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Symbiosis and epigenetics: "bridges" for a unified biology?

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Symbiose et épigénétique : des « ponts » vers une biologie unifiée ?

Résumé

Pendant longtemps, l'accent a été mis sur l'acquisition de mutations aléatoires dans l'étude de l'évolution des espèces d'êtres vivants. Cet article cherche à étayer une conception unifiée de la biologie, en tenant compte d'un changement de paradigme épistémologique. Dans ce contexte, les relations d'association et de symbiose entre les espèces et l'épigénétique peuvent être les « ponts » pour étayer une telle conception. L'approche de la spécificité du comportement humain s'avère toutefois problématique en la matière. Notre espèce a développé des caractéristiques qui remettent en cause les équilibres homéostatiques de la nature, ce qui peut signifier un point de fracture par rapport à l'écologie restante.

Mots-clés : biologie, symbiose, épigénétique, écologie, humain

Simbiose e epigenética: "pontes" para uma biologia unificada?

Resumo

Durante muito tempo foi atribuída ênfase à aquisição de mutações aleatórias no estudo da evolução das espécies de seres vivos. Este artigo procura fundamentar uma conceção unificada de biologia, atendendo a uma mudança de paradigma epistemológico. Neste contexto, as relações de associação e de simbiose entre espécies e a epigenética podem ser as "pontes" para fundamentar tal conceção. No entanto, a abordagem à especificidade do comportamento humano revela-se problemática nesta matéria. A nossa espécie desenvolveu caraterísticas que colocam em causa os equilíbrios homeostáticos da natureza, o que pode significar um ponto de fratura em relação à restante ecologia.

Palavras-chave: biologia, simbiose, epigenética, ecologia, humano

Symbiosis and epigenetics: "bridges" for a unified biology?

Abstract

Emphasis has for a long time been placed on the acquisition of random mutations in the study of the evolution of living species. This study seeks to justify a unified theory of biology, taking into account an epistemological paradigm shift. In this context, relations of association and symbiosis between species and epigenetics may be the 'bridges' to justify such concept. However, the approach to the specificity of human behaviour proves to be a problem on this matter. Our species has developed characteristics that call into question the homeostatic balances of nature, which can pose a divide in relation to the rest of ecology.

Keywords: biology, symbiosis, epigenetics, ecology, human

Introduction

In the wake of Charles Darwin's theory of evolution of species and Gregor Mendel's work on hereditary genetics, scientific literature in the area of ecology has long emphasised studies on the acquisition of random mutations as determining mechanisms in the process of natural selection of living species (Maia, 2017).

However, for some decades now this perspective has been complemented by research developed by authors who highlight the influence of association relations and symbiosis between species in the acquisition of characteristics by individuals of a given species. This type of relations paves the way for the foundation of a unified theory of biology. Therefore, the first aim of this study is to demonstrate the plausibility of this theory by addressing association relations between species based on the works of authors such as Lynn Margulis (1991). This concerns a trans-disciplinary turn in the epistemology of ecology studies towards an eminently post-anthropocentric view of life and the world. In this regard, the theoretical approaches of Humberto Maturana and Francisco Varela (1980), that dealt with the theory of autopoetic machines, of Bruno Latour (2009), with the actor-network theory, or even of Rosi Braidotti (2015), with the theory of 'zoe', can also provide important contributions to justify the theory in question. In the same vein, we note the studies on the human epigenome that highlight the influence of environmental and social factors on body functioning. The specificity of the human nevertheless raises other types of problems. As part of the second objective of this study, this text problematises the unified theory of biology through the specificity of human behaviour. As stressed by philosopher Michel Serres (2008, 2004), when compared to other living species the human being has an incredible ability to manipulate and change its own body and the environment. Technologies are even being developed, which

will be discussed below, aiming at appropriating and controlling, on the part of the human being, symbiotic relationships between species as well as the control of the human epigenome. This is done within the framework of a social and economic system, currently capitalist in nature, which aims to profit from the application of these technologies. As such, the problems arising from human action on nature will be explained, highlighting dilemmas that arise in terms of bioethics.

