

Dialectics of Entropy: Notes on the Topology of Time¹

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Abstract:

This paper is dedicated to sketching out, in broad outline, a system of metaphysics that takes the notion of entropy and the second law of thermodynamics as ontologically as possible. The 19th century saw a dramatic transformation in the basic categories of knowledge. Following the Industrial Revolution, both in metaphysics (dialectical materialism) and in physics (entropy and the second law of thermodynamics), the notions of time and matter became, as is argued here, intertwined. In this paper, I examine the notion of entropy so as to form a notion of a material, emergent temporality. Such a temporality is strongly non-linear and is unevenly distributed among material systems. The goal of this will be to show what the consequences of the Industrial Revolution have been on our conception of the form of time. Rather than the formal, linear time of Newtonian mechanics and Kant's transcendental idealism, I suggest that entropic time implies a world that is temporally non-orientable, relating back to itself in important ways. Taking some topological ideas from Deleuze's treatment of the third synthesis of time in *Difference and Repetition* (1969), as well as Žižek's concept of dialectical materialism from *Sex and the Failed Absolute* (2019), I will show how these disparate notions of material time bear on the topology.

Keywords:

Entropy, Dialectical Materialism, Time, Topology, Deleuze, Kant, Plato

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1. What's the Matter with Time?

The concept of entropy, which names in physics the tendency of matter to wear out and decay, has been a hot-button issue since its inception in the 19th century. With the Industrial Revolution and the prevalence of the heat engine, the temporal characteristics of matter came to the fore, as phenomena related to heat usually entail irreversible change—like burning a piece of paper—garnered more interest. Entropy is the concept aimed at capturing this irreversibility, and so, as I shall argue, the materialisation of time. While Newtonian physics concerned itself with the motions of bodies, it says nothing about changes *internal* to the constitution of those bodies. For Newtonian physics, gravitational dynamics, so-called celestial mechanics, was the main concern, and so it almost exclusively deals with motion in space. Such motions are reversible. In that theoretical frame, time is external to the moving bodies. The concept of entropy captures a temporality that is internal to material bodies. It theorizes changes in the quality of matter, rather than quantity and place. In doing so, thermodynamics breaks with the time-symmetry of Newtonian physics. Changes of quantity are reversible, and so show no affinity to a particular direction of time, while changes of quality can only go in one direction—qualities, thermodynamically speaking, cannot be changed back. Because Newton's laws were taken to be fundamental laws, this disparity raised a serious *aporia*: how can a direction of time emerge from laws that make no directional distinctions?²

This foundational problem for theoretical physics results from a change of metaphysical perspective about the relationship between time and matter. What brings about the question regarding the origin of the direction of time is a change in the role of time in the order of the world. With the development of thermodynamics, time could no longer be understood as something purely formal and external to matter—what is sometimes called mathematical time. Rather, thermodynamics forces an understanding of time as something that inheres in the principles of matter itself. From an entropic viewpoint, it is not that matter moves in accordance with the form of time, as it did in Newtonian physics, but that matter itself is temporal. It is not that matter changes in time, but that time changes matter.

The goal of this paper is to explicate some of the metaphysics I take to be implicit in this rejoining of the concepts of time and matter. The classical view that divorces time and matter is radically transformed in the wake of the Industrial Revolution. In the realm of the concepts of physics, this is most manifest in the notion of entropy, as I will flesh out in what follows. The basic notions of our understanding of the world were drastically revised at the time of the Industrial Revolution and the development of

2 This question was first put forward by Lord Kelvin, to which he also suggested a solution, in W. Thomson, "The Kinetic Theory of the Dissipation of Energy," *Nature* IX, (1874): 441–444. Then again, by Loschmidt, as a paradox, meant as an argument against the work of Ludwig Boltzmann on statistical mechanics, in the *Umkehrwand* paper. For a contemporary discussion of these problems, see David Z. Albert, *Time and Chance* (MA: Harvard University Press, 2000) and TY., Wu, "Boltzmann's *H*-theorem and the Loschmidt and the Zermelo paradoxes," *Int J Theor Phys* 14, (1975): 289–294.

thermodynamics. In this paper, I would like to develop some intimations of the systematic metaphysics that might be implied by the entropic physics that resulted from the Industrial Revolution. The idea that the Industrial Revolution might have had a profound impact on these primary notions (time and matter) is rooted in Sohn-Rethel's thoroughly Marxist notion of a real abstraction, with which he seeks to capture the role of the mode of production in shaping the fundamental categories of thought.³ He writes:

Our explanation thus argues that the categories are historical by origin and social by nature. For they themselves effect the social synthesis on the basis of commodity production in such a way that the cognitive faculty they articulate is an *a priori* social capacity of the mind; although it bears the exactly contrary appearance, that of obeying the principle of the *ego cogito*... Our theory is directly concerned only with the questions of form.⁴

What Sohn-Rethel takes up in this quote, and continues to develop throughout *Manuel and Intellectual Labour: A Critique of Epistemology*, is the determination of the fundamental forms of thought, or categories, by the social forms of production. It is, properly construed, perhaps the most radical materialist inversion of the idea of the categories, traditionally understood to determine the objects of thinking. For Sohn-Rethel, the categories are not only a conceptual framework that shapes our thinking about objects but are also in themselves determined by the objects of thinking. The social forms of production are at work in the categories of thought—they form the very way we conceive of the world around us. In this spirit, the goal of this paper will be to trace out the consequences of one change that occurred in our fundamental categories, namely the profound interdependence of matter and time revealed in the second law of thermodynamics. Guided by the concept of entropy, I will sketch out, in contradistinction with the early modern, or classical view,⁵ of Newton and Kant, the new constraints placed on our notions of time and matter. While I take the historical event to be of supreme importance, the essay will focus on the more systematic or conceptual aspects.

