TIME, CAPITALISM, AND POLITICAL ECOLOGY:

TOWARD AN ECOSOCIALIST METABOLIC TEMPORALITY

by

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DISSERTATION ABSTRACT

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The ecological crises that have already marked the 21st century, and which will continue to do so on an increasingly intense and destructive scale, present theory in every discipline and field of study with a number of problems. Due to the complex historical origins and specific characteristics of these crises, many of the theoretical problems that arise with them, I contend, have to do with time and temporality, and not just in terms of how we *conceive* of time and temporality, but with the ways in which we socially and practically *organize* them, at the level of both the individual and collective, that is, the time of the worker and the time of social production.

In this dissertation, I present an analysis of the problem of time in the warming world and of the temporal logic of capital to gain a better understanding of capitalism's socio-metabolic temporality and the ways in which this specific organization of our interchange with nature produces ecological degradation and destruction. I argue that capital's temporal logic and accumulation imperative, which have produced a global metabolic rift between nature and society, also results in the production of temporal-ecological rifts. In its ceaseless process of valorizing value, I show that capital subsumes ecological temporalities – that is, the life-cycles and rhythms of nature – under its own

alienated, abstract temporality in order to make nature conform to capital's time and accumulation imperatives.

In light of this, I assert that the warming world we now inhabit requires a strain of Political Ecology able to break with capital's temporal logic if we are to foster a just socio-ecological transition that ensures a habitable planet for future generations. For this, we require a dialectical conception of the relation between society and nature and an eco-chronopolitic that considers the ecological long-term – not just the dictates of capital's immediate, short-term expansion. In aiming to ecologically rationalize our socio-metabolic exchange with nature, I argue that we require an ecosocialist society and that Metabolic Rift Theory presents the best theoretical and practical guide for this task.

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To mum,
in aeternum te amabo

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CHAPTER I

INTRODUCTION: TIME, SOCIETY AND ECOLOGY

1. Time, Society and Ecology: Crises in the 21st Century

The ecological crises that have already marked the 21st century, and which will continue to do so on an increasingly intense and destructive scale, present theory in every discipline and field of study with a number of problems. Due to the complex historical origins and specific characteristics of these crises, many of the theoretical problems that arise with them, I contend, have to do with time and temporality, and not just in terms of how we *conceive* of time and temporality, but with the ways in which we socially and practically *organize* time, at the level of both the individual and collective, that is, the time of the worker and the time of society. Present forms of the individual and social organization of time and temporality can be traced to the emergence of capitalism in the 16th and 17th centuries, particularly to the emergence and ascent to socio-temporal hegemony of abstract, mechanical clock-time. The social organization of time - that is, our social time relations - by temporally determining social production, that is, the pace and rates, cycles and rhythms of both production in general and each specific form of production, therefore play a key role in determining the temporality of our socio-metabolic interaction with nature, that is, the pace and rates, cycles and rhythms of the social appropriation and extraction of nature, the pace and rates, cycles and rhythms at which we make use of (and therefore use up) finite natural resources in productive activity, and the quantities of time we allow for nature to regenerate and recover from appropriation and extraction, etc. While social times and temporalities undoubtedly differ greatly from natural times and temporalities, the reciprocal metabolic relation between society and nature and humanity's relatively novel ability to effect, either positively or negatively, the health and balance of the global Earth System, to the point of currently endangering the existential future of the species, makes serious and thorough

consideration of the interrelation of social and natural times and temporalities an extremely important task in our rapidly warming world. If we hope to create an ecologically sustainable society, then the relation between the temporal logic of the hegemonic form of social organization in the 21st century, capitalism, which temporally determines our socio-metabolism, and the ecological crises which presently abound, must be extensively examined and a critical understanding of this relation must form an important part of our Political Ecological theories of and strategies for socio-ecological transition. This brings many questions to the fore, such as what are the problems of time that the current ecological crises give rise to and why is this so; what is the temporal logic of capital and how does it operate; how did the present form of the social organization of time arise and what theoretical perspective is it grounded in; in what ways does the temporal logic of capital determine socio-metabolic interchange with nature; is there a possibility of 'greening' the temporal logic and socio-temporality of capitalism, which theories of Political Ecology take up this task, and are they/can they be successful; and what forms of Political Ecology are necessary for a just socio-ecological transition which can succeed in the long-term? In the following, I propose to take up these questions in order to identify, clarify, and analyze the problems which emerge at the intersection of time, capitalism, and ecological crises, in the hope that this will advance the ecosocialist struggle for an ecologically sustainable society in which genuine freedom beyond the realm of natural necessity can be substantively realized.

2. Chapter Outlines

Chapter 2 begins with an enumeration of the many facets of what I will call *the problem of time in the warming world*. Not localized to a specific problem in a particular area of study, or even just to the realm of theory, the problem of time in the warming world represents a general issue that has emerged across society in the 21st century, and in a particularly intensified way under conditions of global warming. Being a complex,

multifaceted problem that resists simple, uniform analyses in terms of linear, clock-time, and compounded by the urgency of the ecological crises we face such as climate collapse, in this Chapter I set out to explore and describe many ways in which this problem manifests itself, from the phenomenological *experience* of the problem which leaves many today wondering 'how long do we (as a species) have left?' or 'whether there is enough time to save ourselves?' to the reassessment of our conceptions of non-linear and stochastic time through novel scientific paradigms such as complexity theory and systems theory. Time perspectives and concepts in social theory are also challenged by the problem of time in the warming world and so I examine some transformations and developments in this area including certain problems related to the dehistoricization of nature and society, the widely discussed phenomenon of social acceleration, and the limitations of the time concept of the Newtonian paradigm. Moreover, due to the importance of socio-ecological theory in the warming world, I consider the interconnections of social theories and the natural sciences and the ways in which shifting time concepts in these respective domains have forced a reevaluation of the theoretical grounding of their intersection. Finally, I consider the relation of capitalism to time and analyze the fundamental connection between the problem of time in the warming world and both capitalist theoretical conceptions of time and the nature of the social organization of time under this system.

In light of the analysis of the connection of capital and time and, more specifically, the problem of time in the warming world, in Chapter 3 I set out to analyze the temporal logic of capital in order to grasp concretely and with more nuance the foundation of the social organization of time, or what I will later call capitalist socio-temporality. I begin by explicating the historical, dialectical, and materialist method I employ in my analysis, and discuss the ways of conceiving of time and temporality this method enables, before briefly reviewing a selection of antecedent judgements about the role, place, and importance of time

and temporality in historical and dialectical materialist analysis in order to situate my own analysis in this history. Then, I move onto an extensive analysis of the temporal logic of capital by turning predominantly to Karl Marx's *Capital Volume 1*, which Massimiliano Tomba calls "a treatise on time, not only on stolen time, but also on its transformation and ontologisation," in order to draw out and explore the ways in which capital operates *in time* and thus the ways in which it *shapes time* for the individual and for society.[1] Through this analysis, I explicate three interrelated components of the temporal logic of capital. The first, *the necessity of the perpetual cycle*, refers to the ceaseless and limitless movement of capital in circulation, that is, the movement which gives capital its specific character *as capital*. This leads to the second component which is *the exponentially increasing magnitude of the infinite circulation of capital*, or what is more commonly referred to as capital's logic of infinite growth. In this section, the anti-ecological character of the capital system, grounded in the temporal logic being analyzed, begins to be revealed. The third and final aspect of the temporal logic of capital analyzed here is *capital as the 'automatic subject' of the process of self-valorization*, which refers to Marx's characterization of capital as both the 'automatic subject' of the process of self-valorization, that is, the self moving subject in the process of valorization, and the dominant subject [übergreifendes Subjekt] of social processes which stems from the inversion of use-value and exchange-value in the commodity form.[2] I conclude from this analysis that the temporal logic of capital, which I show leads capital to necessarily treat all ecological boundaries as mere barriers to be conquered, so as to continue to expand, produces an abstract form of temporality which is necessarily anti-ecological.

