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DISSIPATIVE INDIVIDUATION

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1

Isabelle Stengers asks how to read a thinker when her ideas had not been put to the test during her lifetime, and how to resist easy seductions and misunderstandings that the resumption of her posthumous ideas may evoke.[1] Such is the case with Gilbert Simondon, she argues, whose ideas had been inventions that were not put to test.[2] Stengers suggests a reading of his work not merely in terms of how his ideas functioned "for him" but rather how they function "for us." Following her, I will discuss in what way Simondon's concept of individuation allows us to reestablish the previously analogical relations between scientific and philosophical concepts at a new ontogenetic level. Despite his untimely applications of certain scientific concepts and seductions in his scientific choices[3], Simondon opens up a new mode of thinking in which philosophy's relation to science takes on a new direction: science ceases to be an analogy to thought. However, for us the test is not to seek the validity of his scientific concepts by lending them to the scientific criteria but to understand the relevancy of his choices and biases within the onto-political field that follows from them. His use of scientific concepts exceeds the restricted value of metaphoric and analogical appropriation of them by conventional philosophy. Simondon's novelty rather lies in his enactment of a non-*hylomorphic* (form-matter) relation between science and thought by demonstrating that metastable equilibrium is in effect an ontogenetical requirement for the individuation of being.

Muriel Combes addresses the issues regarding the reception of Simondon's oeuvre and warns against tendencies that reduce his philosophy to epistemology, metaphysics, or technoscience.[4] She points out that Gilles Deleuze constituted an exception by initiating a new thread that opened up to Simondon's philosophy of individuation.[5] In *A Thousand Plateaus*, Deleuze and Guattari further remark that the politically suggestive concept of individuation inaugurates a new materiality. In Simondon, they write, "what one addresses is less a matter submitted to laws than a materiality possessing a *nomos*"[6]. Such materiality indeed exists in Simondon yet not without problems. In order to prevent the epistemic tendencies that recuperates the form-matter dualities, it is exigent to revisit Simondon's invocation of the scientific concepts in *L'individu et sa genèse physico-biologique* in relation to how they function "for us" and how they reticulate and redistribute the onto-political field yielding multiple threads of thought.[7]

Despite Simondon's candid distinction between the vital and the physical processes, the *physico-biological* genesis demands a commonality between these processes. Without reducing one to the other, Simondon cautiously posits the metastable equilibrium as the condition of possibility of both processes. In the introduction, he draws attention to the technical insufficiency of the existent ontological modalities to conceive the inherent relation between the metastable state and the vibrant matter. Instead, he proposes a new ontogenetic lexicon that draws upon thermodynamics, quantum field theory, and information theory. Despite the restrictions in his application of scientific concepts of the period, his account of ontogenesis nonetheless marks the transition from "a matter to a materiality." In order to register the decisive assonances between the physical individuation and "a materiality with a *nomos*," I suggest probing other physical individuations that extend beyond the limits of equilibrium structures and that further contribute to the constitutive confusion between the vital and the physical.

On the basis of Deleuze's comment, having a *nomos* indicates matter's operative functionalities that defer equilibrium. In their collaborative work *La Nouvelle Alliance*[8] (1978), Ilya Prigogine and Isabelle Stengers posit the onto-scientific constituents of such deferral. They address the physical, chemical, and vital processes in which matter depicts a collective behavior that results in the formation of structures with different degrees of complexity. Simondon's criticism of equilibrium and his theory of the physical and the vital individuations attain their methodological and onto-scientific underpinnings in Ilya Prigogine's theory of dissipative structures. In order to demonstrate the immanent relation between matter's activity and the deferral of equilibrium, it is necessary to extend the conditions of the problem of the physical and the vital individuations to the formation of dissipative structures. Conversely, Prigogine's concept of dissipative structures finds its onto-scientific and onto-genetic relay in Simondon's non *hylomorphic* materiality.

2

In *L'individu et sa genèse physico-biologique,* Simondon explores the constituents of the physical and the vital individuations. He begins his analysis with a critique of stable equilibrium that impedes the ways in which the dynamic processes of individuation may occur. "At equilibrium all possible transformations have been actualized and no force exits. When all potentials are actualized, system having reached its lowest energy level can no longer transform itself"[9] (IG 6). For Simondon, the concept of equilibrium implies a homogenous distribution of the terms that compose it, and thus indicates a flat ontology in which all transformations are ultimately exhausted. Such conception of equilibrium that does not allow for the potential alterations renders matter inoperative. Simondon concludes that the notion of stable equilibrium cannot account for the operation of the physical and the vital individuations since it excludes becoming:

> Individuation has not been able to be adequately thought and described because previously only one form of equilibrium was known--stable equilibrium. Metastable equilibrium was not known; being was implicitly supposed to be in a state of stable equilibrium. However, stable equilibrium excludes becoming, because it corresponds to the lowest possible level of potential energy. (IG 6)

Simondon in this passage posits the metastable equilibrium as the ontogenetic condition of the possibility of individuation. The concept offers a new mode in which matter can be thought beyond the limits of form-matter modality. Metastable equilibrium in effect marks the transition from inert matter to operative materiality denoting the subterranean processes that occur within it.

The concept of metastable in relation to the statistical ergodic theory first appeared in Norbert Wiener's work *Cybernetics* in 1948. On the basis of the probabilistic interpretation of entropy within the information theory, Wiener underlines the inverse relation between information and entropy. His discussion of the metastable equilibrium begins with the role of the entropy function within the statistical mechanics: "[Entropy] is primarily a property of regions in phase space and expresses the logarithm of their probability measure."[10] Due to the entropic function, the probabilistic distribution of a large number of particles within a close system will always corresponds to a homogenous distribution. That is, a heterogeneously distributed state will always evolve toward a homogenous equilibrium, coinciding with an increase in the entropy. After his brief summary on the probabilistic interpretation of the entropy, he emphasizes that "however, in living matter, we lose much of this rough homogeneity."[11] The living matter does not exactly meet the probabilistic expectations since it demonstrates orderliness.

