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A Conceptual History of Entropies from a Stieglerian Point of View: Epistemological and Economic Issues of the Entropocene

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Abstract

In this article I will try to suggest a transdisciplinary conception of entropy in order to analyse the contemporary ecological polycrisis which is usually described as the Anthropocene era. According to French philosopher Bernard Stiegler, the Anthropocence can be understood as an Entropocene, because the current ecological crisis consists of a process of massive increases of entropy in all its forms: thermodynamic entropy (that is, dissipation of physical or chemical energy), biological entropy (as the destruction of biodiversity), and psycho-social entropy (as the reduction of knowledge to data and calculations, through digital disruptive technologies). In order to analyse this situation, we need a transversal conception of entropy: from Bergson's philosophy of life to Stiegler's philosophy of technics, through Schrodinger's physics, Wiener's cybernetics, Lotka's biology and Levi-Strauss's anthropology, I will try to build a conceptual history of entropies from a Stieglerian point of view and to explore its economic and political consequences in Stiegler's thought, in order to open new paths beyond the Entropocene era.

Keywords

entropy, Entropocene, neganthropy, economy, ecology, technology, Stiegler, Georgescu-Roegen

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Introduction

In 1971, a year before the publication of the Meadows Report titled *Limits to Growth*, mathematician and economist Nicholas Georgescu-Roegen published an article titled "The entropy law and the economic process"[1] in which he argued that economic theory should take into account the consequences of the entropy law, which is to say, of the second law of thermodynamics. According to Georgescu-Roegen, orthodox economics is based on a mechanistic epistemology that does not take into account the scientific revolution of thermodynamics, and which, for this precise reason, is no longer relevant. This mechanistic epistemology tends to represent the economic process as a circular process closed in on itself in a state of equilibrium, and thus prevents consideration of the interactions between the economic process and the natural environment. However, as Georgescu-Roegen reminded us, "nature plays an important role in the economic process … [and] … it is high time to accept this fact and to consider its consequences for the economic problem of humanity."[2] Georgescu-Roegen thus insisted on the necessity of rethinking the connections between entropy, ecology and economy.

Almost fifty years later, the French philosopher Bernard Stiegler, inspired by Georgecu-Roegen's analysis, also suggested that the question of entropy should be put back at the heart of ecological and economic debate. Indeed, in a book titled *Bifurcate*[3](2020), he describes the Anthropocene era as an "Entropocene era," that is to say, as a process of massive increase of entropy in all its forms, at the physical and biological level on one side and at the psychic and collective level on the other side: "the various disturbances afflicting the current stage of the Anthropocene era *all* consist in an increase of (1) thermodynamic entropy, as the dissipation of energy, (2) biological entropy, as the reduction of biodiversity, and (3) informational [or psychosocial] entropy, as the reduction of knowledge to data and computation.[4]" Such an analysis no longer relies on an opposition between humanity and life or between culture and nature: on the contrary, the concept of entropy is used to understand the transversal link between the destruction of ecosystems, species and biodiversity on one side (described as an increase in entropy at the environmental and biological levels) and the destruction of knowledge, cultures and "socio-diversity" on the other side (described as an increase in entropy at the informational, psychic and collective level).

Nevertheless, this notion of an Entropocene raises many problems. One of the major problems lies in the fact that the physical concept of entropy cannot be sufficient in order to think the Entropocene,

1 Nicholas Georgescu-Roegen, "La loi de l'entropie et le problème économique," in *La décroissance: entropie, écologie, économie,* trans. Jacques Grinevald and Ivo Rens (Paris: Ellébore-Sang de la terre, 2006), chapter 1.
2 Georgescu-Roegen, "La loi de l'entropie et le problème économique."
3 Bernard Stiegler *et al.*, *Bifurquer* : *Il n'y a pas d'alternatives* (Paris: Les liens qui libèrent, 2020). Bernard Stiegler *et al.*, *Bifurcate: There is no alternative*, trans. Daniel Ross (Open Humanities Press 2021).
4 Stiegler *et al.*, *Bifurcate*, 28.

because the production of entropy does not take on the same forms or the same meaning in the context of physical, vital or psycho-social phenomena: biological life is irreducible to physical laws, just as noetic, cultural or social life is irreducible to biological laws. If we do not want to fall into reductionism, it is necessary, as Stiegler writes, to "specify the articulation of entropy and life, first with regard to the diverse forms of living things, and second with regard to the specific case of human societies."[5] But this is a quite complex task, since, as Stiegler also points out, "the academic system has not [yet] integrated entropy as a question of physics, nor its consequences for the definition of living beings [...], nor therefore the question of the resulting limits for human action."[6].For Stiegler, this means that the question of entropy needs to be thought differently in the field of physics, in the field of biology, and in the field of anthropology and technology, but that all these fields also must cooperate together, which is particularly difficult given the current disciplinary frontiers.