[1] Massimiliano Tomba, *Marx's Temporalities*, trans. Peter D. Thomas and Sara R. Farris (Leiden: Brill Academic Publishers, 2013), 137.
[2] Karl Marx, *Capital: A Critique of Political Economy, Volume 1*, trans. Ben Fowkes (New York: Penguin Books, 1990), 165.

The subject of Chapter 4, which is premised upon the preceding analysis of capital's temporal logic, is capitalist temporality in general, which I define as the socio-material expression of the temporal logic of capital through historically determinate relations of production, social organization, and institutional structuring which give rise to the specific social time relations of capitalist society and its socio-metabolic temporality. Here, I examine the material instantiation of capital's temporal logic in order to understand how it operates in material reality, how it structures the temporality of social production, and how it determines the temporality of our socio-metabolism. This involves an analysis of *the short-termism of capital's restricted systemic temporal horizon* which arises from its abstract and anti-ecological temporal logic, and which propels a socio-temporality focused only on the most immediate possibilities for the valorization of value. From this, I undertake a reconstruction of the historical events and processes which brought about the socio-temporal hegemony of abstract capitalist temporality by investigating the emergence of abstract, mechanical clock-time during the transition from feudalism to capitalism from the 14th to the 17th centuries and the ways in which this form of time became the central temporal structuring force of capitalist production and metabolism. The role and importance of Newton's Absolute time concept, and the mechanistic worldview which his work established as the central scientific paradigm of capitalism, are closely examined in order to understand the ways in which time and temporality in our present society and social relations are rooted in this history.

Chapter 5 offers an analysis of the ecological concerns related to the temporal logic and socio-temporality of capitalism such as the global metabolic rift which is driving ecological crises. In this chapter, I turn explicitly to the history and origins of metabolic rift theory and, by examining the temporal and spatial aspects of Marx's initial analysis, develop a concept of the *temporal-ecological rift* which, as a sub-component of capital's general metabolic rift, specifically captures the destructive relationship between capitalist temporality

and nature. On the basis of this concept, I discuss the relation between ecological imperialism and real subsumption of science at the outset of the 20th century to show how capitalism has been deepening temporal-ecological rifts in order to attend to various ecological crises throughout its history such as the soil fertility crisis of the late 19th and early 20th century. From this, I argue that, in order to maintain accelerating economic expansion, and through the real subsumption of science, capital has undertaken a project of actively producing temporal-ecological rifts in the form of specifically capitalist use-values through a strategy of *incisive temporal domination and control* of nature. I provide three case studies as evidence of this phenomenon: the case of factory farmed chickens and 'for-profit selective breeding'; the case of genetically modified organisms and 'Terminator Technology'; and the case of old growth and tree farms. In each of these three examples, I show exactly how the temporal logic of capital, operating under conditions of monopoly capital, engages its strategy of incisive temporal domination and control to subordinate biospherical temporalities to the temporal logic of capital so as to accelerate production. I conclude this Chapter by arguing that the preceding analysis shows capital to be engaged in a violent project of ecological acceleration which involves temporally distorting nature by subsuming the tempos, rhythms, and cycles of certain organisms in order to meet the needs of its own temporal logic and accumulation imperative. This leads my analysis to consideration of the political struggle for environmental justice and the theories on which struggle rests.

In Chapter 6, I discuss the temporality of transition and argue that, if it is to hold any promise of successfully responding to and countering the metabolic rift, incorporating a critical analysis of the temporal logic and socio-metabolic temporality of capitalism is integral to the development of a transition strategy. In light of this, I turn to Political Ecology, a discipline where theories of socio-ecological transition are developed, and to the most theoretically prominent and politically dominant strain of Political Ecology, Ecological

Modernization Theory. In the remainder of the Chapter, I offer a critique of Ecological Modernization Theory by analyzing the work of some of its leading theorists and show that, since it does not look to move beyond capitalism in its notions of socio-ecological transition, it is theoretically bound to capitalism in such a way that its temporal logic tends to cohere or converge with the temporal logic of capital. On this basis, I characterize Ecological Modernization Theory as a theory of green capitalism. Then, I analyze what I call the temporal-theoretical and the temporal-practical aspects of this theory. In the case of the former, I show that Ecological Modernization Theory is theoretically (and problematically) predicated on an ontological separation of nature and society which is devised through its conception of technology, and a mechanistic conception of the relation of nature and society which, through its absolutization of the social and fetishization of technology, produces a flawed understanding of the ecological crises, especially in temporal terms. Following the analysis of the temporal-theoretical, I engage the temporal-practical aspects of Ecological Modernization Theory and show how its flawed theoretical bases and temporal logic tends to the prescription of temporally flawed strategies (i.e., strategies focused on the economic short-term at the expense of the ecological long-term) with which to face ecological crises. To make this point, I examine a few examples of these concrete strategies, such as its approach to renewable energy technologies and carbon capture and storage technologies, emphasizing the fact that these supposed solutions, while ensuring the continuation of capital and its expansion, in no way ensure a sustainable future for society.

Concluding with Chapter 7, I present an argument for the ecosocialist strain of Political Ecology, Metabolic Rift Theory, as the best theoretical and practical alternative to green capitalist strain, Ecological Modernization Theory. In making this case, I argue that Political Ecology must become conscious of both the temporal logic and socio-temporality of the presently hegemonic capitalist system, and of the temporal logic at work in each given

strain of Political Ecology, and more specifically of how each strain's temporal logic relates to that of capital. For this purpose, I introduce the concept of an 'eco-chronopolitic' to Political Ecology which serves to capture the general temporal logic, perspective, content, and strategies of a given strain of Political Ecology. Here, I argue that any strain of Political Ecology able to guide or produce a just and sustainable socio-ecological transition must prioritize a faithful listening to laws of nature, that is, "the absolutely fundamental laws of humanity's relationship to nature itself: the objective *substratum of our very existence*," over against the anti-ecological temporal logic of capital and its accompanying accumulation imperative.[3] For this, I argue that we require a strain of Political Ecology with a dialectical conception of the relation between nature and society because only on the basis of such a conception can we correctly and accurately understand the interrelation and interaction of concrete social and ecological times and temporalities. Thus, Metabolic Rift Theory, an anti-capitalist, ecosocialist strain of Political Ecology meets the many needs of theory in a rapidly warming world. Contrary to the green capitalist Ecological Modernization Theory, Metabolic Rift Theory's temporalized and historicized conception of nature, its dialectical materialist, metabolic conception of the relation of nature and society, its ability to incorporate the energetic laws of thermodynamics, its move toward a conception of systemic time, and its divergence from the temporal logic of capital, meets the philosophical and scientific criteria expressly required of a theory of Political Ecology in the warming world. Only on this basis, I argue, might we meet and transcend the challenge and burden of historical time, reconcile the metabolic rift, and thus achieve, "a conscious and rational treatment of the land [and nature]

[3] István Mészáros, *The Challenge and Burden of Historical Time: Socialism in the Twenty-First Century* (New York: Monthly Review Press, 2008), 27.

as permanent communal property, as the inalienable condition for the existence and reproduction of the chain of human generations."[4]

[4] Karl Marx, *Capital: A Critique of Political Economy, Volume 3,* trans. David Fernbach (New York: Penguin Books, 1991), 949.