In order to explain the orderliness of living matter despite the increase in entropy, Weiner revisits the problem of the Maxwell demon[12] in the statistical mechanics. He asks, what if, as in the case of the Maxwell demon, a minute mechanism would be able to prevent the particles within a closed system from reaching the homogenous distribution? It is clear that this mechanism would violate the second law of thermodynamics and its probabilistic calculations. Therefore, Wiener argues that nothing is easier than to deny the possibility of such mechanism. But the dismissal of this speculative thought from the outset misses "an admirable opportunity to learn something about entropy and about possible physical, chemical, and biological systems." Following the paradigm of Maxwell's demon, he furthers that there must be a coupling between the so-called mechanism and the particles that it observes. Then the question of entropy consists not in the isolated system of the particles but in the total system of the demon-gas coupling. "The gas entropy is merely one term in the total entropy of the larger system. Can we find terms involving the demon as well which contribute to the total entropy?"[13]. It is at this critical moment that Weiner brings up the concept of metastable. The mechanism, he says, would be decomposed in time. However, during the interval of time before it reaches equilibrium, "we may speak of the active process of the demon as metastable. There is no reason to suppose that metastable demons do not in fact exist; indeed it may as well be that enzymes are metastable Maxwell demons, *decreasing entropy*, perhaps not by the separation between fast and slow particles but by some other equivalent process."[14]

The order that the mechanism introduces to the system coincides with the decrease in entropy in Wiener's analysis. Despite this questionable correlation between information (order) and negative entropy, his discussion raises two significant questions: that of the effects of metastable equilibrium and of the role of the energy exchanges within a system in regard to the total entropy. Although Simondon inherits the inverse equivalence between entropy and information directly from Wiener[15], he does not incorporate these crucial questions into his analysis of the physical individuations and to the role of metastable equilibrium in them. In the introduction, he suggests that the notions of order and of the increase in entropy must be known to comprehend the metastable equilibrium; however, he limits his analysis merely to the availability of the potential energy within systems. Stengers' criticism of Simondon consists in this omission. She stresses that the transductive progress in Simondon, which relates the progression of the crystal to the vital individuation, does not take into account the losses and the neglected alternatives.[16] Stenger's interpretation addresses the problem that any process of physical individuation occurring in metastable equilibrium (far from equilibrium) in fact demands an analysis that involves the question of dissipation.

In the second chapter "Forme et Énergie," Simondon discusses that the potential nature of the thermal energy is inherently related to the transformation of the system through the modifications of its energetic states. He argues that "the capacity to be a potential energy is closely bound to the presence of a heterogeneous relation, of a dissymmetry in relation to another energy support" (IG 76). He aptly observes that in order to sustain the heterogeneity, "one should be able to give order to the disorder of molecules by separating the cold ones from the hot ones" (IG 76). Simondon here underlines the significance of the Wiener's discussion on the hypothetical "Maxwell demon" in *Cybernetics* and states that the potential energy can be extremely instructive in terms of inventing a proper method for the operation of individuation (IG 76). Crucial as this reference to the information theory may be in the development of Simondon's framework, his theory of individuation is not built upon the notion of entropic price. Simondon focuses on the energy functions in thermodynamic systems rather than entropy functions. Stengers takes issue with Simondon's inability to incorporate the entropic price to his ontogenetic formulation and directs her criticism against Simondon's insistence upon energetics. "Energy that intervenes with the phase transitions of the equilibrium does not play any decisive role within the phase transitions of the non-equilibirum."[17]

Despite a certain validity of Stengers' criticism of Simondon, it is possible to interpret Simondon in another direction that has already been taken by Deleuze and Guattari. They invoke Simondon's criticism of the form-matter modality in their brilliant analysis of the science of metallurgy. As opposed to the inductively constituted relation between form and inert matter—the former as the cause of the change in the latter—metallurgy assumes a symbiotic relation between matter and its milieu. "What metal and metallurgy bring to light is a life proper to matter, a vital state of matter as such, a material vitalism that doubtless exists everywhere but is ordinarily hidden or covered, rendered unrecognizable, dissociated by hylomorphic model"[18]. Deleuze and Guattari bring forth the metabolic quality that is inherent in the operation of metallurgic individuation of matter. In order to put emphasis on the metabolic nature of matter with its milieu, they use, after Simondon, the term material. Metallurgy for Deleuze and Guattari becomes a point of interest because it seeks what the material is capable of. In parallel with Deleuze and Guattari, Jacques Roux argues in *Une Pensée Opérative*, the notion of material in Simondon indicates a uniquely fundamental departure from the science of matter, which distinguishes bodies according to their form and thus lacks the vital point that matter has a relation with its milieu.[19]

Such materiality finds its strongest articulation in Simondon's concept of *allagmatique*. The concept genuinely captures the operative mode of materiality, having the sense of change and exchange at once. For Simondon, it is this operative mode of materiality that is elided in the form-matter modality:

> The form-matter model retains only the ends from the two half-chains that the technical operation elaborates; the schematics of the operation itself is veiled, been ignored. There is a hole in the form-matter representation, making the true mediation disappear, the operation itself which attaches one to the other both half-chains by instituting an energy system, a state that has evolved and must indeed exist so that an object appears with its haecceity. (IG 40)

True mediation here refers to the new concept of relation in Simondon's philosophy—"*la relation a valeur d'être*" (IG 68). In excess of the terms that compose it, relation (*rapport*) attains a transductive value which becomes the constitutive of the term *allagmatique* in Simondon. As opposed to the form-matter model, transductive relation implies that the terms do not precede the relation and the relation itself is dynamical. "The relation is a modality of being; it is simultaneous to the terms for which it ensures the existence" (IG 6). The representative logic of the form-matter modality assumes the terms of a relation prior to the relation itself, therefore leading to a tautological trap in the epistemological sense. Simondon elaborates the unwarranted consequences following from the pervasive application of the form-matter modality to the ontogenesis of being in both science and philosophy. He radically alters the impaired definition of 'relation' as representation by introducing the new notion of relation as transduction that ultimately overturns the epistemological dialect of the knowing subject and the known object, by replacing it with a fluxive and metabolic (allagmatic) technicality. Transduction becomes the determining factor in Simondon's methodology since it renders the operation of hylomorphic modality obsolete in materialist constitution of being. Simondon's original contribution lies in his ability to think the relation beyond the limits of dialectics, of excluded middle, and of identity. As he frequently intimates, the hylomorphic modality is incapable of thinking the transductive relation as such: "In order to think the transductive operation, which is the foundation of individuation in its different levels, the notion of form is insufficient" (IG 22).