So, in order to consider the Entropocene era, we need a transdisciplinary and differentiated conception of entropy, but such a conception does not yet exist, because the question of entropy has not been the object of any transversal theorization beyond the field of thermodynamic physics and theoretical biology. Moreover, even in these scientific fields, the question of entropy has been at the origin of many controversial debates between physicists and biologists. In the fields of social science, the situation is even more problematic, because the notion has been monopolized by information theory since the 1950s, which has prevented its appropriation from other perspectives. Although some authors today use such notions as "psychic entropy" to designate a state of "self-disorganization" caused by attention deficit disorder[7] or as "social entropy" to designate the institutional collapse caused by neoliberal and capitalist economies[8], such analyses do not rely on a specific theory of entropy, so they seem to use the notion in a quite metaphorical way.

We are thus faced with a double problem: on the one hand, we must avoid a reductionist conception of entropy (which would limit the concept to its thermodynamic meaning, thus denying the irreducibility of biological life and social life to the laws of physics), and, on the other hand, we must avoid a metaphorical conception of entropy (which would use the concept as an image to describe psychic disorganization or social disorder). To overcome this alternative, I will try to turn back to the history of this notion, not only in the fields of thermodynamics or information theory, but in the fields of biology, anthropology, and philosophy. Indeed, the discovery of the second law of thermodynamics had strong repercussions in all these fields during the twentieth century, and through its circulation in different fields, the notion of "entropy" also went through important transformations. From Bergson's

5 Stiegler *et al., Bifurquer,* §20, 68. (*Bifurcate*, 52)

6 Bernard Stiegler, "Démesure, promesses, compromise," *Mediapart,* September (2020), https://blogs.mediapart.fr/edition/les-invites-de-mediapart/article/070920/demesurepromesses-compromis-23-par-bernard-stiegler.

7 Mihaly Csikszentmihalyi, *Flow: The Psychology of Optimal Experience* (London: Harper Perennial, 1990).

8 Wolfgang Streeck, *How Will Capitalism End? Essays on a Failing System* (London: Verso, 2017).

philosophy of life to Stiegler's philosophy of technics, passing through Schrodinger's physics, Wiener's cybernetics, Lotka's biology and Levi-Strauss's anthropology, I will try to show that, today, we are in possession of some conceptual tools with which to build a transversal and transdisciplinary conception of entropy, which cannot constitute an integrated philosophical system, but which requires an articulation between different scientific fields. I will try to explore the economic and political consequences of this conceptual history of entropies in Stiegler's work, in order to open new paths beyond the Entropocene era : the second aim of this article is to show that we need an "anti-anthropic" economy in order to take care of biodiversity and of noodiversity.

I. From Thermodynamics to the Evolution of Life: From Entropy to Anti-entropy

1. Entropy in Thermodynamics: Degradation and Dissipation of energy

The notion of entropy emerged in the field of thermodynamic physics in the nineteenth century (through the works of Sadi Carnot, Rudolf Clausius, and Ludwig Boltzmann, in particular). In its classical sense, in thermodynamics, entropy designates a "measure of the non-usable energy in a system": in a thermodynamic system, an increase in entropy corresponds to a degradation or a dissipation of energy, which passes from a usable or free state (energy over which man can exercise almost complete control) to an unusable or bound state (energy which man can absolutely not use)[9] Therefore, the law of entropy shows that during the transformation of a physical system, the energy is not consumed but changes its state: for example, to take the case mentioned by Georgescu-Roegen, "when a piece of coal is burned, its chemical energy neither decreases nor increases … but the initial free energy has been so dissipated in the form of heat, smoke and ashes, that man can no longer use it."[10] Energy has been conserved, but it has been degraded: what is generally called "consuming energy," in fact, means dispersing and degrading it, for example, in the form of heat.