CHAPTER II

THE PROBLEM OF TIME IN THE WARMING WORLD

The problem of time in the warming world is a complex, multifaceted problem that resists simple, uniform analyses and instead requires, before it can be broached, a detailed description of its various aspects and levels. Despite its complexity, the problem of time in the time of climate collapse is most commonly a *felt* one that first arises through a general and pervasive sense of uncertainty about our collective ecological, and therefore existential, future.[5] Often the uncertainty confronts us as a simple, though grave, broad and overarching temporal question that can be stated in one of two basic ways: 'how long do we have left?' or 'how long do we have to save ourselves, our environment, our planet?'[6] To answer these questions with a simplified, concrete, fixed quantity of time, however, is to opt for reductive simplicity - that is, the comfort of an affirmation of quantified certainty in the face of what is simply unknown - and thus is to eschew the necessity of tarrying with the temporal complexity and uncertainty of the metabolic rift. In other words, while ecological crises "are brought on by capitalist production relations that peg economic growth forecasts to the clock and the calendar, their resulting consequences cannot be entirely known or controlled through these same disciplinary tempos," such that attempts to temporally "confine and classify the catastrophic impacts of climate change have very little meaning when framed in *Time*."[7]

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[5] E. Ann Kaplan, *Climate Trauma Foreseeing the Future in Dystopian Film and Fiction* (New Jersey: Rutgers University Press, 2016). One prominent example of an expression of the collective temporal anxiety surrounding the uncertainty of our global ecological future can be seen in the *Metronome*: the privately-funded public art installation of a large digital clock in New York City's Union Square which, "instead of measuring 24-hour cycles," is now "measuring what two artists, Gan Golan and Andrew Boyd, present as a critical window [of time] for action to prevent the effects of global warming from becoming irreversible" (Colin Moynihan, "A New York Clock That Told Time Now Tells the Time Remaining," *New York Times*, 20 Sept, 2020).

[6] Vijay Kolinjivadi, Diana Vela Almeida, and Jonathan Martineau, "Can the planet be saved in Time? On the temporalities of socionature, the clock and the limits debate," in *Environment and Planning E: Nature and Space* 3, no. 3 (2020).

[7] Kolinjivadi et al., "Can the planet be saved in Time?" 910. "*Time*," here, is defined "as the linear, predictable and disciplining coordination metrics of modern clocks and calendars (e.g., seconds, minutes, hours, weeks, years, centuries) by which modern society measures and responds to change and categorically distinguishes the 'past' from the 'future'" (Kolinjivadi et al., 906). In other words, abstract, mechanical, Newtonian clock-time.

These questions and many others about climate collapse and ecological crises are, due to the nature of the Earth and Climate systems and the intricacies of human metabolic interchange with nature, extremely difficult to answer and resist basic quantification in clock-time. Despite this, the best predictions of Earth and Climate science tell us that time for action is running out, quickly.

Yet, simply recognizing the urgency of the problem does not permit us to dispense with its difficulties; rather, the urgency demands precisely that we should be proactively attentive to the temporal complexity of the situation so as to avoid missteps in our chosen (hopefully remedial) political, economic, social and metabolic actions. This requires, as some of the foremost contemporary Earth and Climate scientists have already identified, a "deep integration of knowledge from biogeophysical Earth System science with that from the social sciences and humanities on the development and functioning of human societies."[8,9] It is with this call for the integration of currently disparate knowledge in mind that, in the following, I will explore and detail some of the temporal complexity involved in our understanding of the various and interconnected socio-metabolic and socio-economic crises. To begin this task, I will enumerate, describe, and clarify some of the main aspects of the problem of time in the warming world.

1. Materialist Science and the New View of Time

To begin to understand the problem of time in the warming world, we must account for some recent developments (in terms of human history) in our understanding of the history

[8] Steffen, Will, Johan Rockström, Katherine Richardson, Timothy M. Lenton, Carl Folke, Diana Liverman, Colin P. Summerhayes, et al., "Trajectories of the Earth System in the Anthropocene," *Proceedings of the National Academy of Sciences* 115, no. 33 (August 2018): 2.

[9] It is interesting, to say the least, that from those whose direct scientific confrontation with the most significant, wide-ranging socio-ecological crisis humanity has ever faced, a confrontation that demands the most accurate possible understanding of reality, we hear a demand for a form of science that Marx believed dialectical materialism would eventually lead to: "Natural science will in time subsume under itself the science of man, just as the science of man will subsume under itself natural science: there will be one science" (Karl Marx, "Economic and Philosophic Manuscripts of 1844," in *The Marx-Engels Reader, Second Edition*, ed. Robert C. Tucker (New York: W.W Norton & Company, 1972), 91).

of the universe, the earth, life, and the human species. Any investigation of time or history must reckon with the fact that discoveries in the fields of cosmology, physics, geology, and evolutionary theory over the course of the last three centuries - such as the accurate dating of the Universe, of the Earth and life, and of the human species - have resulted in a profound shift in our popular, philosophic, and scientific conceptions and perceptions of time. These discoveries have enabled us to develop a more accurate and complex temporal understanding of the history of the universe, of nature and life, and of our species than previously could have been imagined. For example, we are now able to accurately estimate the age of the universe - 13.77 billion years old (with a remarkably small confidence interval of plus-minus 37 million years) because of progress in cosmology and physics. The religious mystifications of a 'young earth' have been comprehensively overturned by stratigraphy and subsequent carbon and uranium-lead dating techniques developed by chemists and utilized by geologists and archeologists, and we need no longer resort to mysticism and myth to provide an origin and history of the human species thanks to the development of evolutionary biology. These advances have provided compelling answers to three of what, according to Frederick Engels, were the "four materialist problems of 'origin' that remained after Darwin" - answers which Engels, despite the obvious limitations of science in his time, quite remarkably, accurately anticipated.[10] These specific problems of origin were the "*origin of the universe*...which Engels insisted was a self-origin as envisioned in the nebular hypothesis of Kant and Laplace...*the origin of life*...in which he pointed to a chemical origin focusing on the complex of chemicals underlying the protoplasm...[and] *the origin of human society*...in which Engels went further than any other thinker in his time in explaining the evolution of the hand and tools through labor, and with them the brain and language, anticipating the later discoveries

[10] John Bellamy Foster, *The Return of Nature: Socialism and Ecology* (New York: Monthly Review Press, 2020), 380.

of paleoanthropology."[11] The veritable temporal revolution of modernity, brought about by the advances of materialist science and the technological development engendered by labor, has entirely rearranged our conception of the temporal history of the world. For example, "in the eighteenth and nineteenth centuries...it was determined that the world was not just a few millennia old but millions of years old."[12] In response to the dominance of the materialist worldview and the new temporal history of life, it is important to ask: what effect has this new understanding had on our political and social relations? Or, more specifically for our purposes: how, on the basis of this '*scienza nuova*' to borrow a phrase from Vico, since we can no longer justifiably believe in the young earth or creation stories of religious mythology, how should we alter and adapt our metabolic interchange with nature to accord our new historico-temporal scientific understanding? We will return to these questions below, but for now we must continue with our elucidation of the various facets of the problem itself.