Simondon adamantly argues that the physical and vital individuations require metastable (far from equilibrium) conditions. Form and matter become outdated terms in understanding the non-equilibrium conditions that effectuate individuation, and the form-matter modality cannot contain a notion of relation that is capable of individuating itself. In the following passage, he proposes:

> The notion of form must be replaced by that of information, which presupposes the existence of a system in a state of metastable equilibrium that can individuate itself; information, unlike form, is never a unique term, but the signification that springs from a disparation. The ancient notion of form, such as provided by the form-matter schema, is too independent of any notion of system and metastability. (IG 22)

Not to be mistaken by its use in the information theory, one should immediately note that Simondon's understanding of information is evidently different than Weiner's definition of it. Simondon underlines that cybernetics suffers from a similar inability to conceive transmission as a transductive operation. He directs his criticism to the information theory of the transmission technologies that reduces information to a signal or a static medium, ignoring its essential component: the receiver. As Muriel Combes points out, signal in Simondon exceeds its limited use as merely that which is transmitted and attains the sense of that which is also received, by therefore denoting a signification.[20] In parallel with his criticism of the form-matter modality, Simondon observes an operative insufficiency in Weiner's definition of information. He aptly addresses the problem of the information theory and insists on a new conceptual framework that counters it. For him, the term information demands a transductive medium and an allagmatic relation with the milieu. "Information is the exchange, the modality of internal resonance according to which individuation is effectuated. Information is informing and informed at once; it must be seized within the activity of being that individuates" (IG 289). Information as such allows for a reexamination of Weiner's interpretation of the Maxwell's demon. Its specific efficacy consists in ruling out the notion of unilateral transmission effectuated by a single efficient cause that is capable of changing and controlling the system without being affected by it. Information in Simondon, as it is best demonstrated in Brian Massumi's suggestive interpretation, implies a disparity—a difference that makes a difference. Massumi argues that this differencing process, unlike the information theory, cannot be understood in merely quantitative terms, it rather designates a qualitative change (allagmatic). Correlatively, Bernard Stiegler effectively articulates the issue by suggesting that information in Simondon is improbabilistic. Stiegler's insightful comment on the difference between Wiener and Simondon raises the issue to an onto-scientific vicinity. In order to elaborate the issue at hand the imbricate relation between probability and consistency must be posited. Simondon's criticism of equilibrium state, the most probable distribution of the particles in an isolated system, attains its fullest sense in the counterargument of Ilya Prigogine that demonstrates what conditions the emergence of the least probable against Boltzmann's probabilistic calculations of entropy[21].

3

Ilya Prigogine and Isabelle Stengers counteract the problem in their collaborative work *La Nouvelle Alliance*. They lay out the constituents of a radical materiality that enacts matter's evolution toward complexity despite the second law. They illustrate that there exist physical processes that bent the Boltzmann interpretation by effectuating the conditions of what has been considered as improbable. The second law of thermodynamics states that the increase of entropy implies a proportional increase of disorder. At equilibrium, particles become insensitive to one another and their affinity indicates zero-value while entropy reaches its maximum- ultimate disorder. At first sight, it may seem that entropy understood as the measure of disorder contradicts with the emergence of ordered structures. How is it that the particles within a system avoid their entropic fate and individuate into heterogeneous structures with higher complexity? What compels them to acquire affinity despite their tendency to evolve toward equilibrium? In response to this critical question, Prigogine addresses the inherent link between order and entropy.

In order to elaborate the role of entropy in the emergence of complex matter, Prigogine shifts the emphasis from closed systems, which are ultimately categorical and scientific idealizations, to opens systems that are defined by their allagmatic relation with their environment. This shift becomes indispensable for a constructive analysis of individuation in that it allows for a structurally variant nexus to rethink the inherent link between entropy and the physical individuation. The seemingly paradoxical status of entropy as that which tends toward equilibrium and at the same time as that which tends toward increasing complexity becomes the enabling limit of the physical individuation. A system must be posited far from equilibrium in an allagmatic exchange with its environment in order for particles to gain affinity and begin to interact. Prigogine and Stengers emphasize that "thermodynamics leads to an initial general conclusion concerning the systems that are liable to escape the type of order governing equilibrium. These systems have to be 'far from equilibrium" (OC 141).[22] In far from equilibrium—what Simondon calls metastable equilibrium—the tendency toward leveling out the differences and forgetting the initial conditions can no longer be sustained and systems begin to demonstrate sensitivity to possible fluctuations induced by their exposure to outside. Beyond a critical value of an imposed chemical or heat gradient, fluctuations emerge and the system becomes unstable. Instead of evolving toward the attractor state (equilibrium), the system indeed yields unexpected structures with a higher level of complexity. The slightest fluctuation produced under far from equilibrium conditions has the capacity to affect the system globally, changing the behavior of the system. As Prigogine observes, "in cases where instability is possible, we have to ascertain the threshold, the distance from equilibrium, at which fluctuations may lead to new behavior, different from the 'normal' stable behavior characteristic of equilibrium or near equilibrium systems" (OC 141).