The primary question being: what are time and matter when they are thought to be intrinsically intertwined? I hope to show that the change in physical categories not only has radical metaphysical consequences, but that they lead us in the direction of dialectical materialism. Not merely because its sister framework, historical materialism, provides, as in Sohn-Rethel, a sense of the challenge at hand, but much more importantly, because dialectical materialism is *the* metaphysics in which time and matter are insistently thought as mutually immanent. The main bulk of the paper will be dedicated to the

3 Here and in the rest of this section, unlike most of the paper, I use “categories” in the broad, vaguely Aristotelian sense, rather than the particular sense in which Kant employs the term.

4 Sohn-Rethel, *Intellectual and Manuel Labour: A Critique of Epistemology*, trans. Martin Sohn-Rethel (Leiden and Boston: Brill, 1978), 4–7.

5 I use the term “classical” as in “classical physics,” not in the historical sense of the “classical era.”

description of the change between the classical and entropic viewpoints, and the final section will seek, by reference to Žižek's unique brand of dialectical materialism, to relate the entropic view developed with dialectical materialism. This paper aims to sketch out a path, hopefully novel, of thinking about time in light of entropy.

1. The Classical View: Immaterial Time

To get a sense of the radical change in our conceptual framework, as well as to begin to feel out the figure of the new metaphysics that that change might imply, we should begin with the classical view. While Newton was perhaps the first to explicitly put forward the canonical view of classical physics, I will take Kant to be exemplary of it, as his transcendental philosophy has as one of its foremost goals the justification of Newtonian physics by metaphysical considerations. As he declares in the *Metaphysical Foundations*, explaining the need for that book: “*Properly so-called natural science presupposes, in the first place, metaphysics of nature.*”⁶ Because we are here most concerned with the metaphysical consequences, Kant is the most inviting figure to turn to. So let us give an account of the relationship between time and matter in the critical philosophy.

Kant's theory of cognition is divided into the regulative and the constitutive. The regulative is what we associate with reason, and so too with purposiveness and moral consideration. The constitutive part of cognition in Kant's system, namely that cooperation of cognitive faculties that is required to make judgement regarding objects of possible experience, is the understanding and the intuition (mediated by the imagination). The first is general and conceptual, while the latter is particular and sensuous. The intuition is responsible for making possible the reception of objects in perception, while the understanding is the minimal conceptual cargo that is necessary for ordering these objects in judgment. Time, introduced early on in the “Transcendental Aesthetic” where the roles and operations of the intuition are first laid out, belongs to the domain of the intuition. As a form of sensibility, time is not intrinsic to phenomena, but part of the frame in which phenomena may appear. Together with space, it gives us the shape or outline of what it means for something to be phenomenal, to appear, but it is in itself independent of these phenomena. In the “Metaphysical Exposition of Time,” Kant writes:

Time is a necessary presentation that underlies all intuitions. As regards appearances in general, we cannot annul time itself, though we can quite readily remove appearances from

6 Kant, *Metaphysical Foundations*, trans. Michael Friedman (Cambridge, UK: Cambridge University Press, 2004), 5. While this text is not one of the three Critiques, it is a crucial explication of the first Critique, the main goal of which is to justify a concept of experience rich enough for the foundations of science. For a thorough, profound and scholarly exposition of this text and its role in Kant's oeuvre, see Friedman, *The Construction of Nature: A Reading of the Metaphysical Foundations of Natural Science* (Cambridge, UK: Cambridge University Press, 2013), 1–33.

time. Hence time is given a priori. All actuality of appearances is possible only in time. Appearances, one and all, may go away; but time itself (as the universal condition of their possibility) cannot be annulled.⁷

In repeatedly stressing that time cannot be annulled, while the appearances in time—those that appear simultaneously or successively—can be, Kant is positing the independence of the “stuff” of appearance from the form of time to which they conform. For Kant, time is a property of cognition, indeed the form of its sensible faculty, not of things, so that it would by necessity be outside of what appears. Still, what appears has the form of time, it takes part in time and so is constrained by the form of time. There is thus a disconnect between matter and time, or between the form and stuff of appearances. This view is uniquely modern, distinguished from the time of somebody like Plato, who considered time to be a product of the regular motion of the stars.⁸ The regularity of the world, for Kant, is not productive of time, but a product of time. Time itself cannot be learned from experience, for to see simultaneity or succession, things would already have to be either simultaneous or successive. It is thus outside the world and formative of it. In that, Kant echoes Newton, who writes in a famous Scholium of the *Principia Mathematica*: “Absolute space, in its own nature, without regard to anything external, always remains similar and immovable.”⁹

But what is it that time is divorced from? I used the term “stuff of appearance,” but what is it that we mean? I do not mean to refer to some mass of unformed sense data, or raw sensation. It is unclear whether we can ever speak of pure, unformed matter, both for Kant and in principle. Rather, I mean to refer to those concepts applicable to phenomena which bring them closer to what we call matter. Matter is substantive, it is always in a network of causal relations, and so on. Such properties are not consequences—at least not direct consequences—of the form of time. Rather, they are concepts that shape our thinking in general, to the extent that it applies to objects of experience. What makes appearances “material,” is a family of categories that is applicable to them and makes them conformant to something recognisable as matter. The project of the *Metaphysical Foundations* is very much directed at showing how the categories of the understanding, when explicated properly, imbue appearances with the material properties necessary for the physical sciences.

7 Kant, *Critique of Pure Reason*. trans. Werner S. Pluhar (Indianapolis and Cambridge: Hackett Publishing Company, Inc. 1996), A31/B46.