2. The Urgency of the Climate Collapse Challenge

One major temporal feature of generalized ecological crises, particularly of climate change, and which I have already gestured to above, is that of *urgency*. Of course, the main characteristic of the urgency of this problem is the fact that the negative impacts and consequences of climate collapse will be felt sooner rather than later - that is, if they are not already being experienced in some capacity, which is becoming less and less common. However, there is another distinct, albeit related, characteristic of urgency that requires our attention and that is the almost paradoxical situation whereby the more immediate a problem is, or in other words the more desperate one is to solve a problem, the more plausible do any and all possible courses of action seem. To adapt a common adage: desperate times make

[11] Foster, *The Return of Nature*, 380-1. The fourth 'origin' problem is that of the family, and while Engels provides an interesting and compelling historical materialist answer to this question too, it is a problem that is not strictly relevant to the current discussion.

[12] John Bellamy Foster, Brett Clark, and Richard York, *The Ecological Rift: Capitalism's War on the Earth* (New York: Monthly Review Press, 2010), 37.

desperate measures seem reasonable. In the context of climate collapse and generalized ecological crises, which must be dealt with at the political level, this specific aspect of the problem of urgency presents serious dangers.[13] The primary pitfall, when faced with an urgent problem of the magnitude (spatially and temporally) of climate collapse and metabolic rift, would be to choose a solution that merely remedies the issue in the short-term. In other words, when in a situation with a problem that demands immediate relief, it becomes much more difficult to think of both the long-term effects of the problem that are yet to make themselves known *and* the long-term effects that might result from the chosen course of action. Yet, this is precisely what climate collapse and ecological crises demand, since simply negating the worst of the immediate negative impacts of these problems through short-term solutions, without radical transformations in the way society operates, will not suffice to overcome them and they will return in an intensified manner in the (near) future. Opting only for short-term, palliative 'fixes' will not help us in battling ecological crises. Thus, on the basis of the entwinement of the urgency of the situation and the necessity of thinking and

[13] Although this argument is currently being mobilized by the right to warn against the possibility of perceived overreach of the state and the trampling of freedoms secured by the 'free' market (some of those 'freedoms' having led to us into the warming world in the first place), the left too must be wary of the possibility of the politics of climate collapse leading to the emergence of ecofascism (to a degree greater than that which we are already seeing, for example, in the immigration and border policies of right-wing populist governments around the world preventing climate refugees from gaining asylum) (Amnesty International, "UN Landmark Case for People Displaced by Climate Change."). One right-wing philosopher, for example, worries that "Some critics of the draconian lockdowns alleged to be needed to cope with covid-19 have claimed that these measures are merely preparatory steps to accustom Americans to centralized control. *Once the covid-19 hysteria dies down, we will face permanent restrictions to deal with 'climate change*'" (David Gordon, "The Socialists' Plan for 'Ecological Leninism'," *Mises Institute*, emphasis is my own). This concern, however, somewhat misses the point; many governments are already taking restrictive action to some degree or other to deal with the fallout of climate change, the problem is that these actions typically restrict the movement and appeals for asylum of the people displaced and harmed by climate change, restrict the activities of climate activists trying to bring about change, and restrict attempts to pass legislation that could deliver green policy solutions in order to secure the dangerously iniquitous economies of these advanced capitalist nation-states. Gordon's real concern, therefore, is not that governments will introduce restrictions in the face of climate change, but rather that they will introduce the *wrong type* of restrictions and negatively impact the market-actors who currently benefit from the economic drivers of climate collapse (e.g. restrictions on the right to pollute, restrictions on the production and use of fossil fuels, restrictions on the use of natural resources, restrictions on the production, exporting/importing, and consumption of meat, etc.)

acting for the long-term, we confront an onerous challenge in the ecological crises; a challenge perhaps temporally unlike any that humanity has ever faced at this scale and scope.

When considering the climate crisis, we should also recognize that the very nature of the *temporal emergence of the problem* has played a role in bringing us to a point whereby the issue is inescapably urgent. This phenomenon is perhaps best described by Andreas Malm in his text *Corona, Climate, and Chronic Emergency* wherein he draws on the contrasting temporalities of the seemingly instantaneous Covid-19 pandemic and the *perceived* gradualness (a descriptor he rejects) of climate collapse to show how each problem provoked two very different (temporal) political responses.[14] He notes that the difference in the temporal unfolding of these events contributed to the concurrent views that "the future is going to be bad regardless of the steps we take now to address climate change," and that "With coronavirus, it feels as though today's actions will have real and demonstrable consequences."[15] In other words, the different temporal sequences of the emergence of these two events - climate collapse and Corona - have been utilized by capitalist governments to structure the very way that people have (psychologically and emotionally, and also therefore practically) responded to them. In response to this political gamesmanship, Malm contests the fossil capital fueled ideological distortion of the temporality of climate collapse and its (misleading) representation as a 'gradual phenomenon,' arguing that

> Gradualness might not be the appropriate term for the [temporal] quality [of climate change]. Climate breakdown could instead be seen as a landslide that

[14] In the interests of accurately representing Malm's argument, I wish to note that he is not claiming that the differing temporalities of climate collapse and the Covid-19 pandemic are the *sole* explanatory factors for the differing temporalities of the political response to these events, although this temporal difference does play a big part in understanding the different political responses. He also points out that, among other factors, the immediate impact of Covid-19 on elderly, wealthy, white folks in the West (particularly the political class and the bourgeois elite who fund them), and not primarily on poor people of color in the Global South as in the case of climate change, or what Malm calls the "timeline of victimhood," has contributed to such a rapid political response to the pandemic in the West - a point certainly worthy of serious consideration. About these temporally variant political responses, he quips: "Perhaps humanity should thank Covid-19 for taking the early route through Europe" (Andreas Malm, *Corona, Climate, Chronic Emergency: War Communism in the Twenty-First Century* (New York: Verso, 2020), 23).

[15] Malm, *Corona, Climate and Chronic Emergency*, 15-6.

> rolls through the entire earth system, sweeping up material and gathering speed, and every time it hits people standing in the way, the impact is anything but gradual…This appears to be the general form of the process: an avalanche of missiles, standing out from a singular occurrence like Covid-19 not by being gradual but by constituting *a secular trend that persists over decades and centuries* unless brought to a stop.[16]

Due to the fact that climate collapse is a phenomenon with extended temporal longevity or, in other words, is a secular trend, it has been represented as a gradual issue progressing at a slow and steady pace and therefore treated as an issue that can be demoted in the list of political priorities in order to deal with supposedly more urgent issues. Covid-19, in contrast, unfolded as a shock - an explosion-like event - around the world and as such was treated with extreme political urgency. "Whichever way we look, we are drawn back to the differences in time: global heating as secular, Covid-19 as shock."[17] While the urgency of the political response to Covid-19 was undoubtedly warranted and necessary, the lack of urgency in the political response to climate collapse betrays the short-sightedness of capitalist states, since climate collapse will, in the long run, become a problem of an infinitely greater magnitude - for both the labor forces that capitalist nation states depend upon and for the bottom lines and shareholder's return on investment - than Covid-19 has been. We can, therefore, understand the inconsistency in the political responses to these events as a revealing of a politico-temporal contradiction of capitalist governance that is produced - I will argue more fully later - by the temporal logic, engendered by the imperative of accumulation and the principle of competition, of capitalist society itself. Below, I will return to the problem of urgency in order to more fully explore how the difficulty of the temporal urgency of climate collapse is compounded by the global capitalist socio-economic system.

[16] Malm, *Corona, Climate and Chronic Emergency*, 16-7.
[17] Malm, *Corona, Climate and Chronic Emergency*, 25.