It is necessary to note that closed systems not only ignore the initial conditions but are also immune to the fluctuations that may occur in them. Essentially, receptiveness requires being open to a milieu such that particles can begin to communicate and interact under unstable conditions yielded by the system's relation to its milieu. Open complex structures feed on the flux of energy that they receive from their environment, and isolation from their environment consecutively results in death—the logical conclusion of the second law. Therefore, they have to be in exchange with their milieu in order to avoid thermal and chemical equilibrium. However, the energy and matter flux coming from outside induces systems to produce more internal entropy. Given the second law, we know that internal entropy production ultimately leads to an equilibrium state. Then how does an open structure avoid its death while it produces internal entropy induced by its environment? Prigogine explains that "The heat or matter flux coming from the environment determines a negative flow of entropy d_eS, which is, however, matched by the entropy production d_iS due to irreversible processes inside the system. A negative flux d_eS means that the system transfers entropy to the outside world"[23] (OC 139). In order to maintain its consistency and stability, system exports the produced entropy to its milieu. When the linear region is exceeded by a system under the effect of thermal, chemical, gravitational or any other force, the system becomes unstable. Fluctuations engender an increase in the entropy production within the system and this increase is compensated through the entropy transfer from d_iS to d_eS, which is incorrectly termed negentropy. Stengers addresses the problem with this derivative concept that is too readily accepted in technoscience:

> [M]any were satisfied by a single elegant answer to the question of the relation between the second principle and the kind of stable order characterizing living beings. The answer was that such an order corresponds to a production of negentropy that is 'negative entropy'. This is indeed a perfectly satisfying answer since it corresponds to the old vitalist idea that one way or another, life must be defined as against physics, the rules of physics corresponding to death, the loss of the active coherence of life.[24]

A further critical analysis of the concepts that underlie this quasi-term is required to elicit the physical individuations despite the entropic tendency toward equilibrium. Prigogine's unparalleled contribution lies in his reenactment of the concept of entropy in a radically different facet that withstands the old vitalist idea. He brilliantly frames the problem and states that entropy cannot be considered solely as a concept of degradation and disorder, but it must also be posited as a concept of production: "increasing entropy is no longer synonymous with loss but now refers to the natural processes within the system" (OC 141).

Schrödinger in his work *What is Life?* coins the term negentropy in response to the question of how an organism avoids the rapid decay into the inert state of equilibrium. As the organism continually maintains the activities of sustenance in contact with its milieu, it produces internal entropy and thus tends toward the ominous state of maximum entropy. Schrödinger argues that it can only avoid equilibrium- biological death- by continually importing negative entropy from its environment. However, he immediately corrects the expression and states that "hence the awkward expression of 'negative entropy' can be replaced by a better one: entropy, taken with the negative sign, is itself a measure of order. Thus the device by which an organism maintains itself stationary at a fairly high level of orderliness (=fairly low level of entropy) really consists in sucking orderliness from its environment"[25]. This explanation unavoidably raises ontological problems by reinforcing the old division between order (information) and disorder (entropy) in a negatively teleological manner: it posits entropy merely as a concept of degradation and death. In retrospect, Weiner recuperates the same division by reducing information to negative entropy, and thus fails to see the conditions that underlie the relation between the second law and the living matter. Prigogine effectively detects the negative overtones of this divide that equates entropy with death. Stengers informs us that:

> If Prigogine could not accept negentropy as satisfying the problem of life, defining life as an exception or as some kind of antagonist power opposing the general power of the second principle, it is not because he wanted to explain life in terms of physics, but because for him it was not a solution, just another name for the problem. In order to characterize non-equilibrium situations, you can no longer rely on the second principle to define stable states. All situations in an open, far-from-equilibrium system, that is, a system whose exchanges with its environment keep the processes going on, do satisfy the second principle.[26]

Prigogine mathematically demonstrates that for open systems total entropy variation in time is equal to the sum of internal entropy production and external entropy flow, formulated as $dS = d_eS + d_iS$. The distinction must be made in order to conceive the inherent structure of non-equilibrium which effectuates open-complex structures with irreversible processes. As early as 1865 Clausius had already illustrated that the inequality $d_iS/dt > 0$[27] is due to the irreversible changes involved in entropy production. According to Prigogine, this interpretation paved the way to the distinction between entropy flow and entropy production. He explains that at equilibrium, all the quantities such as temperature become time independent ($dS=0$) such that the quantity of the internal entropy production and the quantity of the external entropy flow even out each other. In other words, if the internal production is positive, then the external entropy flow has to be its negative equivalent.[28] In order to avoid equilibrium ($dS=0$), the system has to remain at a lower level of entropy. However, Prigogine observes that internal entropy production cannot change its sign as time goes on because the process is not reversible[29]. Instead, it transfers entropy to the environment to remain at a low level. This transfer of entropy is known as d_eS, negative entropy flow. More accurately, purchasing order from outside implies, in effect, transferring negative entropy flow to the environment. Schrödinger reductively argues that if entropy implies disorder it must also indubitably imply order when it takes a negative sign. However, the obstacle here is that entropy production cannot change its sign (entropy barrier). Accordingly, as Prigogine demonstrates, it is this limit that conditions the emergence of ordered structures[30].