This degradation of energy corresponds to the passage from a certain ordered structure (an unlikely and improbable configuration) to a state of dispersion and disorder (a more probable configuration): as Georgescu-Roegen puts it, "free [usable] energy implies a certain ordered structure comparable to that of a store where meats are on one counter, vegetables on another, etc." whereas "bound [non-usable] energy is energy dispersed in disorder, like the same store after being hit by a tornado."[11] This is why "entropy is also defined as a measure of disorder," and entropy increases as "the process of moving from less probable macroscopic states to more probable macroscopic states."[12] In this sense, entropy increase

9 Georgescu-Roegen, "La loi de l'entropie et le problème économique," 68.
10 Georgescu-Roegen, "La loi de l'entropie et le problème économique," 68.
11 Georgescu-Roegen, "La loi de l'entropie et le problème économique," 68.
12 Georgescu-Roegen, "La loi de l'entropie et le problème économique," 68.

implies the disappearance of improbable characteristics, and their replacement by more probable ones, resulting in the erasure of the past: for example, a drop of ink will tend to disperse in water until it reaches a uniform situation, thus erasing the initial situation in which the drop had an improbable position.

So, at a physical level, the increase in entropy corresponds to a dissipation and degradation of energy: energy goes from a usable state to a non-usable state and from an improbable and structured configuration to a more probable but less ordered configuration. Entropy can therefore be defined as a tendency towards disorganization, destructuring and disorder. This tendency characterizes any isolated physical system: the second law of thermodynamics states that the entropy of a closed system is constantly increasing, which means that the order of such a system is continually being transformed into disorder. In a broader sense than the strict thermodynamic definition, an entropic process can therefore be described as a process in which a system tends to exhaust its dynamic potentials, as well as its capacity for conservation or renewal by dissipating its energy and gradually reaching a state of disorder and inertia.

2. The Creative Evolution of Life: Towards Negative Entropy

In *L'Evolution créatrice* (1907), Henri Bergson explicitly took the question of entropy into account where he considered the evolution of life. [13] Bergson was interested in the metaphysical consequences of the second law of thermodynamics, which states that entropy can only increase in isolated physical systems. This physical law has both scientific and cosmological consequences. At the scientific level, it leads to the idea of the irreversible nature of physical transformations, contrary to classical mechanics, which does not consider the arrow of time. According to Bergson, the law of entropy is "the most metaphysical of the laws of physics since it points out ... the direction in which the world is going."[14]. Indeed, according to Bergson, this law means that the heterogeneous changes and the diverse forms which are characteristic of nature and life will be more and more diluted into homogeneous changes and elementary vibrations.[15]

But beside these considerations about the entropic physical becoming of the universe, Bergson also notices that within this entropic physical becoming, the activity of living organisms manifests a counter-tendency. In fact, as he points out, the activity of life consists in "suspending," "deferring" or "postponing" this dissipation and degradation of energy: while feeding and moving, organisms accumulate energy which they spend in various and unpredictable directions. According to Bergson, life can thus be described as "an effort to accumulate energy and then to let it flow into flexible channels, change-

13 Henri Bergson, *L'Évolution créatrice* [1907] (Paris : PUF, 2013).
14 Bergson, *L'Évolution créatrice,* 244. (*Creative Evolution*, 265).
15 Bergson, *L'Évolution créatrice,* 244. (*Creative Evolution*, 265–66).

able in shape, at the end of which it will accomplish infinitely varied kinds of work." [16] Through the activities of plants and animals, which accumulate, transform and release energy, life thus constitutes a counter-tendency to the law of entropy: even if living beings can only temporarily defer the irreversible production of entropy (because all living beings end up dying), life appears as a counter-tendency to the dissipation of energy and as a way of postponing the state of inertia through the accumulation of energy, the organization of organic matter, the diversification of living forms, and the production of unpredictable changes.