8 This is, of course, not meant to be a scholarly conclusion regarding Plato. This view is put forward in *Timaeus*, whose namesake says “the wanderings of these five planets, which are bewilderingly many and amazingly complex, do constitute time.” Plato. *Timaeus and Critias*, trans. Robin Waterfield (Oxford: Oxford University Press. 2008), 39d.

9 Isaac Newton, *Mathematical Principles of Natural Philosophy and his System of the World*. trans. Andrew Motte, rev. Florian Cajori (Berkeley, Los Angeles, London: University of California Press, 1974), Bk. 1.

What is important for me here is that we have two senses in which time and matter are decoupled: First, because time is a form of sensibility and is so principally independent of appearances. Second, because the material properties of appearances are a product of a different faculty of cognition. They do not appear in sensibility as such but result from the synthesis of the understanding. I take Kant to be saying that what is material about matter is not gained in sensation. Or, that properly speaking, nothing “feels like matter.” Rather, something seems material to us because of the way in which we put those feelings together. Something appears material because it is thought materially. It must be conceived in a community of mutual effect, where it causes motion and its motions are caused by something else, and it must endure these changes, in order for it to seem like matter. We find this need for mutual effect reflected in the fact that Kant takes mechanics to be an explication of the categories of relation.¹⁰ This is in contradistinction with time, which is immediately given to us in all things. We cannot, in mere sensation, feel that something is material, but we cannot fail to feel, in mere sensation, that something is temporal, that it conforms to the form of time.

Expressive of different faculties of cognition, time and matter are conceptually decoupled. They are independent. Not only that, but there is a clear hierarchy—time outranks matter. Time is truly outside the world of things, and, in a crucial sense, governs it. To see this, we should briefly recall the schematism.¹¹ While it is true that the understanding and the intuition are heterogeneous, they must come together in determinative judgement, which always subsumes a particular under a concept (“this is a *chair*”). Thus, there is something of a common ground to them, or at least a faculty of cognition responsible for bridging the gap between the two. As Kant develops it, what mediates between the sensible and the conceptual is the imagination, guided by the form of time. Concepts are synthesised in time—that is, they are taken to apply only to the extent that they unite multiple sequential experiences—and particulars always take part in the form of time. Thus, time is not only sensible but also responsible for relating the sensible and the conceptual. For our purposes, it means that the materiality of things expresses itself in time. Not only are those things temporal, but *their temporality is the condition of their materiality*. Simply put, matter would not be matter if it could not *move* like matter. Thus, while matter and time belong to different faculties and have different origins, matter is subordinate to time, and materiality can only be made manifest because of the form of time. Note that the ontological primacy of time is a curiosity of Kant’s transcendentalism, and not shared by Newton or classical physics generally. So, for Kant, formal time is ontologically prior, while in the classical frame more generally, the two are simply independent.

10 Kant, *Metaphysical Foundations*, 75–92.

11 This is a famously difficult and dense part of the first *Critique*. For commentary, see Martin Heidegger, *Kant and the Problem of Metaphysics*, trans. James S. Churchill (Bloomington: Indiana University Press, 1965), 93–113, and Béatrice Longuenesse, *Kant and the Capacity to Judge: Sensibility and Discursivity in the Transcendental Analytic of the Critique of Pure Reason*, trans. Charles T. Wolfe (Princeton and Oxford: Princeton University Press, 2000), 243–274.

Kant's view is Newtonian, or belongs to classical physics, in the sense that it takes time to be almost a purely mathematical thing. It is the indifferent and overarching order of matter and its events. Time and matter belong to different realms—one is an essential formal condition of experience, and the other is a name for some cluster of properties. The crucial point here is that this divorce of time and matter makes irreversible change foreign to this conceptual framework. Irreversible change takes matter to be a measure of time, to cohabit with it and, in an important sense, condition it. As long as the two are divorced, and time has the upper hand, all change is change of place, locomotion, because time can never really "enter into" matter. This clean conceptual divide is challenged by phenomena related to heat. Thermodynamic phenomena require that time be more internal to things than their form, they require that the materiality of things intermix with their temporality. If entropy—a decay that is internal to matter—is the origin of the arrow of time, time must be, in some sense, a product of materiality. So, we should formulate more clearly how the notion of entropy, together with the second law of thermodynamics, challenges the classical view.

1. Introducing the Second Law

Entropy is a notoriously elusive concept. While much has been written about it, its uncanny sprawl makes it difficult to capture. To conceive of entropy properly is to tie together phenomenological thermodynamics, statistical mechanics and information theory, and in so doing also simplify that common insight into a simple, conceptual language. Seeing as I would like to say something meaningful about entropy and do not possess such penetrating insight, I should stick to a particular aspect of the second law of thermodynamics. If, as I presented it, the framework of classical physics is one in which temporality is the condition of materiality, the second law is an inversion. I suggest that the second law pushes us to say that materiality is the condition of temporality.

In its first and most primitive appearance, entropy—originally called "transformational content" [*Verwandlungsinhalt*] – is defined by the following equation:

$$dS = \int \frac{\delta Q}{T}$$

where $δQ$ is an element of heat given off by a body, T is that body's absolute temperature, and dS is the change of entropy. In 1862, Rudolf Clausius put down that formulation, hypothesising that in reversible processes $dS = \frac{δQ}{T}$, while in irreversible processes $dS > \frac{δQ}{T}$.¹² Meaning that a system out of thermodynamic equilibrium will tend towards maximum entropy. Three years later, he coined the name entropy, from the Greek *en-trope*, meaning "to be in direction" (literally, "in-direction"). The thought behind the name was that matter itself had a directional character. Phenomena of heat reveal a content of matter that is transformational by nature and forces things into the order of time. That order of time is one shaped and formed from that transformational content. Entropy puts things into the order of time because we can always say that some time has passed by saying that the entropy has increased. That increase is the measure of irreversibility.