Our final observations admit that the foundation of the unified theory of biology in an evolutionist logic that has taken place over a fairly long period of time is plausible. However, one thing that comes into play is that the emergence of the human being and technological evolution it has undertaken may constitute differentiating factors and even be the cause of divides between long standing environmental and ecological balances.

1. Symbiosis relationships and epigenetics

Species relations based on phylogenetic nature have for a long time been a dominant paradigm in ecological studies. Neo-Darwinists have insisted that the accumulation of random mutations through natural selection is the major source of innovation in evolution, with these mutations passing from generation to generation through sexual reproduction. However, such an idea does not explain adaptive radiation phenomena in which an individual species evolves into many species living differently in the same geographical space (Wilson, 1997; McFall-Ngai, 1991).

Note should also be made of studies such as those by Lynn Margulis (1991), which highlight the possibility that the alteration of the ontogenesis of living beings may occur as well in symbiotic relationships between species. To that extent, the non-justification of Lamarckism will be a fallacy since individuals will acquire characteristics throughout their lives that can eventually be passed on to the next generations. In fact, living beings will be products of an evolution that also took place in association relations between species. For example, the symbiosis of microbial communities in animals implied the acquisition of genes, which were not natural to them, but which provided them with certain characteristics and advantages, which from then on were transmitted hereditarily. Such relations in cells draw our attention to genetic transmissions which occur outside the cell nucleus and which are not in accordance with Mendelian hereditary mechanisms. This stresses the recognition that organelles such as chloroplasts and mitochondria possess all the components necessary for life, such as DNA, RNA transcription enzymes, and all the apparatus required for protein synthesis (Margulis, 1991; Sapp, 1991). All this has led researchers to consider the possibility, under experimentation,

to manipulate or intervene in the ecology of living beings, including human beings, both in terms of the external environment and the environment within the body. It is thus a technology that in its development places the emphasis on the horizontal relationship between species rather than on the vertical relationship.

In this respect, note should be made of the research carried out in a recently studied field of genetics, epigenetics. In addition to the genome, the human body has a vast network of epigenetic markers which react to environmental stimuli. The epigenome is thus formed by a set of markers and biochemical signals, present throughout the genome, which respond to environmental signals and subsequently switch genes on or off, increasing or reducing their activity. Studies in the field of epigenetics have revealed that environmental factors such as diet, stress or prenatal nutrition are the cause of genetic markers that are passed from generation to generation. However, epigenetics is not evolution in that it does not alter DNA. Instead, it represents a biological response to environmental disturbance or pressure. To this extent, once the environmental disturbing factors are removed, the epigenetic markers will, in time, succumb and DNA will return to its natural state. Nonetheless, while these marks still exist, they can have a very significant effect on the life and health of the individual (Al-Rodhan, 2011).

2. Theoretical basis of a unified theory of biology

Several authors have developed theories and concepts that support a unified theory of biology. It is important to address the theories presented by these authors in order to understand what is meant by such concept, since it contains an eminently post-anthropocentric vision of life and the world. In this regard, the Italo-Australian philosopher Rosi Braidotti (2015) draws attention to the advances made in the study of molecular biology showing that matter is self-organised, seeking to base herself on the concept of autopoiesis of the works of biologists Humberto Maturana and Francisco Varela. Braidotti's work is influenced by a wide range of authors and currents. Braidotti draws on Spinoza's monist philosophy to add that matter is structurally relational and, therefore, connected to a variety of environments, and refers to notions of the actor-network theory, including the interconnection of human and non-human actors from the work of Bruno Latour. However, Braidotti also claims the influence of the work developed by authors such as Lynn Margulis, inter alia, in the study of symbiotic relationships between species:

> *Parisi strengthens this case by cross-referring to the new epistemology of Margulis and Sagan (1995), through the concept of endosymbiosis, which, like autopoiesis, indicates a creative form of evolution. This means that the genetic material is exposed to processes of becoming freed from ontological foundations for difference but is not confined by social constructivism* (ibidem: 158-159).