Bergson's philosophical intuition, which was inspired by the works of Lalande and Boltzmann[17], was transformed in 1944 through the work of physicist Erwin Schrödinger, who, in *What is life*,[18] describes life as feeding on "negative entropy." Schrödinger's reflections are not the same as Bergson's : firstly, because they are not metaphysical speculations on the nature of life, but scientific descriptions of living organisms, and secondly, because the physicist does not maintain that life *is* negative entropy, but that living organisms *need* negative entropy in order to survive (organisms consume negative entropy). Through his theory, Schrodinger insists on the different behaviours of, on the one hand, physical systems, and, on the other hand, living organisms. Indeed, while physical systems tend to evolve towards disorder and to reach an inert state where no further events are observed (a state of thermodynamic equilibrium or of maximal entropy), Schrödinger notices that living organisms not only maintain their organization throughout their life, but also never stop moving and evolving, as if they were constantly postponing or deferring their ineluctable decay towards the state of maximal entropy, that is, death. Schrödinger then suggests the notion of "negative entropy" (which will later be called "negentropy") to describe this specific behavior of what he calls "living matter": "living matter, while not eluding the 'laws of physics' … is likely to involve 'other laws of physics' hitherto unknown."[19] What Schrödinger thus wants to say is that living systems or organisms, which exchange matter and energy with their environments, degrade energy and produce entropy, but at the same time, accumulate energy, maintain their organization, exchange with their environments, and continue to evolve. Thus, they slow down their descent towards death (and thermodynamic equilibrium). It is probably for this reason that five years after Schrödinger's theory, Norbert Wiener, in his book on cybernetics,[20] describes living organisms as "pockets of decreasing entropy in a framework in which the large entropy tends to increase," "local zone of organization in a world whose general tendency is to run down" where "locally anti-entropic processes … resist the general tendency for the increase of entropy," even if this resistance, as Bergson had already shown, is always local and temporary.[21] For Bergson, though, material decompo-

16 Bergson, *L'Évolution créatrice,* 244. (*Creative Evolution*, 276–77).
17 Bergson, *L'Évolution créatrice*, 166–168, citing Ludwig Boltzmann, "*Vorlesungen* über *Gastheorie*," (1898), and André Lalande, *La dissolution opposée à l'évolution dans les sciences physiques et morales* (1899).
18 Erwin Schrödinger, *Qu'est-ce que la vie ?* [1944], trans. Léon Keffler (Paris: Points, 1993).
19 Schrödinger, *Qu'est-ce que la vie ?,* 166. (*What is Life?*, 68).
20 Norbert Wiener, *Cybernétique et société: L'usage humain des êtres humains* [1952], trans. Pierre-Yves Mistoulon (Paris: Points, 2014).
21 Wiener, *Cybernétique et société : L'usage humain des êtres humains,* 65–66.

sition (entropy) was conceived as a counter-tendency of living creation (negative entropy) which, for him, is at the origin and at the end of evolution. To the contrary, Wiener insists on the fact that through living, living organisms continue to degrade energy and to produce entropy: every living being will at some point end up dying, every living being will return to dust. Negative entropy is not eternal, whereas the entropic tendency is irrevocable.

3. Anti-entropy in Contemporary Biology: Organization, Historicity and Functional Novelties

In their more recent works in the field of theoretical biology,[22] Giuseppe Longo and Francis Bailly complicated Schrodinger's work, adding to the notion of negative entropy or negentropy the notion of anti-entropy, in order to give a more precise account of "biological organizations in their historicity" and of the functional novelties generated by living organisms. They state living organisms not only maintain their organization but also transform themselvesin the course of time by producing new functions, through which "new singular and viable organizations emerge. Contrary to the notion of negentropy, which, after Schrödinger, had been used in physics to describe the production or emergence of order from chaos, the notion of anti-entropy applies only to living beings, and is intended as a way of describing their evolutionary dynamics, which involves the conservation of the species' history and the constitution of functional novelties. The notion of anti-entropy thus makes it possible to consider the irreducible nature of living systems. Indeed, living organisms are not reducible to physical systems insofar as living structures are characterized not only by a certain level of complexity or by a certain order, but by the cohesion between their parts (the whole of the organism is greater than the sum of its parts), by their historicity (the organization of living organisms results from a singular history and not from the random aggregation of elements) and by the emergence of functional novelties (new organizations which are functional for the organism). The concept of anti-entropy thus makes it possible to consider the irreducibility of the character of life to physical laws, thanks to the distinction between a complex order (negentropy) and a living evolution (anti-entropy): for example, in the case of a tumour, there is an increase in complexity (so an increase in negentropy in the physical sense of the term), but there is a decrease in functionality because this complexity is not functional for the organism; or, when an organism dies, we witness the transformation of biological anti-entropy into physical negentropy (there is still an organization or an order, but it is no longer functional, and it will eventually degrade and lead to a production of entropy.[23]