Foregoing for the moment epistemological questions, and questions pertaining to the correct, scientific interpretation of these ideas, let us dwell a moment on the consequences of the notion that guided Clausius here. It seemed that energy dissipation appeared not to be a coincidental thing but pointed to something essential to matter. All matter, it seemed, is perishable by necessity. The brilliance in the name "entropy" is that it indulges in a rather unexpected twist. We could have said that all matter is perishable because temporality is the condition of all matter, to begin with. That all things exist in time, so must pass away. But in terming the quantity of dissipating energy "entropy"—calling it "what puts things in direction"—Clausius pushed in the opposite direction. Instead, he invites us to consider that *materiality is the condition of temporality*, that the fact that the order of time in one direction rather than the other is not a property of the transcendental constitution of phenomena, but a formal feature that emerges immanently from matter. It is a property of matter that puts us in a direction, not a directionality that makes materiality into a property.

The crucial theoretical point not to be missed is that the entropic worldview is the materialisation of time. To take the concept of entropy to heart, to place it in the centre of our field of concepts, is to understand time as a feature of matter. The metaphysical challenge at hand is that of thinking of time as belonging properly to matter, without discarding its formal nature. True, it is an immanent rather than a transcendental notion of time. Still, we should not thereby disregard the fact that succession and simultaneity are not in and of themselves content. It would be too quick and too easy to disregard form

¹² Clausius, "Ueber verschiedene für die Anwendung bequeme Formen der Hauptgleichungen der mechanischen Wärmetheorie," *Annalen der Physik und Chemie* 125, no7 (1865): 353–400. 390: "Sucht man für S einen bezeichnenden Namen, so könnte man, ähnlich wie von der Gröfse U gesagt ist, sie sey der *Wärme- und Werkinhalt* des Körpers, von der Gröfse S sagen, sie sey der *Verwandlungsinhalt* des Körpers. Da ich es aber für besser halte, die Namen derartiger für die Wissenschaft wichtiger Gröfsen aus den alten Sprachen zu entnehmen, damit sie unverändert in allen neuen Sprachen angewandt werden können, so schlage ich vor, die Gröfse S nach dem griechischen Worte ἡ τροπή, die Verwandlung, die *Entropie* des Körpers zu nennen. Das Wort *Entropie* habe ich absichtlich dem Worte *Energie* möglichst ähnlich gebildet, denn die beiden Gröfsen, welche durch diese Worte benannt werden sollen, sind ihren physikalischen Bedeutungen nach einander so nahe verwandt, dafs eine gewisse Gleichartigkeit in der Benennung mir zweckmäfsig zu seyn scheint."

altogether in taking time to be immanent. What is at stake is understanding time as a form that emerges from matter, rather than one imposed on it from without (by a transcendental subject, for example). Time would thus not be conceived as linear, not a straight line of events, with strict and simple past, present and future.¹³ For time to belong to matter, it must be local and non-uniform, just as matter itself is.

Speaking of entropy in somewhat essentialist terms may invite the sense that this directionality that belongs to matter is uniform. Namely, that all things tend uniformly to expenditure and decay. This is, however, not so. There are cases in which the entropy of systems decreases. If we put work into a system, we may decrease entropy—or increase the inverse quantity, sometimes called negentropy. The decrease of entropy is a common feature in cooling systems, and much more interestingly, in living systems, and was, in fact, first coined by Schrödinger in *What is Life?* in the attempt to explain life as a physical phenomenon.¹⁴ Entropy is, mathematically speaking, a non-uniform scalar field, a function that varies from place to place, increasing and decreasing at different rates at different times and places, in different systems. Every system, every part and every mechanism has a different entropy and a different rate—and direction—of the change in that entropy. This is because matter itself is profoundly heterogeneous. A living system is an essentially different kind of matter—organic—from a dead body, a steam engine or a planet. If time is, as suggested, a formal directionality that emerges from and exists immanently in matter, we must take time to be unevenly distributed, paced differently and directed differently in different places.

So, while we would like to retain something of the formal in the description of material—or entropic—time, the main characteristics of formality must be discarded: uniformity and homogeneity, that all things that have a particular form are in some obvious sense identical. If time can no longer be understood as external to phenomena, but must instead be construed as internal to them, it must be as variable and non-uniform as the phenomena themselves. Time then emerges as a peculiar and particular feature, a quirk of every specifiable bit of matter, rather than a universal and homogenous thing.

Think of that oft-quoted William Gibson line, “The future is already here—it’s just unevenly distributed.”¹⁵ To my mind, it captures exactly what it means to think entropically or to think of time materially. Time is not dissimilar to, as the line well suggests, an aether-like substance filling space, or capital, distributed across the socius, flowing from one place to another. The future may be imported

13 Of course, the theory of relativity, both general and special, have undermined the usual notion of linear time. What I have in mind for the metaphysics of thermodynamics here is somewhat different, as will be shown.

14 Schrödinger made use of “negative entropy”, which Léon Brillouin abbreviated to “negentropy.” Schrödinger’s idea was that “What an organism feeds upon is negative entropy.” See Erwin Schrödinger, *What is Life? and Mind and Matter* (Cambridge, UK: Cambridge University Press, 1992), 47.

15 *The Economist*, December 4, 2003.

and exported, time can be slowed down or accelerated. What this implies is the express opposite of the quote given above, from Kant's "Metaphysical Exposition of Time." Under the eye of entropy, we should say that if appearances (matter) are annulled, so is time, and that where there is no matter there is no time. In that sense, *time matters*. And so, it is nothing without matter. What is more, there is matter without time. Matter *can* be in perfect equilibrium, perhaps completely static and unchanging, having reached a state of maximal entropy. In that case it would be, *de facto*, outside of time. But time can never be outside of matter. Kant's metaphysical exposition is fully inverted. And so, the question is raised: What is the form of material time?

