers. It is time to realize what is happening and to go back from the "Anthropocene" [25] and what I call the "Virtualcene," to real life, made of flesh, blood, connections with other humans and with the biosphere and its inhabitants, whose diversity is being lost at a hundred or thousand times faster pace than in all five earlier extinctions.

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