22 Giuseppe Longo and Francis Bailly, *Mathématiques et Sciences de la Nature: La singularité physique du vivant* (Paris: Hermann, 2006) and Francis Bailly, and Giuseppe Longo, "Biological Organisation and Anti-Entropy," *Journal of Biological Systems* 17, no 1 (2009): 63–96.

23 Maël Montévil, "Entropies and the Anthropocene crisis," *AI & Society : Knowledge, Culture and Communication* (Berlin: Springer Verlag, 2019); and Montévil Maël, "Sciences et entropocène," *Ecorev' - Revue critique d'écologie politique* 50, no.1 (2021): 109–125.

Whether it is Bergson, who considers life as a struggle against entropy, Schrödinger, who considers living organisms as attracting upon itself a stream of negative entropy, Wiener, who considers living organisms as anti-entropic processes, or Bailly and Longo, who insist on the need to distinguish between physical negentropy and biological anti-entropy, the issue is always the same: living organisms need to be considered in ways that are not explainable simply by invoking physical laws, not only because living organisms exchange matter and energy with their environments, but also because life involves an accumulation and expenditure of energy, along with a conservation of memory and the production of unpredictable functional novelties. Through this memory and these novelties, living organisms introduce the possibility of a bifurcation in entropic becoming, even if this bifurcation is always local and temporary.

II. From Anthropology to Economy: From Anthropy to Anti-anthropy

1. Exosomatic Evolution: the Anthropic Power of Technical Externalization

The concepts of negative entropy or anti-entropy thus make it possible to describe the evolution of life or the behaviour of organic matter, as distinguished from physical becoming or the behaviour of inorganic matter. But a new problem arises when it comes to thinking about technical living beings, i.e., about organisms which cannot survive only with the aid of their biological organs, but who need to produce artificial organs and who therefore constitute arrangements between organic matter (organisms) and organized inorganic matter (technical organs). Indeed, one year after the publication of Schrödinger's book on life, mathematician and biologist Alfred Lotka wrote an article titled "The law of evolution as a maximal principle," published in *Human Biology*,[24] in which he shows that the form of life that we usually call "human" not only involves the production of biological organs and organizations, but also the production of artificial or technical organs and organizations. Lotka describes this as a process of "exosomatisation": "exosomatic" organs are those which are situated outside of the body, such as technical prostheses or artificial tools, as opposed to "endosomatic" or biological organs, which belong to organisms. According to Lotka, these exosomatic organs raise new questions for the theory of life as negative entropy, because contrary to biological or endosomatic organs, technical or exosomatic organs do not necessarily generate evolution and diversification. Indeed, these organs are ambivalent. First, they complete human organisms and increase their sensory functions and their motor functions, so they are necessary to human life, and they allow the human species to accumulate huge quantities of energy. They are negentropic in this sense. But at the same time, they carry a huge destructive potential, especially if they are not "adjusted" to the needs of the species, and in this sense, they can produce huge amounts of entropy. According to Lotka, a great danger arises because scientific and technical knowledge has developed very quickly since the nineteenth century, whereas the wisdom

24 Alfred Lotka, "The law of evolution as a maximal principle," *Human Biology* 17, no. 3 (1945): 167–194.

which was supposed to adjust technical developments to the need of the human species did not develop at the same rhythm: "'knowledge comes but wisdom lingers' if by wisdom we understand that adjustment of actions to ends which is for the good of the species."[25] According to Lotka, the consequence of this dis-adjustment is that "from preservation of life we have turned to the destruction of life, and from expansion of the human race we have, in some of the most advanced communities, turned to its curtailment."[26] In other words, according to Lotka, the technical development necessary for the preservation of exosomatic life can also serve the destruction of this very same life and accelerate entropic becoming in an exponential way.