3. Time Reformed

What is at stake in the form of material time is a form that emerges out of heterogeneous matter. That is, it is the question of how form might be wrought out from matter rather than applied to matter. In this regard, the view that Kant and Newton take falls into generally Aristotelian lines. It is a hylomorphic view of time. Time is the form of phenomena in that there is the matter of appearances, and there is, from a separate ontological origin, their form. Form and matter are, on such a view, simultaneous and independent of one another. As the classic Aristotelian example goes, there is wood and there is the form of the cabin. The wood exists independently of the cabin and the idea of the cabin exists, as a form, independently of the wood in the mind of the cabin-maker.¹⁶ In insisting on understanding time as internal to matter and emergent from it, we are forced out of this Aristotelian picture. What we are after is a genetic notion of time. Or, an account of how temporality originates from materiality—how matter is generative of time.

The ontological problematic of generation—the problem of ontogenesis—has a rich history, dating back to Anaximander, and has, in modern philosophy, had its most fruitful examination in Simondon and Deleuze. For both, standard ontology—what may be broadly cast as an Aristotelian or hylomorphic tradition—goes astray in thinking of form and matter as separate things brought together in the constitution of an individual thing, e.g., a wooden cabin. Rather, to account for individuals one must account for the processes of individuation, wherein form and matter are indistinguishably involved. That is, the process by which something becomes what it is, is inexorably tied to a formation that is internal to its matter. The hylomorphic model puts forward the following image: a craftsman

¹⁶ Take, as an example of this, a beautiful passage from *Metaphysics* Λ: "The causes which initiate change <are causes> inasmuch as they have come to be previously, while the things which are causes in the sense of formula exist simultaneously. For it is when the human being is healthy that health also exists, and the shape of the bronze sphere exists at the same time as the bronze sphere. Whether something remains afterwards too has to be considered, since in some cases nothing prevents it; for example whether the soul is of such a sort—not all soul but intellect... [as in] the case of the arts as well: for the medical art is the formula of health." Aristotle, *Metaphysics* Λ. trans. Lindsay Judson (Oxford: Clarendon Press, 2019), 1070a21-30.

approaches some material with an idea of what can be done with it, and after a process of labour, forces that idea on the material. From the viewpoint of ontogenesis, the craftsman's labour has a dialogical aspect, a mutual choreography, wherein the craftsman responds to the matter, trying to unveil forms and potentials hidden in it. Whatever the craftsman attempts to do is immediately responded to by the matter—some things it allows and others it does, some things are possible, but still very difficult to achieve, and so on. There is an interplay between form and matter. For Simondon, the model for this is crystallization, a process where matter is transformed, given new form, but not by external imposing.¹⁷ Rather, it is an actualisation of something that exists potentially in the matter and comes to light from within.

While Simondon's work on ontogenesis is geared towards questions of technology and information—following the broadly post-metaphysical line of questioning opened up by cybernetics¹⁸—it does not address something like the categories of time, space, causality, etc. Deleuze, picking up on Simondon's cue, sees in that notion of ontogenesis a path towards a reconsideration of traditional metaphysical categories. His work is not so much a reconsideration of Aristotle's view of art [*techne*], but an attempt to invert Kant's entire transcendental project. For him, what is required by the project of ontogenesis is a retelling of Kant's critical philosophy from the viewpoint of its genesis.¹⁹ Not in justified ordinary experience, but in examining the radical and problematic experience from which ordinary experience might emerge. It is from this point that his overarching transcendental empiricism and immanent metaphysics begin.

Keeping this in mind, it should be obvious that in order to approach the question of time after entropy, we must follow along the lines of the ontogenetic project. The metaphysical groundwork for this new notion of time, the appropriate, proverbial “flipping” of Kant on his head, is most lucidly undertaken by Deleuze. There is, however, an absolutely crucial difference. Ontogenesis is concerned with coming into being. It is concerned with how forms come into being through their matters. But the concept of entropy, which guides this proposed reconsideration of the notion of time, is a concept of decay, of passing out of being, rather than coming into it. What is at stake in entropy is not so much the viewpoint of genesis, as it is the viewpoint of decay. Time emerges as intrinsic to matter precisely in

17 For his introduction to the notion of ontogenesis, see Gilbert Simondon, *Individuation in Light of Notions of Form and Information*. trans. Taylor Adkins (Minneapolis: University of Minnesota Press, 2020), 1–10.

18 On the relationship between cybernetics and metaphysics, see Hui, Yuk. *Why Cybernetics Now?* in *Cybernetics for the 21st Century, Vol1: Epistemological Reconstruction*. ed. Yuk Hui (Hong Kong: Hanart Press, 2024) and Jean-Pierre Dupuy, *On the Origins of Cognitive Science: The Mechanisation of the Mind*, trans. M. B. DeBevoise (Cambridge, MA: The MIT Press, 2009), 15–22.

19 This is how Deleuze interprets the third *Critique*, and in light of that *Critique*, the very sense of the term “critique.” As he takes it, the third *Critique* asks about the problem of the genesis of the relationship between the faculties of cognition and reveals in that that all critique is a matter of genesis. See Gilles Deleuze, *Desert Islands and Other Texts, 1953–1974* (New York and Los Angeles: Semiotext(e), 2004), 56–71. As well as, Joe Hughes, *Deleuze's Difference and Repetition* (London and New York: Continuum International Publishing Group, 2009), 1–7.

that matter decays in and of itself. That is, the emergence of the form of time is not in the genesis of the individual but is rather manifest in its death.²⁰ Thus, what we aim to extract from Deleuze's project, for our purposes here, is a notion of how form can be inextricably internal to matter. The difference we would like to draw is that this inextricability is a fact of decay, rather than generation.