In this sense, Braidotti does not work entirely within any form of social constructivism, but prefers to emphasise the non-human vital force of life, which she codes as 'zoe'.

> *Zoe as the dynamic, self-organizing structure of life itself (Braidotti 2006, 2011b) stands for generative vitality. It is the transversal force that cuts across and reconnects previously segregated species, categories and domains. Zoe-centred egalitarianism is, for me, the core of the post-anthropocentric turn: it is a materialist, secular, grounded and unsentimental response to the opportunistic trans-species commodification of Life that is the logic of advanced capitalism* (ibidem: 60).

For Braidotti (2015), the concept of 'zoe' thus has a vitalist, inter/multi-relational, self-organising but also materialist nature, outside any religious or spiritualist concept. It introduces a post-anthropocentric vision that contradicts any status of human superiority in relation to other forms of life on Earth.

Going back to the reference to the works by Maturana and Varela (1980), we note that living systems are characterised by a so-called contiguity. The concepts of regulation, control or function relate only to the referential relations specified by the observer. The circularity in living systems represents the self-regulated homeostatic organisation, along the lines of what these authors refer to as 'autonomous matter'. It is in this sense that Maturana and Varela introduce the concept of autopoiesis, which defines living beings as autopoietic machines in that there is a closed network of molecular production. In this theoretical context, the ideas of the actor-network theory developed by Bruno Latour add elements to the equation by highlighting the continuity between nature and human culture, considering a principle of generalised symmetry, where both nature and society need to be explained and such explanation starts from quasi-objects. The very notion of culture is an artefact that results from our estrangement from nature. Sciences and techniques are, therefore, remarkable in that they multiply the non-humans involved in the construction of collectives and make the community we form with these beings more intimate. Society only becomes incomprehensible as a residue from which we remove the non-humans added by the collective (Latour, 2009).

3. Application through technology

The exploitation of the symbiosis between species, particularly for medicinal purposes, can be dated back to several thousand years with biotea, the traces of its use having been found in ancient civilisations such as Greece, Rome, and Japan by intersecting knowledge between East and West. Biotea takes advantage

of the medicinal properties of various plants to stimulate detoxification, hydration and revitalisation processes in the human body. Moreover, administered in accordance with a clinical diagnosis, biotea can be useful to aid the treatment of several medical conditions, namely of the respiratory, digestive and circulatory systems, as well as obesity (Sakai, 2015).

However, from the point of view of direct human manipulation, the development of new applications of symbiosis technology makes this technology eligible to be part of emerging technologies. Microbial communities have been harnessed to solve real-world problems in areas such as energy and medicines due to the properties developed in these relationships. Metabolic capabilities tend to expand in communities allowing division of labour between organisms, as has been seen in photosynthetic and methanogenic communities. In fact, communities can be said to dominate the microbial world. Organisms that coexist cannot help but interact. Interactions include touching, the use of dedicated signals, horizontal gene transfer, competitive or cooperative scenarios where microbes compete for resources or to provide resources, and of environmental changes to influence the growth of neighbours (Hays *et al*, 2015). As referred above, these communities are nevertheless complex, as symbiotic/cooperative relationships and also competitive or even parasitic relationships exist even in the relationships they establish with humans. It is not always easy to distinguish or understand what type of relationship is involved in a given association. Often the definition of such association depends on the objectives of the experience being developed and the social constructs it involves. There thus exists a phenomenological dimension that is inherent to the classification of the type of relationships developed between organisms in communities.