The physical individuation is effectuated by the allagmatic relation between the internal entropy production d_iS and the negative entropy flow d_eS. In far from equilibrium system's exposure to environment is so heightened that it has to produce internal entropy to compensate. The dynamical dependency on the milieu conditions the possibility of dissipative structures: "the interaction of a system with the outside world, its embedding in non-equilibrium conditions, may become in this way the starting point for the formation of new dynamic states of matter—dissipative structures" (OC 143). The physical individuation at far from equilibrium is dissipative due to the entropic price paid for its formation.[31] Prigogine gives the renowned example of Benard Cell in order to illustrate the role of allagmatic exchanges (d_iS and d_eS) during the physical individuation. When the lower surface of a liquid is heated (d_eS) to a given temperature, heat flux moves from bottom to surface and after a threshold the fluid's state of rest becomes unstable. Convection cells (d_iS) appear corresponding to the coherent motion of molecules, increasing the rate of the heat transfer from bottom to surface. The coherent motion of a large number of molecules that forms hexagonal convection cells at macroscopic levels is defined as the spontaneous self-organization emerged within non-equilibrium conditions. During the transportation of heat, entropy production increases, leading highly ordered complex structures. Rather than evolving towards disorder (equilibrium), the process creates highly ordered convection cells. The entropy barrier here appears as the enabling limit. The heat flux is formed according to the temperature difference between the lower and upper surface of the liquid. Molecules when exposed to surplus energy from outside choose the best possible way to transmit the heat from the lower to upper surface so that they could reach equilibrium faster. The way that they organize themselves to increase the rate of heat transfer corresponds to the entropy production. However, the fluid cannot reach its initial state of rest (equilibrium), as long as it receives thermal energy from outside. The singular event of the Benard's Instability gives a more primordial sense to Stiegler's innovative comment on the physical individuation such that it informs the relation between order and entropy in a radically different manner. The number of complexions corresponding to the coherent motion of cells during convection is so small that according to the Boltzmann principle this event is highly improbable to occur. Yet it happens.

Whereas at equilibrium there is no production, in far from equilibrium the internal entropy production increases by articulating differences. The communication and interaction among the particles yield the condition of possibility of production. In far from equilibrium conditions, entropy can neither be simply associated with transition nor with waste or decay, but it emerges as a concept of production. Although in classical thermodynamics heat transfer was considered as a source of waste, in Benard Instability it becomes the source of production. According to Prigogine, this suggests that open systems, interacting with the milieu, initiate the emergence of new dynamic states of matter—dissipative structures.

4

The Aristotelian and Hegelian methodologies fall short in explaining the evolution of matter toward complexity. The relation between internal entropy production and negative entropy flow cannot be understood through the principle of identity or of excluded middle. Neither can it be explained through dialectics that consists in negation. On the other hand, Simondon's methodology responds to the pressing need for a conceptual framework that effectively articulates the relation between the entropy production and the individuation of complex matter. His concept of metastable equilibrium and of allagmatic relation with the milieu helps ontologically conceptualizing the entropy production inside the system that yields higher level complexities rather than reaching equilibrium. Simondon elicits the incompatibility and the inadequacy of the existent methodologies that draw upon the principles of representation- identity and excluded middle- and utilize the form-matter terminology that consists in the interchangeable application of form and matter. He emphasizes the necessity of displacing the form-matter modality and its ominous conclusion that leads to the identical relation of being to itself with a new method that renders being non-identical to itself. Moreover, the principles of identity and of excluded middle can neither conceive nor contain the notion of non-identical relation that in fact is the constitutive of an ontogenesis that embarks upon the capacity of being to fall out of itself. Within the solipsistic and reflective boundaries of the form-matter model, non-identity of being appears at best to be a paradox of thought that must be avoided at all expenses. However, according to Simondon, being's non-identical relation to itself is the indispensable constituent of individuation toward complexity. In order to further his analysis of being's non-identical relation to itself, he deploys the suggestive tenets of modern science at the disposal of the ontogenetics that is disentangled from the ominous principles of hylomorphic and substantialist modalities: "Instead of supposing substances in order to account for individuation we take the different regimes of individuations… the notions of substance, form and matter are replaced by the more fundamental notions of information, internal resonance, metastability, potential energy and orders of magnitude" (IG 17).

Individuation in Simondon refers to the process of incessant deferral of equilibrium. Prigogine's scientific account of this deferral shows that individuation is effectuated by the commutual relation between internal entropy production d_iS and negative entropy flow d_eS. In far from equilibrium, the system's exposure to the environment is so heightened that it has to produce internal entropy to compensate. The second law states that the entropic sum (dS) always increases until its terms (d_iS and d_eS) cancel out each other. However, this entropic barrier becomes constructive under metastable conditions insofar as the system is in allagmatic reaction with its milieu. This dynamical co-dependency between a system and its milieu determines the condition of the possibility of individuation. Simondon states that "individuation must be considered as a partial and relative resolution that occurs in a system that contains potentials and encloses a certain incompatibility to itself—an incompatibility made of tension of forces..." (IG 4). In order for a system to contain tension and incompatibility, it must be posited far from equilibrium for the very reason that at equilibrium, as Simondon points out, all tensions and potentials are exhausted. In far from equilibrium particles become sensitive and develop a capacity to affect and be affected. Individuation corresponds to the process in which system defers death by a productive activity of affected particles under metastable- far from equilibrium- conditions. When the system reaches a critical threshold due to the fluctuations yielded in far from equilibrium, particles begin to interact and communicate in order to compensate for the additional energy introduced to the system from outside. System transfers the surplus entropy produced internally during the productive activity of particles to its milieu. It is this allagmatic entropy exchange between outside and inside that marks the ontological transition from inert matter to a materiality that possesses a *nomos*.

In *A Thousand Plateaus* Deleuze and Guattari redefine *nomos* as a new mode of distribution without enclosures. In their analysis, the term attains its full sense as an operation pertinent to nomadology with concomitant strategies that undermine the form-matter ideologies dictated by *logos*. "The nomos came to designate the law, but that was originally because it was the distribution, a mode of distribution, one without division into shares, in a space without borders or enclosure. The *nomos* is the consistency of a fuzzy aggregate: it is in this sense that it stands in opposition to the law or the polis"[32] This specific mode of distribution suggests an informative relation with the open as shown in the individuation of dissipative structures. Deleuze and Guattari constitute a corresponding nexus that connects Simondonian materiality with the operative functionalities of matter that are best illustrated in Prigogine's theory of dissipative structures. *Nomos* here indicates an immanent operability that is derivative of the non-equilibrium conditions which transductively distribute the singularities in heterogeneous space. Individuation of dissipative structures reveals the subterranean processes in which a "fuzzy aggregate" takes a hold (consistency) by means of the communication of otherwise unrelated singularities.