To treat Deleuze's ontogenesis fairly requires that one tarry with it carefully and quite possibly for the duration of several chapters of a book, especially if one, as I do, intends to adopt something of Deleuze's without taking his framework as is. So, what I would like to do now is present something of a sketch of Deleuze's view, in broad outline, in order to clarify what it means for form to emerge in this context. The common portrayal of Deleuze as a philosopher of difference hits the mark exactly here. Formal and universal features are liable to emerge from pure, immanent content because immanent content is ontologically prior to identity, and is therefore difference as such. What we have been thinking about as matter should be, on this Deleuzian approach, a field of pure differences—sheer heterogeneity. It is not to be thought of as a homogenous mess, as we sometimes intuitively do, because such an image of thought implies that every bit of it is in a sense identical to every other. That would be a primary assumption of form—the form of identity. If form is truly to be considered posterior to matter, pure matter must be understood to be everywhere heterogenous, other to itself. We cannot speak of this heterogeneity as something universal, in the sense that all differences are in some sense of the same kind, but rather of that pure difference as repeating throughout matter. Two differences are not of the same kind because both are in some sense a difference, but rather we sense each is a repetition of another. One difference seems to recall and re-enact the other difference. Just as two actors playing Hamlet, or for that matter, two productions of Hamlet, recall each other—neither seeming in principle prior to the other—so too, one difference recalls another.²¹

Difference and repetition, the eponymous concepts of Deleuze's masterwork, are brought together in thinking of form as something internal to content. The main idea is that the unity that one associates with form is derived not from notion of identity, a oneness which is presumably manifest to an external observer, but is in itself an expression of internal difference. Something sticks together by demarcating itself from its environment and by differentiation of its internal parts. While Deleuze's manner of thinking is abstract enough to accommodate potentially everything under this frame, it is, for Simondon, always modelled on the organism and the machine. So, for example, we can speak of an organism being unified, being *an* organism, because it is doubly differentiated—both from its milieu, its surroundings, and is host to the differentiation of organs. Its unity is primordially difference: the difference of its parts and its difference from the world. From the genetic viewpoint, the unity is articulated in the

20 This is, in a sense, already an intimation of the dialectical approach to the matter. Dialectics may be broadly and crudely characterised as that dynamic mode of thinking in which something's death shows its truth.

21 Deleuze, *Difference and Repetition*, 9–11.

doubled difference, rather than those differences being comparative articulations of a prior unity.

Keeping this metaphysical frame in mind, let us look at how this notion of self-otherness as primary ontogenetic difference might be an active agent in forming time. In the so-called third synthesis of time, a key moment of the “Repetition for Itself” chapter of *Difference and Repetition*, Deleuze addresses precisely that problem. There he recalls one of four poetic formulae he used to introduce Kant’s philosophy: Rimbaud’s “I is another.” He suggests that Kant’s transcendental view of time results from a fundamental split between the ego, or the empirical self, and the I, or the transcendental self. Time emerges as what mediates the active, determining I and the passive, determined ego. He writes:

The I and the Ego are thus separated by the line of time which relates them to each other, but under the condition of a fundamental difference... I am separated from myself by the form of time, and nevertheless I am one, because the *I* necessarily affects this form by carrying out its synthesis and because the Ego is necessarily affected as content in this form... the determined ego represents determination as an Other... It is the thread of time.²²

The crucial theoretical point here is that Kant’s linear and formal time doesn’t have to be accepted as simply given by and to transcendental subjectivity. Paying particular attention to the relationship, in Kant’s own system, between the ego and the I, we are able to glean a genetic condition for time as an empty form. A split, a mediated split between active and passive is, on Deleuze’s account, the genetic condition of empty form. It is an inversion of Kant: beginning with the split in the self, rather than the conditions of sensibility, and taking these not be consequences of those conditions of sensibility, but vice versa. The split self conditions the possibility of forms of sense. It is, I suggest, exactly the twist required to cash out the metaphysical debts of entropy. Before translating these ideas from the split internal to the subject into the split internal to matter, let us say a little more about how this split leads to a linear, empty form of time.

Deleuze contrasts Hamlet’s “time is out of joint” with the common Greek idea—explicitly addressed both in Plato’s *Timaeus* and Aristotle’s *Metaphysics XII*—that time is subordinated to the circular motions of celestial bodies. The time of the Greeks is neither formal nor transcendental, it belongs to the world of phenomena. It is the regularity of the planets, that in its turn produces the regularity of seasons, that is responsible for the order of time. There, time is joint to the world. It is bound to it. “The joint,” Deleuze writes, “is what ensures the subordination of time to... [that] which it measures.”²³ On the other hand, Kant’s time is out of joint in the sense that it is “freed from the events which made

22 Giles Deleuze, *Kant’s Critical Philosophy: The Doctrine of the Faculties*. trans. Hugh Tomlinson and Barbara Habberiam (London: Athlone Press, 1984), viii–ix.

23 Deleuze, *Difference and Repetition*, 88.

up its content, its relation to movement is overturned.”²⁴ Formal time, undetermined by events, is a temporality that cannot bring one back to the starting point. It is not, as with the Greeks, a time of pure repetition, of eternal recurrence, but a time of progression and detachment. So, we ask: what is it that might not allow the world to return and fold back in on itself? Well, on Deleuze’s view, it is an internal split. Something that becomes self-differentiated cannot return, cannot be seasonal, but must, in that movement of self-differentiation, detach itself from the world in which it started. Formal time is a time of self-othering because it is self-othering that disallows the eternal return of the same—everything must return otherwise—things are forced to move forward.