From an experimental perspective, the move towards a greener economy has implied the study of community relationships between species of organisms, notably in the areas of renewable raw materials, bioproduction and biofuels, for example, the growth of oily microalgae for the production of biofuels. Studies have shown that the culture of a certain type of microalgae with a certain type of bacteria provides increased growth and lipid content in these cultures compared to pure cultures (Nascimento, Dublan, Ortiz-Marquez, 2013, *in* Hays *et al*, 2015). Similar benefits have been found in this type of approach to using cellulose sources for energy, which is metabolically expensive but is effectively achieved with 'consortia' between organisms. Incidentally, these types of cultures are designed to take the system even further, from cellulose to product. Research has achieved this by pairing a fungus, which breaks down cellulose, with altered E.coli bacteria, producing isobutanol. This is an excellent example of how natural and synthetic systems can be combined, such as a fungus that can degrade raw

materials, without modifying them, while E.coli is designed and optimised for the production of isobutanol (Minty *et al*, 2013, *in* Hays *et al*, 2015). In addition, important work with microbial communities has also been carried out in wastewater treatment, pollutant cleaning, nitrogen fixation in soil, and in other areas (Hays *et al*, 2015).

However, a core area of applications that have been developed with microbial communities is the health area. Human beings themselves have multiple species of bacteria living constantly in their bodies, the so-called human microbiome. There are ten times more bacteria in our bodies than the total of our own cells, the gut alone accounting for approximately 100 trillion bacteria (Costello *et al*, 2015). It has been proven that in vertebrates, such as humans, from early on, the transfer of maternal microbes to the infant through natural birth and breastfeeding is important for the infant's health, in that it builds up the structure of the microbiome with beneficial microbes (Funkhouser, Bordenstein, 2013, *in* Aschenbrenner *et al*, 2016). However, there is a peace-war relationship in our microbiome which arises from the possibility of there being both species with non-pathogenic properties and species with pathogenic properties. The discussion of the logics of the association between organisms is complex and follows subjective and relative properties, as mentioned above. Whether microbiome activity is a consequence or a cause of immune-mediated diseases in humans is still unclear, even though considerable evidence points to the role of the microbiome in driving immune-mediated disease in animals (Costello *et al*, 2015). Conversely, studies show that eukaryotic viruses have the ability to support intestinal homeostasis and shape mucosal immunity, similar to commensal bacteria that have no pathological effects on human health (Kernbauer, Ding, Cadwell, 2014, *in* Costello *et al*, 2015). All this data confirms that we still know very little about gut health associated with the microbiome. At any rate, gut microbiome modelling is increasingly perceived as a target for new therapies containing probiotics[1] and faecal transplants [2] (Costello *et al*, 2015).

On the other hand, similar efforts are being made with regard to epigenetics. Scientists have been looking at how they can manipulate the growing knowledge they have gained about epigenetics, for example by comparing the epigenome of diseased cells with the epigenome of healthy cells to understand how epigenomes can lead to cancer or other diseases. Epigenetic drugs have already been produced in this field to treat malignant blood diseases. These drugs can target epigenetic markers that smooth out genes in blood precursor cells that are over-expressed. Thus, after the challenge of mapping the human genome, the challenge of mapping the human epigenome composed of many millions of markers is now also underway. Such an achievement requires further advances in computer technologies,

but when achieved it will imply the possibility of changing the genetic predispositions of individuals (Al-Rodhan, 2011).

4. The bioethical debate

If one accepts a unified theory of biology as being related to dynamic, self-organised living matter transversal to living species, then the mechanisms on which the relations of association between species or even epigenetics are based may constitute important bases to substantiate this theory. The work of Bruno Latour (2009), within the actor-network theory, may strengthen this theory by drawing attention to the links between human culture and nature. To this extent, the elements developed from the technology of our society will be extensions of a whole integrated in nature. Some authors, however, have warned about the asymmetric dimension of human constructions in relation to other nature. In effect, human beings may, through their civilisation and culture, be breaking the homeostatic balances established in the natural world. In line with Francophone beliefs, when discussing the concept of humanism, philosopher Michel Serres concludes that we humans are born from the mutation of technique and free knowledge. We do not know where we are going, but we do know where we come from. The recent discovery of the secrets of genetics is a new form of a manipulation that has long been inscribed in our behaviour. Humans are thus animals of fetishism and uses symbols that correspond to their urge to universalise themselves and to unite with the world. Fetishism is our apocalyptic liberation from animals (Serres, 2008). It is in this line of reasoning that the author creates the concept of hominescence, which includes the way our body has been transformed:

> *In short, therefore, we construct our body by means of the products of our body, since the technical objects are prepared by it. In this way, hominisation looks less like vital evolution than self-production; if the word did not sound so bad I would prefer to say that, in this case, it is a process of self-hominisation. We construct ourselves*[3] (Serres, 2004: 50).