3. Complexity and Non-Linearity in Earth and Climate Systems

In contemporary Earth and Climate science, the integration of complex systems analysis, itself a synthesis of complexity theory and systems theory, has resulted in the recognition of *nonlinearity* as a central characteristic of the functioning of the Earth system and Climate systems. Signaling the importance of continuing developments in complex systems theory, renowned evolutionary ecologist Richard Levins has stated that "Understanding dynamic complexity is the central scientific problem of our time."[18] Although complex systems theory is a broad generalization that encompasses myriad disciplines, subdisciplines, and interdisciplinary works in the natural, social and computer sciences, what unites the array of fields captured by this term is their adherence to the science of complex systems. For their part, climate scientists Steffen et al. highlight the relevance of complex systems theory to both natural and social sciences under conditions of ecological crises by pointing out that "Increasingly, concepts from complex systems analysis provide a framework that unites the diverse fields of inquiry relevant to the Anthropocene."[19] For this reason alone, scholars attending to the need for a 'deep integration' of currently disparate bodies of knowledge in the fight against climate collapse should take note of systems and complexity science. In the following section, I will provide some introductory remarks on complexity and nonlinearity and the role that these concepts play in the historical emergence and development of Earth and Climate science, and briefly explain the connection between this and the problem of time in the warming world.

In his remarkable exegesis of the crisis in modern physics, Christopher Caudwell gives an account of a crisis-related transitional moment within the discipline, which is also an important historical antecedent to the emergence of complexity and systems theories, by

[18] Richard Levins, *Talking About Trees: Science, Ecology and Agriculture in Cuba* (New Delhi: LeftWord Books, 2011), 48.
[19] Steffen et al., "Trajectories of the Earth System in the Anthropocene," 2.

identifying a break in the domination of the 'Old School' of Einstein and Plank and a challenge by those of the 'New School,' consisting of proto-complexity thinkers such as Heisenberg and Schrodinger. Describing the last of the 'Old School' he writes that

> "Einstein and Planck are the last physicists who accept the old metaphysics of science uncompromisingly, and who therefore attempt to site [*sic*] their empirical discoveries in an ordered world-view. They are the last physicists sharing the philosophy of Newton and Galileo…[they] are the last of the solid 'Old guard' of Newtonian physics."[20]

What is telling, however, is that Caudwell describes this particular crisis as "different from the previous crises of physics," before going on to call it as a "revolutionary crisis" whereby "the contradictions discovered in practice, cannot be met by a rearrangement of content within the categories of the domain of ideology concerned" such that "no real solution is possible, unless the most basic and fundamental categories...are more or less rapidly transformed."[21] The Nobel Prize winning chemist, Ilya Prigogine, broadens and adds to this diagnostic survey, commenting that "Classical science, the mythical science of a simple, passive world, belongs to the past, killed not by philosophical criticism or empiricist resignation but by the internal development of science itself."[22] It is against this backdrop that complex systems theory emerged in the latter half of the 20th century; that is, in response to the shortcomings and failings of the Classical scientific paradigmatic hegemony of reductionism and Newtonianism, a methodology and worldview that became dominant and had remained fairly robustly intact since Descartes' initiation of modern philosophy, and Newton's initiation of modern physics, in the 1600s.[23]

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[20] Christopher Caudwell, *The Crisis in Physics* (New York: Verso, 2017), 21.

[21] Caudwell, *The Crisis in Physics*, 20.

[22] Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature* (New York: Bantam Books, 1984), 55.

[23] This is, at least in part, due to the fact that the reductionist paradigm and Newtonian worldview were successful in providing bourgeois society with the means of solving its pressing *mechanical* problems associated with trade, manufacture, and war. On this point, see Hessen and Grossman's *The Social and Economic Roots of the Scientific Revolution* (Boris Hessen and Henryk Grossman, *The Social And Economic Roots Of The*

Exploring the shifting grounds of physics from a contemporary perspective, Melanie Mitchell, in her essential guide to complexity theory, remarks that "twentieth-century science was also marked by the demise of the reductionist dream. In spite of its great successes explaining the very large and very small, fundamental physics, and more generally, scientific reductionism, have been notably mute in explaining the complex phenomena closest to our human-scale concerns."[24] So what, in this context, does complex systems theory mean, and what does it offer scientists in the 21st century? In a general sense, complex systems theory refers to the "attempt to find common principles underlying the behavior of complex systems—systems in which large collections of components interact in nonlinear ways"; while nonlinearity refers to the fact that "the system can't be understood simply by understanding its individual components; nonlinear interactions cause the whole to be 'more than the sum of its parts'."[25] Complex systems, while difficult to sharply define, can be identified by the following behavioral characteristics: "*self-organization* into patterns…*chaotic behavior* where small changes in initial conditions…produce large later changes…*'fat-tailed' behavior*, where rare events…occur much more often than would be predicted by a normal (bell-curve) distribution…*adaptive interaction*, where interacting agents…modify their strategies in diverse ways as experience accumulates…[and] *emergent behavior* [which] is an essential requirement for calling a system 'complex'."[26] Nonlinearity, a concept that describes the existence of positive and negative feedback loops in a system, also serves to express the temporality of a system as diverging from our typical understanding

Scientific Revolution: Texts by Boris Hessen and Henryk Grossmann, ed. Gideon Freudenthal and Peter Mclaughlin (Boston: Springer, 2009)).

[24] Mitchell, *Complexity: A Guided Tour*, *x*.

[25] Melanie Mitchell, "How can the study of complexity transform our understanding of the world?" BigQuestionsOnline.com. January, 2014, 1.

[26] John H. Holland, *Complexity: A Very Short Introduction* (Oxford: Oxford University Press, 2014), 5-6.

of linear temporality (or even atemporality[27]) implied by the simple cause-effect model of classical physics - in other words, the temporality of nature according to Newtonianism. By recognizing the nonlinear temporality of complex adaptive systems, scientists are better able to conceptualize the "emergent, sudden, non-linear and unpredictable" temporalities of the complex Earth and Climate systems.[28] In contrast to those temporalities that have been subsumed by the temporality of capitalist mechanical clock-time,[29] "The increasing non-linearity of climate tipping points and positive feedbacks stands testament to a temporality that does not align and cannot be made to tick to the *Time* of capital."[30] However, given that a great majority of human scientific knowledge production has been concerned with developing linear analyses based on the Newtonian conception of nature as a "law-abiding, docile, and predictable, instead of being chaotic, unruly, and stochastic,"[31] coupled with the fact that complex systems theory has only emerged in the last half century or so, we are dealing here with a novel yet burgeoning and incredibly important scientific conceptual apparatus; one for which scientists are finding more and more fruitful applications at a quite incredible rate.[32]

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[27] "The world of classical physics is an atemporal world which, if created, must have been created in one fell swoop, somewhat as an engineer creates a robot before letting it function alone" (Prigogine and Stengers, *Order Out of Chaos*, 49).

[28] Kolinjivadi, Almeida, and Martineau, "Can the planet be saved in Time?" 904.

[29] On the use of the phrase 'mechanical clock-time,' it is important to note the following: "We use the term 'mechanical' not only because this abstract time was originally measured by a mechanical device (the mechanical clock, but it makes no difference whether it is measured by electronic or atomic means, as presently), but more fundamentally because it refers to the time concept which lies at the heart of Newtonian mechanics, which shaped modern science paradigmatically" (Andri W. Stahel, "Time Contradictions of Capitalism," *Capitalism, Nature, Socialism* 10, no. 1 (March 1999): 120). I will discuss this in more detail in Chapter 4.