How, then, are we to conceive of this with regard to matter itself, rather than subjectivity? This is a difficult question. Implied here is a dramatic change in perspective. Not merely a materialist turn, but a materialism of replacement. The question implies that subjectivity, in all its twists, turns, hopes and dreams, may be substituted, by some formal analogy, for completely material systems. Questions about the relationship between matter and subjectivity are varied, and I do not fain to hope that anything I can say here is definitive. Still, in service of the line of thought that I have started to develop here, I would like to describe that material analogy, setting aside the critical, open questions involved in it. So, if the split between the I and the ego is to be formulated in material terms, we need to find for ourselves a sense in which a material system is both active and passive or is both conditioned and conditioning. I mentioned earlier that a material body must be constituted by a doubly articulated differentiation. An internal differentiation between organs and an external differentiation from its milieu. The internal differentiation is, to my mind, promising for this formal analogy. That is, because the organs or parts of the body are related to it as active parts on a passive, constituted background and because the body itself is related to its milieu as an active agent in a passive world, it seems that we may be able to think of the body, and the environment, as an empirical self, an ego—a representation of material system, in a sense, its trace—on the one hand, of the parts, and the body, as an active transcendental self, an I that might determine its own representation in its world.

On such a view, material systems, just as the transcendental subject, are always in the dual business of constituting and being constituted, conditioning and being conditioned. This double activity leads, in every material system, to a private form of time. Each system and each part—which, of course, taken by itself, can be thought of as its own system—involves a split between active and passive. Thus, in mediating between these two sides, for each system, there must also emerge a form of time. That form would invariably be proper to that system and only to it. Each mediation requires a form, and so two systems that do not relate to each other in any way, could not be said to share a form of time. The proper nature of the materially emergent form of time is not, as for both Kant and Deleuze, singular and universal, because it is not constituted by an observer seemingly external to things. Rather, it is

24 Deleuze, *Difference and Repetition*, 88.

that each difference in the material world is, by definition, mediated temporally, and so must retain for itself a private time. There is no form of time but forms of time. The crucial difference between the transcendental approach and the material approach is that for matter, time must always be said in the plural. The heterogeneity of matter should be construed as producing a heterogenous family of times, a unique form and duration for each system.²⁵

In the material context, this self-othering, which for Deleuze is a condition of genesis, is rather a condition of decay. The manifestation of difference in the ontogenetic framework is the manifestation of the primal stuff of individuation, and so what is in principle responsible for things being as they are, for their forms, actualities and capacities. However, in matter, differences make themselves most apparent in decay, where the constituent parts of a material body come apart, and the body diffuses into its environment. On the statistical interpretation of entropy, the notion of decay is understood to be the tendency to become like a gas—diffuse, decomposed. When things decay, their structures disappear, they dissolve into their building blocks. Formal time, by which we can tell that something moves forward in time, is, on the entropic view, correlated with decomposition rather than generation.

In the fifth chapter of *Difference and Repetition*, Deleuze writes about this characteristic of entropy, that it is an extensive quantity prefigured by an internal, pure difference. It belongs to the direction of space and time, just as pressure and heat, or even “the high and the low, the right and the left, the figure and the ground;” but it is an extension that manifests itself from out of an intensive quantity, out of the pure energy of pure difference. He writes: “entropy is an extensive factor but, unlike all other extensive factors, it is an extension or ‘explication’ which is implicated as such in intensity, which does not exist outside the implication except as implicated.” As an “implicated extension,” entropy intrinsically hints at the possibility of general movement, of the space time in which things in general move, beyond the particular difference from which it emerges. In that sense, it is expressive of the difference that makes the difference for the forms of extensive quantities. In his words, “[entropy] has the function of *making possible* the general movement by which that which is implicated explicates itself or is extended.”²⁶

4. A Dialectical Rejoinder

In the duration of this paper, I told two parallel stories regarding the nature of time, both ending with a rough sketch of a material time. First, a story that belongs to the history of physics, from Newton to Clausius, where the turn away from the regular motion of the stars to the internal dynamics of heat brought about the need to conceive of a material property that might order events. Then, a philosophical

25 In this regard, there are *entropies* rather than entropy, as I discussed in the previous section. Entropy is a vastly varied field, differing drastically from system to system.

26 Deleuze, *Difference and Repetition*, 229.

story from Kant's formal, transcendental time, to Deleuze's genetic viewpoint, wherein time emerges from a movement of self-othering. An important difference between these two accounts is that in the philosophical one, we find an earlier position—that of the Greeks. When I speak of inverting the classical view, it is crucial to note that it is, in itself, already an inverted view. One may recover a Kantian form of time by inverting a Platonic form of time, by detaching time from the motions of the planets and insisting on its belonging to a subject and so independent from the world. The question is thus raised: Is the material time I have been trying to describe here simply a return to Plato? Is the suggested view simply a temporality regulated by matter, as in the case of the celestial bodies?

The answer, of course, is no. We should insist that this double inversion of Plato in fact leaves us as far as we have ever been from Plato. It is in that sense that the demand and search for a notion of a material time that I have tried to develop here is dialectical. We have taken up a dialectical view of time in the sense that each description of time given is not abstractly negated by the view that comes after it, but diverges from it in a particular, concrete way. Platonic time is not simply negated, but its particular aspect, its being bound to phenomena, is negated. So, both Platonic time and Kantian time are regular. Then, what is negated in Kantian time is not its mediation of a constitutive split, but its ready-made nature. We related time back to matter in a specific way: by insisting on viewing time as emergent from matter. Thus, the entropic time I would like to suggest here is not Platonic in that it is not subordinate to regular phenomena, but emergent from all material systems and thus strongly non-regular. In this sense, I argue that we should say that entropy is a dialectical conception of time—a concept of time that strongly negates both Platonic time and Kantian time in particular and concrete ways.