It should be noted that the underlying concept of communication here does not have any resemblance to its definition in the information theory (Shannon, Wiener, et.al.). Rather than the mere transmission of signals, communication here denotes a heterogeneous distribution of the singularities that begin to relate transductively when a threshold is reached under sufficient far from equilibrium conditions. Prigogine and Stengers note that "We can speak of a new coherence, of mechanisms of 'communication' among molecules. But this type of communication can only arise in far from equilibrium conditions" (OC 13). In order to understand fully the originality of this new type of communication, we must think it in its relation to De Donder's concept of affinity. The term signifies a transductive function that exceeds the notion of transmission, which is limited to an inactive medium incapable of transforming itself and its terms. De Donder, the precursor of this new mode of communication, reformulated the second principle of thermodynamics—previously used to be limited to an understanding of equilibrium laws for which production was zero—by constituting a relation between entropy production and a chemical reaction. The affinity function extends the problem of static interaction to the transductive relationality among the chemical forces by inaugurating a conceptual correspondence to the famous Spinozian question: What is a body capable of? Affinity here indicates a correlative potential structurally embedded in "being capable of." Furthermore, it allows for an understanding of the allagmatic exchange that consists in the transductive capacity "to affect" and "to be affected" at once. Prigogine and Stengers emphasize that affinity here revives the alchemist interpretation that construe the elective relations between chemical bodies—the likes and dislikes of molecules (OC 136).

Communication as such becomes the defining conjunction of both the physical and the vital individuations. Simondon warns us against the reductive logic of vitalisms that posits a receding hierarchy between matter and life announcing that inert nature, unlike life, does not contain a higher level of organization. In contrast, he suggests that if one posits the physical nature as already highly organized, this primitive error that reduces the complex to the simple can be avoided. "However if, from the beginning, we think that matter is provided with a very high level of organization we cannot easily hierarchize life and matter" (IG 141). Simondon succeeds in developing an understanding of complexity that is not evolved from the simple but has always already been coterminous with the individuation of being. However, his choice of crystallization as the paradigm of physical individuation nearly undermines this understanding to the extent that crystals are in fact equilibrium structures with having significantly different properties than that of dissipative structures. As Stengers argues that the effect of this paradigm may contradict what it pretends. "Far from corresponding to a process of invention, is not the transductive power of allagmatic proposition that Simondon developed in fact an assimilative power analogous to that of crystal formation; in other words, a power operating through compatibility and not a process that mind discovers?"[33] She calls into question the process of adhesion that occurs during the amplifying propagation of crystals and notes that transduction as such—mere adhesion—fails to account for dissipation.

During the crystallization, molecules position themselves with the neighboring molecules in order to maintain a 'ground state' with minimum energy. As Prigogine and Stengers explain, their positioning is defined by another thermodynamic function, the minimum free energy, different than that of the internal entropy production. The inner structure of the crystal is based on the forces of attraction and repulsion of the molecules that produce it. And the sum of its kinetic energy yielded through the molecule interactions is less than its potential energy stored within the bonds that form the crystalline structure. "Equilibrium structures can be seen as the result of statistical compensation for the activity of microscopic elements (molecules, atoms). By definition, they are inert at the global level" (OC 127). Crystals can retain their position indefinitely unless an outside energy is introduced to the system in order to change their positioning by deforming the established bonds among them. Regarding the essential difference between the crystal and dissipative structures, Prigogine and Stengers state that "the biological structure thus combines order and activity. In contrast, an equilibrium state remains inert even though it may be structured, as, for example, crystals" (OC 131).

Drawing upon the paradigm of crystallization, Simondon distinguishes between the vital and the physical individuations and argues that the living maintains a permanent activity, which is not concentrated at its limit as in the case of crystals. He stresses that both the physical and the vital individuations have internal resonance, but the latter requires a permanent relation with its milieu, unlike crystals, and maintains a degree of metastability with itself.

> In the domain of the living, the same idea of metastability may be used to characterize individuation; but in this case, individuation no longer occurs, as in the physical domain, only in an *instantaneous*, brusque and definitive manner that is like a quantum leap, leaving behind it a duality of environment and individual, with the environment being impoverished by the individual that it is not and with the individual no longer having the dimension of the environment. (IG 8-9)

However, this distinction, seemingly the object of Stengers' criticism, compels us to question the sustainability of crystallization as the paradigm of physical individuation. Bénard Instability strikingly demonstrates that the energy exchange with the milieu is not limited to the vital individuation. On the contrary, it is the preliminary condition of the physical individuation toward increasing complexity. Life and matter are not the unrelated terms of being, they rather appear as the different phases of being, both having the common condition for their existence: deferral of equilibrium. As Simondon himself points outs in his conclusion to *L'individu et sa genèse physico-biologique* "The physical individuation and the vital individuation are mode of resolutions, they are not absolute points of departure" (IG 272).

Simondon's enigmatic stance regarding the physical individuation allows us to prolong the conditions of the problem to the emergence of dissipative structures. The critical yet uncertain character of his concepts compels us to ask "how to inherit Simondon" today. Even though we may sometimes feel obliged to read Simondon against himself, it is in effect the ruptures and incises in his thought that enable us to practice an apprenticeship with his oeuvre and to create further resonances with his concepts. To prolong the question of individuation is to introduce relevant inventions that communicate with Simondon's concepts by opening up new possibilities of thinking. Stengers credits Simondon's approach that conceptualizes the process of crystallization in terms of a compatibility that preexists the molecules that compose it. As opposed to a predetermined form, the compatibility suggests that the process of crystalline propagation is not independent from the metastable conditions that effectuate it. "In this sense, crystallization may designate an event, and more precisely an '*avènement*'" (139). Nonetheless, she questions whether the transductive adhesion suits the non-equilibrium processes in which the milieu, as opposed to its role in the amplifying propagation of crystallization, not only prevents equilibrium but also renders the collective activity possible. This critical nuance becomes the measuring component of physical individuation in which the regime of collective activity appears under a constraining relation with the milieu.