[30] Kolinjivadi, Almeida, and Martineau, "Can the planet be saved in Time?" 910. For the definition of "*Time*," see footnote 3.

[31] Prigogine and Stengers, *Order Out of Chaos*, 63.

[32] See, for example, Melanie Mitchell, *Complexity: A Guided Tour* (Oxford: Oxford University Press, 2009) for a general but wonderfully detailed overview of complexity and systems theory, and Edward N. Lorenz, "Deterministic Nonperiodic Flow," *Journal of the Atmospheric Sciences* 20 (March 1963), for a classic paper on the application of complexity theory to the possibility and accuracy of long-range-weather prediction.

Complex systems theory, as a model for understanding complexity and nonlinear change, has been applied to fields as diverse as economics and ecology and, through this application, has begun to seriously challenge many of the assumptions about the world that were developed on the grounds of the Newtonian worldview and reductionist paradigm. In fact, Richard Levins, from the perspective of a dialectician and employing a healthy skepticism, understands systems theory as "the attempt of a reductionist scientific tradition to come to terms with complexity, non-linearity and change through sophisticated mathematical and computational techniques, a groping toward a more dialectical understanding that is held back both by its philosophical biases and the institutional and economic contexts of its development."[33] Complex systems theory, then, while certainly a dialectical advance on the weaknesses of Newtonianism and reductionism, should not be treated as a panacea for scientific problems because science itself arises in and is shaped by a social system that contorts science to its own (self-reproductive) needs.[34] The complexity perspective entails a view not of discrete objects abstracted and treated in isolation from their environments, but rather of "large numbers of relatively simple entities organize themselves, without the benefit of any central controller, into a collective whole that creates patterns, uses information, and, in some cases, evolves and learns."[35] From this scientific perspective, Mitchell offers the following definition of a (complex) system: "a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or

[33] Richard Levins, "Dialectics and Systems Theory," in *Dialectics for the New Century*, ed. Bertell Ollman and Tony Smith (New York: Palgrave Macmillan, 2008), 46.

[34] Among dialectical thinkers and Marxists of different stripes, there are currently quite varied views on the usefulness and relevance of complex systems for dialectical perspectives. For a skeptical view of the possibility of a synthesis of dialectics and systems theory, see Levins, "Dialectics and Systems Theory,"; for a more optimistic view about the possibility of this synthesis, see Poe Yu-ze Wan, "Dialectics, Complexity, and the Systemic Approach: Toward a Critical Reconciliation," *Philosophy of the Social Sciences* 43, no. 4 (2012).

[35] Mitchell, *Complexity: A Guided Tour*, 4. In the case of a complex system that "evolves and learns," it is referred to as a 'complex *adaptive* system.'

evolution."[36] In other words, since complex systems theory does not operate according to a basic cause-effect model of causation involving discrete, atomized individual objects as in Newtonianism, it offers a powerful alternative methodology for capturing the truth of the processes of nature in greater nuance and accuracy. In much contemporary Climate and Earth science, both the climate and the Earth are treated as complex adaptive systems, made up of and influenced by their interactions with and reactions to other complex systems such as human societies. What, then, does complex systems theory and its concept of nonlinearity offer us in broaching the issue of time in the warming world?

In their work on climate collapse and ecological crises, the team of climate scientists perhaps most closely associated with Earth Systems theory, Johan Rockström et al., describe the earth system as such: "Although Earth's complex systems sometimes respond smoothly to changing pressures, it seems that this will prove to be the exception rather than the rule. Many subsystems of Earth react in a nonlinear, often abrupt, way, and are particularly sensitive around threshold levels of certain key variables."[37] This passage is indicative of an emphasis that runs through their work, derived from the form of complexity and systems theory approach that they adopt, on the nonlinearity of the Earth system responses to anthropogenic drivers of climate collapse and Earth system thresholds or 'tipping points.'[38] That is to say, in their approach to climate and earth science, there is no simple cause-effect explanatory model of gradual changes in the balance of the earth system, but rather an acknowledgment of the complexity of causation in such a vast and interconnected system and

[36] Mitchell, *Complexity: A Guided Tour*, 13.

[37] Johan Rockström, et al. "A safe operating space for humanity," *Nature* 461, (24 September 2009): 472, https://doi.org/10.1038/461472a.

[38] "We offer a formal definition, introducing the term ''tipping element'' to describe subsystems of the Earth system that are at least subcontinental in scale and can be switched—under certain circumstances—into a qualitatively different state by small perturbations. The tipping point is the corresponding critical point—in forcing and a feature of the system—at which the future state of the system is qualitatively altered." (Timothy M. Lenton, et al., "Tipping elements in the Earth's climate system," *Proceedings of the National Academy of Sciences* 105, no. 6 (February 2008): 1786.)

set of subsystems that can mean gradual or abrupt change. Indeed, the very notion of a 'tipping point' refers to the fact that "at a particular moment in time, a small change can have large, long-term consequences for a system, i.e., 'little things can make a big difference'."[39] From their complex systems theoretical perspective, the emphasis on nonlinearity and feedback loops in their view of Earth systems highlights the fact that "current climate models may significantly underestimate the severity of long-term climate change for a given concentration of greenhouse gases…[because] *these models do not include long-term reinforcing feedback processes that further warm the climate*."[40] Analyzing feedback loops, or internal intersecting systemic dynamics, leads Steffen et al. to argue that "there is a significant risk that these internal dynamics, especially strong nonlinearities in feedback processes, could become an important or perhaps, [*sic*] even dominant factor in steering the trajectory that the Earth System actually follows over coming centuries," or, in other words, when we move beyond the 2ºC warming threshold "intrinsic biogeophysical feedbacks in the Earth System...could become the dominant processes controlling the system's trajectory."[41] For our purposes, we can consider that, based on the best current estimates of the world's foremost Climate scientists, our social temporality - that is, the temporality of society engendered by the temporal logic of our current capitalist system - is exerting dominant control over the (temporal) dynamics of the Earth system.[42] This is one aspect of the meaning of the Anthropocene. Yet, if business as usual is to continue, at some point in the quickly

[39] Lenton et al., "Tipping elements in the Earth's climate system," 1786.

[40] Rockström, et al., "A safe operating space for humanity," 473. Emphasis is my own.

[41] Steffen et al., "Trajectories of the Earth System in the Anthropocene," 2-3.

[42] This is essentially what is meant by the Anthropocene, despite the depoliticized guise of this term. Some scholars argue that a more appropriate term would be the Capitalocene (Jason W. Moore, *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism* (Oakland: PM Press, 2016)). I agree this is more appropriate *for the current moment*, at least insofar as it identifies the cause of ecological crises, but would warn against its implicit determinism. The Anthropocene does not have to be the Capitalocene. It is still possible, I maintain, to create a new form of Anthropocene; one wherein capitalism is not the system that dictates our socio-metabolism, but rather one where the temporal logic of our social system, and therefore the temporality of our socio-metabolism, operates in such a way as to preserve the conditions on earth which allow human society to flourish.

approaching future, this relation will invert irreversibly, leading the temporalities of change in the earth system to become completely untethered from any social or human influence such that the nonlinear internal dynamics of the Earth system will come to dominate human society; natural temporalities will subsume social temporalities. Should capitalism definitively move humanity onto a pathway towards a "hothouse earth," our journey along this pathway "would be propelled by strong, intrinsic, biogeophysical feedback difficult to influence by human actions, a pathway that could not be reversed, steered, or substantially slowed."[43] This is what we must avoid.