An important consequence of the strong non-regularity of emergent material time is that it does not allow us to think of the world as temporally oriented. It does not have a single direction of time. If, as the second law as I presented it, implies identifying the direction of time with an increase in entropy, it follows that the decrease of entropy is tantamount to going back in time.²⁷ And if entropy, like all material properties, is heterogenous and variable, it is surely conceivable—and indeed it is very much the case—that some systems have decreasing entropy and some have increasing entropy. The arrow of time would thus be unevenly distributed—some places going back and some forward. In mathematical terms, the inability to fix, universally, a direction on some manifold is called non-orientability. And if we follow what I sketched out, we cannot fix a universal temporal direction to the world, and so may call it temporally non-orientable. In rejoining time to phenomena, we have rejoined it slightly askew, unevenly, as one does when constructing a Möbius strip.²⁸

27 Nick Land develops the idea that increase in entropy might be thought of as going into the future. See Nick Land, *Templexity: Disordered Loops through Shanghai Time* (Urbanatomy Electronic, Kindle Edition, 2014).

28 The Möbius strip may be constructed, heuristically, by taking a strip, cutting it at some point, turning one end 180 degrees and reattaching. This construction is non-orientable in that going around it left turns to right, up to down and vice versa.

While this description holds for a local view of systems, there is still the matter of the universe as a whole, or of global entropy. The question of global entropy is crucial but cannot be fully taken up here. I hope to discuss this point in depth elsewhere. For the time being, let me say that the question of a global or universal direction is dependent on our capacity to speak of the universe as a totality. So to speak, to view it from God's viewpoint. For any real, physical observer can only measure entropy for quasi-isolated systems, and never for the whole of the universe. It is exclusively from a divine perspective that one can make sense of global entropy. Any notion of universal or global entropy is predicated on a totality. Reichenbach, for example, argues that there is universal increasing entropy because whenever we include a system's surroundings, we see increasing entropy. His argumentation is subtle and multifaceted, but his account necessarily relies on the potential existence of an overarching whole. The idea that we could always, and therefore infinitely expand our view. While scientifically sound, this is a philosophically problematic approach.²⁹ As there are good reasons to argue against the idea of the universe as a whole (as a closed system). Bergson makes a similar argument against totalisation in his *Creative Evolution*. For him, the concepts of mathematical physics are predicated on closing and isolating systems, and the open nature of the universe provides a profound conceptual difficulty for their generalisation.³⁰ Another argument, more in line with Kant, is that empirical concepts are only valid within possible experience, and the whole is experience is not itself an experience – one cannot speak of the whole of the universe empirically, only of partial manifestations.³¹ Thus, it is not false but metaphysically imprudent to speak of universal entropy. If the view of time as emergent from local material difference that I proposed here carries any weight, we should make more of the partiality that belongs to particular observers than to the attempts, however successful, to universalise the products of that partiality.

By way of conclusion, I would like to indicate how this view of time, following something suggested by the notion of entropy, does relate to dialectical materialism. In my introduction, I referred to Sohn-Rethel's unique brand of historical materialism—a view on which changes to the mode of production induce changes to the most fundamental categories of thinking. In that reference, I also implied that we may view entropic physics and dialectical materialism to be sister world-views, both being changes to the fundamental categories of thinking, induced by the Industrial Revolution, as a change in the mode of production. To restate, in a slightly more substantial way, the sense in which these are sister world-views, let me compare the view developed here with that of Žižek's in *Sex and the Failed Absolute*. The notion of an emergent, material time that I indicated in this paper is remarkably close to the definition of dialectical materialism that Žižek develops in that book. The position proposed here is of

29 See Hans Reichenbach, *The Direction of Time*, ed. Maria Reichenbach (Berkeley, Los Angeles, London: University of California Press, 1971), 125–135, and 133 especially.

30 See Henri Bergson, *The Creative Evolution*, trans. Arthur Mitchell (New York: Random House, 1944), 18–27.

31 See Kant's discussion of the first Antinomy: Kant, *Critique of Pure Reason*, A426/B454–A434/B462.

a materialist view of time, that understands the world as temporally non-orientable. Žižek's view was put together in an attempt to rescue a notion of historical progress that refuses the naive Enlightenment view of a steady trend toward the perfection of mankind. For Žižek, the dialectical materialist must be committed to viewing the world as a non-orientable surface, in which the progress of history is not linear and universal but moves at different paces and in different directions in different regions and times.

In his introduction, Žižek gives four theses that define his idea of dialectical materialism. The latter two are, as I understand it, reflected in the entropic view of time I argued for here:

1. "progress is always localized, the overall picture is that of a circular movement of repetition, where what is today 'reactionary' can appear tomorrow as the ultimate resort of radical change."³²

2. "antagonism [is] the constitutive contradiction of an entity with itself: things come to be out of their own impossibility, the external... is always the externalisation of their immanent self-blockage and inconsistency."³³

I hope that this view of time as local, non-linear and materially emergent, speculative as it is, might help to illuminate, to some extent, what is revolutionary about the Industrial Revolution: Perhaps, that it forces us out of an orderly and ideally regulated world, to a world dominated by a kind of chaos—not in the abstract sense of disorder, but in the sense of a fluid and heterogenous order, one manifest in the phenomena of genesis and decay, rather than stable existence.

32 Slavoj Žižek, *Sex and the Failed Absolute* (London: Bloomsbury Academic, 2020), 4.

33 Žižek, *Sex and the Failed Absolute*, 5.

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