In 1955, ten years after the publication of Lotka's article, the anthropologist Claude Lévi-Strauss, who was undoubtedly unaware of Lotka's work, reached the same conclusion: in the conclusion of *Tristes tropiques*,[27] Lévi-Strauss also insists on the highly entropic potential of technical and industrial developments. Lévi-Strauss thus suggests that through the process of technical and industrial evolution, "*anthropos*" (which is the object of anthropology) is actively participating in the "process of degradation" which characterizes the physical universe. Indeed, Lévi-Strauss asks, "From the time when he first began to breathe and eat, up to the invention of atomic and thermonuclear devices, by way of the discovery of fire … what else has man done except blithely break down billions of structures and reduce them to a state in which they are no longer capable of integration?"[28] Through the extraction of mineral resources and the degradation of biodiversity, human civilizations thus participated in "the disintegration of the original order of things and hurrying on powerfully organized matter towards ever greater inertia, an inertia which one day will be final."[29] For this reason, according to Lévi-Strauss, "civilization, taken as a whole" has the function "to produce what physicists call entropy": this is why he maintains that "anthropology" should be described as "entropology."[30]

2. The Possibility of Anti-anthropy: Social Organization and Noetic Diversity

Sixty years after Lévi-Strauss' statements, in 2015, in a book entitled *Automatic Society*,[31] Bernard Stiegler engaged in a discussion with the entropologist on this precise point. Of course, like Lotka and Lévi-Strauss, Stiegler insists on the fact that the production of technical organs through the process of exosomatization and industrialization can lead to an acceleration of entropy: not only because the production of technical organs always requires a process of combustion and dissipation of energy,

25 Lotka, "The law of evolution as a maximal principle," 192.
26 Lotka, "The law of evolution as a maximal principle," 192–193.
27 Claude Lévi-Strauss, *Tristes Tropiques* (Paris: Plon, 1955).
28 Lévi-Strauss, *Tristes Tropiques,* 495.
29 Lévi-Strauss, *Tristes Tropiques,* 495.
30 Lévi-Strauss, *Tristes Tropiques,* 495.
31 Bernard Stiegler, *La Société Automatique t.1 L'avenir du travail* (Paris: Fayard, 2015). Bernard Stiegler, *Automatic Society, Volume 1: The Future of Work*, trans Daniel Ross (Hoboken: Wiley, 2017).

but also because "*industrial standardization* seems to be leading the contemporary Anthropocene to the possibility of a destruction of life as the burgeoning and proliferation of differences – as … biodiversity, sociodiversity ('cultural diversity') and psychodiversity."[32] Nevertheless, according to Stiegler, and contrary to the nihilistic perspective of Lévi-Strauss, exosomatic life is not only entropic, but also constitutes "an agent of *increased differentiation*," through the diversification of technical organs and social organizations.[33] Indeed, as the paleoanthropologist André Leroi-Gourhan has shown,[34] technical externalization leads to a new type of evolution and diversity: beyon vital evolution and biodiversity (through the emergence of biological organs and organisms) there is also technical and social evolution, technodiversity and sociodiversity (through the production of new technical organs, new ways of life, new social organizations). According to Stiegler, these new forms of organization, evolution and diversity can be described as neganthropic or anti-anthropic, in order to distinguish them from biological forms of organization, evolution and diversity. Indeed, Stiegler argues that in the case of the exosomatic form of life, "the questions of life and negentropy arising with Darwin and Schrödinger must be redefined,"[35] in order to take into account the ambivalent character of exosomatic organs : exosomatic organs can lead to the destruction of ecosystems and biodiversity, but can also serve as supports for the formation of social organizations and sociodiversity, provided that individuals develop the various kinds of knowledge which are necessary to adopt them.

Indeed, according to Stiegler, it is only through the practice of different types of knowledge (not only theoretical knowledge but also every form of know-how, including knowing how to live, practical knowledge, along with familial, artistic, technical, existential and spiritual knowledge) that exosomatic beings can adopt their constantly changing technical milieu. In other words, only in this way can they learn to live together in a milieu and to take care of their technical organs and environments so as to ensure that these technical organs do not become destructive for natural environments, for social organizations, and for individual organisms or minds. According to Stiegler, the practice of different kinds of knowledge:

> is what allows human beings to make their exosomatic organs bearers of more neganthropy than anthropy. In all its forms, as knowing how to live, knowing how to do or knowing how to conceptualize, knowledge is what allows human beings to take care of themselves, and with them, of their environment and of the future of life on Earth.[36]

This is why Stiegler maintains that activities of work (which he defines as the practice of any kind of

32 Stiegler, *La Société Automatique t.1 L'avenir du travail,* 31. (*Automatic Society*, 13).
33 Stiegler, *La Société Automatique t.1 L'avenir du travail*, 31. (*Automatic Society*, 13).
34 André Leroi-Gourhan, *Le geste et la parole t.2 La mémoire et les rythmes,* (Paris: Albin Michel, 1965).
35 Stiegler, *La Société Automatique t.1 L'avenir du travail*, 31. Stiegler, *Automatic Society*, 13.
36 Bernard Stiegler, *L'Emploi est mort, vive le travail* (Paris: Fayard, 2015), 66.

knowledge) are necessary to adopt the technical milieu:

> Only by understanding work in this way can we identify the exosomatic innovations (whether technical or technological) actually required by and compatible with a desirable future for a locality …. This is the work of *noesis*, that is, of thinking, in *all* its forms, and as practical as well as theoretical, familial, artisanal, sporting and artistic knowledge, and thus theoretical, juridical and spiritual knowledge in the broadest sense. This belongs to what we therefore call *noodiversity* and *noodiversification*.[37]

Indeed, through the practice of such knowledge, exosomatic beings form collective groups with collective rules, which vary from place to place and evolve with time: the practices of all kinds of knowledge are thus necessary for social cohesion as well as for social diversity and social evolution., They are what allow human groups to maintain and transform themselves, through the re-appropriation and transformation of a collective memory or an inherited past, and which can open an unpredictable and incalculable future. Thus, the different kinds of knowledge produce organization, diversification and novelty at a psychic and social level: they are at the basis of social organization and of cultural diversification and evolution, and this is why they can be said to have an anti-anthropic value.

3. Towards an Anti-anthropic Economy: Valorization of Knowledge and Revival of Desire in Digital Consumerist Societies

Therefore, an economy which aims at limiting the entropic and anthropic effects of exosomatic organs should work towards a revalorization of the different kinds of knowledge which, since the beginning of the Anthropocene, have been "*progressively transformed into machinic formalisms*"[38] and into proletarianized activities. Indeed, Stiegler identifies different stages of automation, each one of which involves an anthropic process of proletarianization, through the decomposition of singular and diverse knowledge into simple and homogeneous tasks. First, in the nineteenth century, the externalization of know-how into machines led to the industrial division of work and the proletarianization of workers. Then, in the twentieth century, the prescription of "ways of life" through marketing and cultural industries led to the standardization of the knowledge of how to live and the proletarianization of consumers. And finally, in the twenty-first century, algorithmic automation led to the externalization of theoretical knowledge and its reduction to statistical calculations performed on massive amounts of data, which implies the proletarianization of thinkers. Stiegler describes this process as "generalized proletarianization":

37 Stiegler *et al.*, *Bifurcate*, 57.
38 Stiegler *et al.*, *Bifurcate*, 24.

> Nineteenth-century industrial capitalism destroyed work-knowledge [*savoir-faire*] by turning workers into proletarians, in the sense defined by Karl Marx. In the twentieth century, this proletarianization was extended to practical and theoretical knowledge: the knowledge of everyday life has been destroyed by the cultural industries and by permanent innovation based on marketing, and intellectual knowledge is now disintegrated by software substitution, including in scientific activities.[39]

This disintegration of knowledge produces a situation of symbolic misery in which individuals, lacking the power to individuate themselves collectively through neganthropic or anti-anthropic activities, compensate for their frustrations through anthropic consumerist behaviours:

> We ingest more and more sugar and fat, we eject and *produce more and more CO_2 because we are in this situation of symbolic misery, and we try to make up for it through things that make us consume an enormous amount of materials*, and materials that, consumed under those conditions, produce an enormous amount of toxins. But this toxicity is first of all that of the destruction of the symbolic.[40]

For Stiegler, this symbolic misery produced through the industrialization of culture, lifestyles and desires must be understood as a problem of ecology and energy:

> *when desire is treated industrially, it leads to the destruction of desire*, which triggers the demotivation of the worker and the consumer. … *We say that this is an ecological problem*. We have exploited oil fields, coalmines, and we have destroyed that which we exploited, and we must find renewable energies. It's the same in the realm of desire: *we must find a renewable energy of the libido*.[41]

According to Stiegler, only a "revival of desire" could stimulate the necessary imperative: "individual behaviors must become more conscious, more attentive, more caring towards that which surrounds them" and initiate "meaningful transformations … in the future of the planet."[42]

Thus, in the Entropocene era, the necessity of saving or economizing natural resources (chemical, physical or mineral energies) is intrinsically linked with the necessity of saving and economizing psycho-social resources and libidinal energies. Just as Georgescu-Roegen insisted on the need to stop ex-

39 Stiegler *et al.*, *Bifurcate*, 97.
40 Bernard Stiegler, "De l'économie libidinale à l'écologie de l'esprit," Entretien avec Frédéric Neyrat," *Multitudes,* no. 24 (2006): 94 (Bernard Stiegler, "From Libidinal Economy to the Ecology of Spirit," interview with Frédéric Neyrat, trans. Arne De Boev, *Parrhesia* no.14 (2012): 14.
41 Stiegler, "De l'économie libidinale à l'écologie de l'esprit" interview with Frédéric Neyrat, 88.
42 Stiegler, "De l'économie libidinale à l'écologie de l'esprit" interview with Frédéric Neyrat, 94.

ploiting the stock of fossil fuels and to base the economy and industry on renewable energy flows (such as sun or wind), Stiegler insists on the need to stop exploiting the drives of consumers and to base the economy and industry on the renewal of libidinal energy, that is, on the valorisation of contributory activities through which people practise, share and transform different kind of knowledge. The function of the contributory income promoted by Stiegler in *Automatic Society*[43] and in *Bifurcate*[44] is precisely to renew these libidinal energies, through the remuneration and valorisation of anti-anthropic activities, through which individuals socialize their drives, produce collective desires and invest their libidinal energies into local and singular projects, and through which they take care of themselves and their environments.

According to Stiegler, such activities can be defined as activities of work, which he distinguishes from labour or employment: activities of work are neguanthropic or anti-anthropic because they are based on the practice of different kind of knowledge, which imply "techniques of the self and others" and lead to the "trans-formation of oneself" and "trans-formation of others"[45], psychic and collective evolution and diversification. Through the practice of knowledge, people acquire automatisms, but they also de-automatize and transform what they have learned, producing different kind of bifurcations (artistic bifurcations, political bifurcations, technical or theoretical bifurcations, etc.) which are intrinsically improbable, and can be said anti-anthropic in this sense. On the contrary, employment most of the time requires repetitive behaviours through which people cannot transform themselves and others because they have to adapt to "protocols supported and defined by machines, apparatus, manuals, procedures, reporting systems and management control."[46] Such activities can easily be automatized and can be said entropic, because they are not open to any evolution or diversification. For this reason, contributory economy is also an attempt to switch from an economic model based on employment to an economic model based on work, in which "the time saved by automatization must be invested in new capacities for dis-automatization, that is, for the production of negentropy."[47]

The aim of the contributory economy is to go beyond a consumerist and entropic economic model based on employment—which increases proletarianization, depletes psychic energies, and destroys ecosystems through addictive consumption—by opening up the possibility of an anti-anthropic economic model based on work, which would valorise and intensify the practice of different kinds of knowledge in order to protect biodiversity, sociodiversity and noodiversity.

43 Stiegler, *La Société Automatique t.1 L'avenir du travail,* 81.
44 Stiegler *et al.*, *Bifurquer,* 127.
45 Stiegler, *La Société Automatique t.1 L'avenir du travail*, 185.
46 Stiegler, *La Société Automatique t.1 L'avenir du travail*, 161.
47 Stiegler, *La Société Automatique t.1 L'avenir du travail*, 7.

Conclusion

We can see that through Stiegler's reflections, the question of entropy becomes a question of political economy : the notion of entropy, which was first raised in the field of physics seems to have crossed many different theoretical fields in the XXth century, from biology to anthropology and economy. This article aimed at giving a partial overview of the history of the notion, in order to understand the Stieglerian political propositions from an epistemological point of view and to show their necessity in the current context of the Entropocene.

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