In this possible future, the social temporalities of human existence, regardless of politico-economic system or form of governance, will be completely dominated by the temporalities of nature in extreme crisis - to say that the Anthropocene would be short lived would be an understatement. Thus, the problem of time in a warming world, as it emerges in Earth and Climate systems science, highlights the relationship of concrete social and natural temporalities and the form of the relationship in which they exist. The identification of the quickly approaching (from a human perspective) inversion of the current relation of social and natural temporalities points immediately to the necessity of redressing a social temporality - which is currently completely shaped and driven by the temporal logic of capital - that is leading to a Hothouse Earth future. In this temporal view, a Hothouse Earth can be understood as the destructive dominance of natural temporalities in crisis over social temporalities, and the correlated rapid rate of change in the processes and functioning of Earth and Climate systems, which impedes the possibility of the existence of human society or any kind of human wellbeing. In order for human society to continue to exist, *our social temporalities must operate in deference to the temporalities of the Earth system in order to*

[43] Steffen et al., "Trajectories of the Earth System in the Anthropocene," 6.

preserve the conditions on Earth suitable for human life, society, and flourishing; this will be a central component of Chapter 7 in the present work.

4. The Dehistoricization of Nature, the Return of History, and the Revenge of Time

At this point, it is important to highlight that, in a handful of recent texts focusing on the ecological crises, expositions of some aspects of the problem of time in the warming world have been offered, albeit somewhat briefly. These include Foster, Clark, and York's staple of climate change theory, The *Ecological Rift*, and Andreas Malm's *The Progress of this Storm* and *Fossil Capital*, among others.[44] The insightful and suggestive remarks in these texts have been markedly influential in the formation of the present work, yet I offer that these remarks are preliminary and represent the beginning of a larger task for theory, and as such have not fully fleshed out the issues connected to the problem of time in the warming world.[45] However, they have provided a solid foundation upon which much of the present work is to be built. In light of this, it is necessary to now detail some of these ideas in order to account for the ways in which they contribute to the present work and shape the larger discussion of the temporality of climate collapse and of the metabolic rift.

In the introduction to *The Ecological Rift*, Foster, Clark, and York discuss the material and theoretical causes of the "dehistoricization of society" and the "dehistoricization of nature" and argue that, especially in the contemporary social sciences, "what has *become* is treated as absolute," referring to both human society and to nature.[46] According to the authors, the theoretical dehistoricization of nature in the social sciences is predicated on a

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[44] Foster, Clark, and York, *The Ecological Rift*; Andreas Malm, *The Progress of this Storm: Nature and Society in a Warming World* (New York: Verso, 2018); and Andreas Malm, *Fossil Capital: The Rise of Steam Power and the Roots of Global Warming* (New York: Verso, 2016).

[45] In fact, the author's would seem to agree that their work is only the beginning of the task of analyzing the temporal complexities of ecological crises since, first, the discussion of the dehistoricization of nature occurs in the "Introduction" to *The Ecological Rift* and, second, the section directly following Malm's discussion of the return of history is given the subheading: "Some Tasks for Theory" - some tasks set, presumably, in light of the return of history (*The Progress of this Storm* 11).

[46] Foster, Clark, and York, *The Ecological Rift*, 33. Due to reasons of scope and our purposes here, we will focus on the latter.

mistaken analytical separation of nature and human society, with the core of their argument presented as follows:

> From this perspective [of the social sciences], nature stands for what is fixed and unchanging, or *changing too slowly to be of direct relevance to human society*. Theodore W. Adorno observed that "losing its genesis," as a natural-historical phenomenon, nature is transformed into "something which in principle...is unalterable"...*It thus became customary in the social sciences to view the realm of humanity/society/culture/the mind as a realm constructed apart from nature*...Although denying any need to address the natural conditions of human society, social science, in its more abstract-empiricist form, has often tried to replicate the methodological successes of natural science...This has almost invariably meant, however, the *dehistoricization of both nature and society* - modelling all of human society (and nature itself) on the basis of either an unchanging status quo or a structuralist-functionalist and teleological notion of "modernism."[47]

The dehistoricization of nature enacted by the contemporary social sciences, they contend, produced a form of social science premised upon a "radical separation [of human society] from nature...particularly from notions of natural history or evolution," and thus social science was left severely debilitated when faced with rapidly shifting climate and other earth systems.[48] By analytically severing nature from its processes of historical development, and even going so far as to render it as static or immutable, although positively contributing to an ideology well suited to requirements of capitalist society, social science has also cut itself off from a recognition and understanding of natural temporalities, rhythms, and cycles and their impacts on human society. Moreover, by following this path, social science has denied itself the possibility of developing methods and research practices that allow for an account of the impacts of natural temporalities, rhythms, and cycles on human society - clearly a disastrous position to be in when confronted with the temporal complexity of climate change. What is required instead, Foster, Clark, and York claim, is a form of social science encompassing the

[47] Foster, Clark, and York, *The Ecological Rift*, 33. Emphasis is my own.
[48] Foster, Clark, and York, *The Ecological Rift*, 32.

"realism, dialectical understanding, urgency, and commitment to revolutionary transformation in human society" that the ecological crises demand.[49]

Similarly, Andreas Malm, drawing on Fredric Jameson's famed text *Postmodernism*, posits that our lived experience of time, mirroring the conceptualization of society and nature in the social sciences, is a thoroughly dehistoricized (but also defuturized) one:

> We continue to live on a stage where there is nothing but the present. Past and future alike have dissolved into a perpetual now, leaving us imprisoned in a moment without links backwards or forwards: only the dimension of space extends in all directions, across the seamless surface of the globalized world...time has ceased flowing.[50]

But Malm's thesis involves an initial borrowing and subsequent rejection of Jamesons' classic depiction of postmodern society. Instead of simply reproducing Jamesons' insight, Malm uses it in order to highlight the radical disruption of the postmodern form of space-time experience by noting that we are forced to recognize, in the face of climate collapse and extreme weather events, that "Such man-made weather, however, is never made in the present. Global warming is a result of actions in the past."[51] Malm's point is that despite our collective confinement to the perpetual present of postmodernity/ism, in the experience of global warming we are suffering the effects of the total accumulation of historical acts of fossil fuel combustion throughout the past two centuries - of history. Through climate change, history has returned to our dehistoricized lived experience in a disastrously violent way. In other words, "*We can never be in the heat of the moment, only in the heat of this ongoing past*...the air is heavy with time."[52] "There is no synchronicity in climate change" Malm contests, "Now more than ever, we inhabit the diachronic, the discordant, the

[49] Foster, Clark, and York, *The Ecological Rift*, 37.
[50] Malm, *The Progress of this Storm*, 1.
[51] Malm, *The Progress of this Storm*, 5.
[52] Malm, *The Progress of this Storm*, 5.

inchoate...History has sprung alive, through a nature that has done likewise."[53] And in a final refutation of Jamesons' thesis, he writes that "Postmodernity seems to be visited by its antithesis: a condition of time and nature conquering ever more space. Call it *the warming condition*."[54] The return of history and the resurgence of the flow of time is, for Malm, both theoretically and materially unavoidable in the warming world. This diagnosis brings to mind a famous passage from Walter Benjamin's *Theses on History*: "Where we perceive a chain of events, [the angel of history] sees one single catastrophe which keeps piling wreckage upon wreckage and hurls it in front of his feet."[55]