Besides the corporal dimension, Serres completes the concept of hominescence with the links to the world and to others, while expressing concerns in this respect. We live in a globalised society in which information networks allow instantaneous communication on a global scale, leading to the compression of space-time. However, although this gives us a sense of omnipresence and even transcendence, we are increasingly becoming societal machines due to the control exerted on us by the new communication and information technologies and the way they lead to our consensual opinion (Serres, 2004). Meanwhile, our world faces an ecological crisis and inequalities at various levels. This generates a feeling of indifference in

us towards others and the environment, which we threaten to seriously destroy. As E.O. Wilson contends (1997), never in the history of the planet have there been so many living species as there are today. But precisely because of human action, the rate of extinction of species has reached extremely high levels today, hovering over the scenario of a sixth mass extinction of life on Earth.

Many of the concerns expressed about the future of humanity stem from the ecological problems caused by the impacts of human activities. According to authors who focus on social environmentalism, we are even living through a new period in the Earth's geological history called the Anthropocene. For Ramón Fernández Durán (2011), the Anthropocene will be a new epoch of the Earth that arises as a consequence of human being's implementation of the urban-agro-industrial system on a global scale, coinciding with an unprecedented increase in world population. From this perspective, the Anthropocene has acted as an authentic geological force with strong negative environmental implications. Firstly, the functioning logic of the human socio-economic system does not respect the functioning of nature itself. In human activities, cycles of material use develop, separated into resources (biophysical inputs) and waste (biophysical outputs). In nature, there are no resources and no waste because everything functions as an interrelated system, activated by external solar energy. On the other hand, the urban-agro-industrial system, today in its capitalist version, gives rise to serious social and economic asymmetries between different regions of the world. These discrepancies and phenomena have progressively created negative impacts on the life of indigenous communities, the pollution of ecosystems, the contamination of the food chain, the desertification of large regions, the promotion of political-military conflicts and, in general, the contribution to climate change.

Michel Serres, however, highlights two other realities of what he refers to as the new human condition: the loss of finitude and the loss of finality. The loss of finitude because, as we are subject to a certain omnipotence, little by little we become "causes of ourselves and of certain totalities concerning the future of the world[4]" (Serres, 2004: 66). The loss of finality because today we build artefacts without a specific purpose, like the computer, which merge into our life and, thus, we believe the human being is constructed today as having no purpose (Serres, 2004).

It is necessary to recognise the logics in which biotechnologies operate, as they are necessarily framed within a given social and economic system. For example, Rosi Braidotti (2015) criticises the current political economy of biogenetics which, according to her, turns life or zoe, that is, human and non-human intelligent matter, into merchandise for trade and profit. This economicist logic also blurs the distinction between the human and other species when it comes to profiting from

them. For the author, this indicates that the political economy of bio-genetics is post-anthropocentric in its very structures, but is not necessarily or automatically post-humanist. It inherently carries a dimension of social and human construction, although it nevertheless tends to be profoundly inhuman in terms of its lack of sensibility and morality.

Concluding remarks

The greatest awareness in the scientific community to the importance of association relations between species and to epigenetics in the functioning of organisms is related to an epistemological turn in the study area of ecology. The emphasis that was long given to the acquisition of random mutations as determining mechanisms in the process of natural selection of living species is related to a classical evolutionist perspective that neglected transdisciplinarity as a holistic view of the world and nature. Indeed, hereditary genetics was assumed as a scientific discipline that took precedence over other disciplines in this field of study. Research into the association relationships between living species and epigenetics has drawn attention to a whole range of factors that interfere both with the external ecology and the internal ecology of living organisms, including human beings. As such, in addition to hereditary mechanisms, the door is opened for the acceptance of environmental and social factors in the organisation and evolution of life. It is plausible that for a long time in the evolution of life on Earth random genetic mutations passed from generation to generation have functioned alongside the mechanisms of association between living species. In this context, ecosystems have been characterised by homeostatic regulation that allows life to be sustained as we know it today.