Prigogine's invocation of the chemical clocks adequately embodies the tight economy between the milieu and the emergence of collective behavior. When one of the chemical components exceeds a chemical threshold, the system leaves its steady state and becomes unstable. It starts oscillating between two attractors, yielding a limit cycle. In contrast to the Boltzmann Principle, chemical clocks demonstrate how far from equilibrium conditions stimulate otherwise indifferent entities by yielding a new regime of collectivity. Prigogine and Stengers posit the entropy production as the veritable source of communication that effectuates higher level of individuations at the physical level. Their analysis irreversibly alters the paradigm of physical individuation assigning it a sense of *nomos*.

> Such a degree of order stemming from the activity of billions of molecules seems incredible, and indeed, if chemical clocks had not been observed, no one would believe that such a process is possible. To change color at once, molecules must have a way to 'communicate'. The system has to act as a whole. We will return repeatedly to this key word communicate, which is of obvious importance in so many fields, from chemistry to neurophysiology. Dissipative structures introduce probably one of the simplest physical mechanisms for communication. (OC 146)

Dissipative structures put into question our instrumental notion of communication by introducing a reticulative relationality that is determined by the non-equilibrium conditions that produce it. The complex character of such communication renders irrelevant the intelligibility of that which produces the collective. Communication in dissipative structures appears not as a result of the linear multidirectional amplification but as a consequence of the non-equilibrium conditions in relation with the milieu. Stengers detects that the dissipative processes cannot be explained by means of adhesion or by *avènement*. What then adequately responds to this radically altered notion of communication? We must reinscribe here what compelled Simondon to introduce a new concept of relation that he termed transduction. It was initially Simondon's critical objection against the representative models of relation that are incapable of conceiving the non-identity of being as such.

> However, in order to render this terminological and conceptual change possible, a new method and a new notion are needed… A relation must be understood as relation in being, as a relation of being, a manner of being and not a simple relation between two terms that could be adequately known using concepts because they would have a separate and prior existence. It is because the terms are understood as substances that the relation is a relation of terms, and being is separated into terms because being is primitively—that is to say before any investigation of individuation—understood as substance. If, however, substance is no longer taken to be the model of being, it is possible to understand relation as the non-identity of being to itself—as the inclusion in being of a reality that is not only identical to it… (IG 6)

This notion marks the moment of transition from the representative models of being into a materialist technicality of becoming. Simondon stresses that the principles of identity and excluded middle, from the outset, reject the possibility of the fundamental condition of being that is "to fall out of itself" (*se déphaser*). He proposes the notion of transduction to capture this previously unthinkable sense of relation that is non-identical to what effectuates it and that has no foundation in the whole of which it may be a part. It posits a non-teleonomic activity that undermines the principle of identity by producing heterogeneous and non-identical effects that have no resemblance to what yields them. Such notion finds its accurate rendition in the concept of dissipative structure that demands a non-identical relation due to both the processes of production and dissipation that occur within it. In the case of the Benard cells and the chemical clocks, transduction exceeds its adhesive definition as propagation (crystallization), and captures the dissipative and complex character of being that is not identical to itself. After all, do not we find the most adequate expression of this new alliance between Simondon's concept of individuation and Prigogine's concept of dissipation in Stenger's own words? "Far from equilibrium, it is the (nonlinear) couplings between the processes that start to play a predominant role, determine the regimes of stability and the zones of metastability that give a sense to '*dissipative individuation*'"[34] This bifold articulation of dissipation and individuation allows us to conceive the aforementioned notion of materiality possessing a *nomos* such that it introduces a radically different notion of communication and collectivity as a result of the non-linear couplings between processes at far from equilibrium.

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NOTES

1. Stengers, Isabelle. "Pour une mise à l'aventure de la transduction" *Annales de l'Institut de Philosphie de l'Université de Bruxelles: Simondon*. Ed. Pascal Chabot. Vrin: Paris, 2002.
2. See also Muriel Combes' rigorous articulation of the relation between "the test of Zarathustra" and "the test of transindividuality." *Simondon. Individu et collectivité: Pour une philosophie du transindividuel*. PUF: Paris, 1999, 34-39.
3. Stengers gives a suggestive summary regarding this issue in "Pour une mise à l'aventure de la transduction."
4. Simondon's dissertation (1958) was published in two volumes separated by an interval of twenty five years: *L'individu et sa genèse physico-biologique* (1964) and *L'individuation psychique et collective* (1989). Mureil Combes explains that *Du mode d'existence des objets techniques* (1958) was more publicized at the time. Simondon was acknowledged as the "thinker of technics" and his philosophy of individuation was regrettably overlooked (*Simondon. Individu et collectivité*, 4).
5. Deleuze wrote a review on *L'individu et sa genese physico-biologique* after two years of its publication, indicating the affinity between Simondon's concept of internal resonance and the theory of affects, implicitly referring to Spinoza. He also celebrated Simondon's inspiration by what is contemporary in science. The review is originally published in *Revue Philosophique de la France et de l'Erranger* 156 (1966), 115-118.
6. 408.
7. One notably observes the ontopolitical ramifications of Simondon's theory of individuation in Bernard Stiegler, *Technics and Time I*. Trans. Richard Beardsworth and George Collins. Stanford University Press: Stanford, 1998; Etienne Balibar. "Spinoza: From Individuality to Transindividuality." *Mededelingen vanwege het Spinozahuis* (1997 3-36), 71; Paulo Virno. "Angels and the General Intellect: Individuation in Duns Scotus and Gilbert Simondon," *Parrhesia* 7 (2009, 58-67).
8. The English translation of this work is Ilya Prigogine and Isabelle Stengers, *Order out of Chaos: Man's New Dialog with Nature.* Bantham Books: New York, 1984, 9. This and all parenthetical references to IG are taken from Gilbert Simondon, *L'individu et sa genèse physico-biologique: l'individuation à la lumière des notions de forme et d'information*. Paris:PUF, 1964.
10. Norbert Weiner, *Cybernetics: or Control and Communication in the Animal and in the Machine*. Cambridge: The MIT Press, 1965, 56.
11. Ibid., 57.
12. This notion originates from the following passage in J. C. Maxwell's famous work *Theory of Heat*: "If we conceive of a being whose faculties are so sharpened that he can follow every molecule in its course, such a being, whose attributes are as essentially finite as our own, would be able to do what is impossible to us. For we have seen that molecules in a vessel full of air at uniform temperature are moving with velocities by no means uniform, though the mean velocity of any great number of them, arbitrarily selected, is almost exactly uniform. Now let us suppose that such a vessel is divided into two portions, A and B, by a division in which there is a small hole, and that a being, who can see the individual molecules, opens and closes this hole, so as to allow only the swifter molecules to pass from A to B, and only the slower molecules to pass from B to A. He will thus, without expenditure of work, raise the temperature of B and lower that of A, in contradiction to the second law of thermodynamics." James Clerk Maxwell, *Theory of Heat*. London: Longmans, Green, and CO., 1872, 308. This thought experiment has been later on refuted by Leo Szilard (1929) and Leon Brilloin (1949) on the basis of the entropy production: information acquisition is dissipative, that is, the act of acquiring information by the being would require an expenditure of energy.
13. Ibid., 58.
14. Ibid., 58 [My Emphasis].
15. "[I]nformation is, as expressed by Norbert Wiener, that which is opposed to the degradation of energy, to the augmentation of entropy within a system; it is essentially negentropic" (IG 251).
16. "Pour une mise à l'aventure de la transduction," 140
17. Isabelle Stengers, "Comment hériter de Simonson? " in *Gilbert Simondon: Une Pensée Opérative*. Saint-Étienne: Publications de l'Université de Saint-Étienne. 2002, 306.
18. Deleuze and Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*. Trans. Brian Massumi. Minneapolis: The University of Minnesota Press, 2005, 411.
19. Roux, Jacques. "Entre le Moule et l'Argile: La Science des Matériaux est-elle Allagmatique?" in *Gilbert Simondon: Une Pensée Opérative*. Saint-Étienne: Publications de l'Université de Saint-Étienne. 2002, 275.
20. Muriel Combes, "Vie, Pouvoir, Information" in *Gilbert Simondon: Une Pensée Opérative*. Saint-Étienne: Publications de l'Université de Saint-Étienne. 2002, 170.
21. Boltzmann principle states that in an isolated system the probabilistic distribution of a large number of particles ultimately leads to a homogenous distribution—defined as the most probable state.
22. This and all parenthetical references to OC are taken from Ilya Prigogine and Isabelle Stengers, *Order out of Chaos*. New York: Bantam Books, 1984.
23. *S* stands for entropy while *dS* stands for entropy variation, and (*e*) stands for external while (*i*) stands for internal. In relation to Boltzmann's probability calculations, Schrödinger coins the ambivalent term "negentropy" during his lectures in February

1943 at Trinity College. However, the term implies negative flux deS defined by Prigogine.
24. Isabelle Stengers "The challenge of complexity: Unfolding the ethics of science. In memoriam Ilya Prigogine" *E:CO Special Double Issue* 6:1-2 (2004, 92-99), 94.
25. Erwin Schrödinger, *What is Life? The Physical Aspect of the Living Cell*. New York: The Macmillan Company, 1945, 73.
26. Stengers, "The Challenge of Complexity," 94.
27. This equation states that the internal entropy increases in time.
28. If $dS=0$, then $d_eS= --d_iS<0$
29. "Note that the positive sign of *diS* is chosen merely by convention; it could just as well be negative. The point is that the variation is monotonous, that the entropy production cannot change its sign in time" (OC 118).
30. Prigogine's theorem of the minimum entropy production states that the entropy production decreases as the system approaches equilibrium. Therefore entropy reaches its maximum value and the entropy production ceases at equilibrium. However, in order to conceive the emergence of dissipative structures it is indispensible that entropy be considered as a concept of production.
31. Prigogine and Stengers explain that a new line of inquiry was introduced during the nineteenth century with the developments in Thermodynamics. In 1811 Jean-Joseph Fourier mathematically formulated the propagation of heat in solids, observing that the heat flow is proportional to the gradient of temperature. In other words, the distribution of temperature is progressively equalized within a closed system until homogeneity is reached resulting in thermal equilibrium. This new theory was completely alien to the Newtonian science in that heat propagation implied an irreversible process. However, despite the mathematical formulation of the heat propagation and its use in engineering, the relation between the thermal equilibrium and the irreversible processes was not established until Clausius redefined the Carnot cycle in 1850. He posited that the ideal thermal engine imagined by Carnot ignored the price paid for the restoration of the engine to its initial thermal conditions. The Carnot cycle did not take into account the irreversible processes that indeed effectuated its actualization. It disregarded the fact that there was an irreversible energy lost: the coal was burning in order to maintain the machinic cycle. Clausius reformulated these questions and introduced a new concept called *entropy* in 1865. As Prigogine and Stengers argue, he made the first distinction between the "useful" energy exchanges that is conserved and the dissipated energy that is irreversibly lost (OC 117). Prigogine's account of dissipative structure consists in the double articulation of dissipation and production.
32. Deleuze and Guattari, *A Thousand Plateaus*, 380.
33. Stengers, "L'Aventure de la Transduction," 138-139.
34. Stengers, "L'Aventure de la Transduction," 145 [My Emphasis].