On the other hand, the human being, through society and the technology it has developed, expands the relationship between culture and nature. Examples of this are the countless artefacts that humanity has built from nature in order to satisfy multiple purposes. Technologies are being developed today to control the relationship of association between species for various purposes, ranging from energy production to health and environmental cleanliness. Drugs are also being developed that could act on the human epigenome to treat diseases such as cancer. However, the ideas of Bruno Latour (2009) about the interconnection of human and non-human actors, in a line of continuity between nature and culture, prove problematic to sustain a unified theory of biology. As Michel Serres (2008) argues, the fetishist action of the human has an apocalyptic liberation dimension from the animal world and, as such, goes far beyond the cohesion of natural life, as has been the case for a long time. In line with

what the author calls the concept of hominescence (Serres, 2004), human beings are developing their own capacity for omnipotence by constructing artefacts that enable the loss of finitude and finality. However, because of the control and conditioning imposed on us by the new information and communication technologies we have become societal machines increasingly indifferent to the negative impacts of the civilisation we have built. In fact, as a civilisation that has adopted a certain social and economic model with an urban-agro-industrial base, we have caused serious social asymmetries and serious environmental and ecological damage. The current political economy of biogenetics, despite breaking down some boundaries between human life and non-human life, reveals an economicist logic with the primary aim of profiting from its products. It is certain that even in the case of the association relations between species and in the case of epigenetics we are dealing with ecological and biological contexts about which we know very little. As such, by interfering in these relations we may be altering the internal and external ecology of living beings, this having unpredictable effects. Although scientific research in these areas may be useful for various purposes, it should follow ethical codes to avoid possible negative effects on human health and ecology.

It is true that the political economy of biogenetics, in the economicist and capitalist logic in which it operates, reveals an inhumanity devoid of moral or sentimental values. Still, we can assume that these kinds of values are mutable elements arising from socio-historical constructs. In relations of association between species, the classification of the type of association comprises a phenomenological dimension inherent to the properties of experience and to the choices of those who develop it. The evolutionary logic of life on Earth itself was not concerned with value judgements between good and evil, despite having been influenced by homeostatic regulation mechanisms. Will the human being, despite all the threats they pose to life on the planet, place that same life on other levels of homeostatic balance, even though this may mean loss of biodiversity and environmental deterioration in the process? The sixth mass extinction of life that will occur in the framework of the Anthropocene epoch may mean a transitional process, albeit painful for many, to a new period characterised by other patterns of natural life and perhaps of social organisation. None of the five previous extinctions proved to be the last massive extinction of life on Earth. Or, on the contrary, are we this time irremediably condemning life on the planet to a more or less slow end, taking into account the transformative (and destructive) capacity of human beings? Regardless of what the future may hold, for the moment it seems likely that the unified theory of biology, although possible, finds in human action a barrier to its current definition.

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Notes

1. Living organisms that, when administered in adequate amounts, provide health benefits to the host.

2. Type of medical treatment aimed at repopulating the gut with beneficial bacterial flora.

3. *Em suma, portanto, nós construímos o nosso corpo por intermédio dos produtos do nosso corpo, uma vez que os objectos técnicos são preparados por ele. Deste modo, a hominização parece-se menos com a evolução vital do que com uma produção própria; se a palavra não soasse tão mal eu preferiria dizer que se trata, neste caso, de um processo de auto-hominização. Nós construímo-nos a nós próprios.*

4. *…causas de nós próprios e de determinadas totalidades respeitantes ao futuro do mundo.*