In his *Fossil Capital,* Malm again eloquently discusses some of the temporal complexities of climate change, in this case focusing on the fact that "Wherever we look at our climate change, we find ourselves in the grip of the flow of *time*."[56] At a very basic level, this simply means that, due to the cumulative effects of quantitative CO_2 buildup over time, "the effects are always delayed."[57] Thus climate collapse is a historical phenomenon with extensive (in relation to a single human life) temporal longevity. This has the peculiar effect of limiting the impacts of any immediate actions we might take against climate change. For example, "If we...demolish the fossil economy in one giant blow, it would still cast a shadow into the future…[and] the sea might continue to rise for many hundreds of years."[58] In other words, our actions have to be directed towards a thoroughly uncertain future in order to mitigate the deleterious effects, which have already been produced in the past and are being compounded and intensified in the present. Further, in a point that he returns to throughout

[53] Malm, *The Progress of this Storm*, 11.
[54] Malm, *The Progress of this Storm*, 11.
[55] Walter Benjamin, *Illuminations*, trans. Harry Zohn (New York: Schocken Books, 2007), 257.
[56] Malm, *Fossil Capital*, 7.
[57] Malm, *Fossil Capital*, 7.
[58] Malm, *Fossil Capital*, 8. This, of course, should not be read as a discouragement against immediate actions, but rather as a way of showing how the problem of climate change presents a situation of temporal complexity oriented far into a distant and very contingent future.

his oeuvre, Malm writes that "At its core...climate change is a messy mix-up of time scales. The fundamental variables of the process...operate over seemingly unrelated temporal spans, all refracted in the moving, elusive present of a warming world...that is non-contemporaneous with itself."[59] But perhaps the most important point Malm makes about the connection of past, present and future in the context of climate collapse concerns the historical weight that our present actions carry:

> For every year global warming continues and temperatures soar higher, living conditions on earth will be determined more intensely by the emissions of yore, so that the grip of yesteryear on today intensifies - or, put differently, *the causal power of the past inexorably rises*, all the way up to the point when it is indeed 'too late'. The significance of that terrible destiny, so often warned of in climate change discourse, is the final *falling in of history on the present.*[60]

In this, Malm shows convincingly that "this tempest is eminently temporal" and, importantly, emphasizes the necessity of comprehensively *thinking through* the temporal complexities of the problem - moral and otherwise - precisely due to the fact that our actions will necessarily carry great historical weight.[61] On the one hand, this presents a fairly novel political situation whereby the historical consequences of our actions (or non-action) extends forward into the future in an dauntingly elongated way.[62] Climate scientists Steffen et al. affirm that "social and technological trends and decisions occurring over the next decade or two could significantly influence the trajectory of the Earth System for tens to hundreds of thousands of years" and so "Humanity is now facing the need for critical decisions and actions that could influence our future for centuries, if not millennia."[63] Actions taken today will irrevocably determine the future humanity will inherit. On the other hand, the very gravity of the situation legitimizes immediate and unprecedentedly transformative socio-economic and socio-

[59] Malm, *Fossil Capital*, 8.
[60] Malm, *Fossil Capital*, 9.
[61] Malm, *Fossil Capital*, 11.
[62] Perhaps only the use or non-use of nuclear weapons is the closest analogue in terms of the clear and distinct yet unprecedented historical weight of human actions.
[63] Steffen et al., "Trajectories of the Earth System in the Anthropocene," 2, 6.

ecological political choices. The same climate scientists, tentatively broaching the political implications of their findings, point out that "the transformations necessary to achieve the Stabilized Earth pathway require a fundamental reorientation and restructuring of national and international institutions towards more effective governance at the Earth System level."[64] The current system, which has brought us to this precipice, must be changed if we are to prevent a Hothouse Earth. Both features of the present moment - the long-term implications of our action and the imminent opportunity for radically transformative action - must be fully accounted for as we address climate collapse and the metabolic rift. By bringing together aspects of the philosophical question of time and temporality, the temporal implications of complexity and nonlinearity in Climate and Earth System science, and the question of political response to climate collapse explored in various strains of Political Ecology, I intend to begin to address some of the questions raised by the problem of time in the warming world.

5. Time-Perspectives and Temporal Logic in and Across the Social and Natural Sciences

When considering the relation of temporality and (the relatively new field of) time studies to the social sciences, we should first acknowledge that "From the very beginning, modern social sciences have been interested in the topic of time. Indeed, 'the founders of the social sciences,' says Barbara Adam, 'have been concerned to encompass time in their respective theories'."[65] Impressing the importance of the category of time for the founding theorists of social science, Martineau adds that "time and the various concepts related to its understanding as a social phenomenon have been 'important themes of historical and anthropological research'."[66] Although not directly produced by the warming world itself, yet still related to it in its renewed relevance and seriousness when viewed in the context of

[64] Steffen et al., "Trajectories of the Earth System in the Anthropocene," 6.
[65] Adam quoted in Jonathan Martineau, *Time, Capitalism and Alienation: A Socio-historical Inquiry into the Making of Modern Time* (Leiden: Brill Academic Publishers, 2016), 22.
[66] Abbott quoted in Martineau, *Time, Capitalism, and Alienation*, 22.

climate collapse and the metabolic rift, there is a distinct theoretical problem of the variance of time-perspectives in and throughout the social sciences. In light of this, "An interdisciplinary literature on time has emerged in the last few decades, and many thinkers and scholars nowadays endeavour [*sic*] to study the broad relationship between time and society."[67] While this should be seen as an encouraging development, I wish to stress that if social scientists are to theorize and tackle the various interconnected global and local ecological crises successfully, it is necessary that they operate with a sophisticated and accurate understanding of the temporal interconnections of social and biophysical systems. The importance of this point is thrown into relief when we consider two points in conjunction. First, that "How the present is viewed [temporally] is of considerable importance in determining the questions we ask and the actions we take"[68], and, second, as Hartmut Rosa explains, that "we cannot adequately understand the nature and character of modernity and the logic of its structural and cultural development unless we add the temporal perspective to our analysis."[69] In other words, the social and political questions we ask and actions we take to address climate collapse are and will be fundamentally construed, structured and chosen by the ways that we understand time and temporality. The temporal logic and the connected temporal perspective employed by any given social theory *must*, therefore, be able to contend with multiple, complex intersecting temporalities between society and nature, which requires, fundamentally, a correct account of the relation between society and nature, otherwise the theory is unfit for purpose. Looking forward, I will take up this particular issue in the context of one of the major strains of Political Ecology in Chapter 6.

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[67] Martineau, *Time, Capitalism, and Alienation*, 23.

[68] George W. Wallis, "Chronopolitics: The Impact of Time Perspectives on the Dynamics of Change," *Social Forces* 49, no. 1 (1970): 105.

[69] Hartmut Rosa, "Social Acceleration: Ethical and Political Consequences of a Desynchronized High-Speed Society," *Constellations* 10, no. 1 (2003): 4, doi:10.1111/1467-8675.00309.

Though the importance of the temporal perspective is well known to researchers working on issues of ecological crises and climate collapse from a range of disciplines, in attempts to develop integrated socio-ecological perspectives, "Inconsistent assumptions about time, cycles and tempos can be so thoroughly embedded in the theories, methods and instrumentations intrinsic to particular specializations that multidisciplinary initiatives are often hobbled or defeated despite concerted efforts to establish a common agenda."[70] Furthermore, the time-perspective problem is not confined to the social sciences as, despite the practice of explicitly temporally grounded disciplines such as chronobiology, debates around the 'time-dependent rate phenomenon' (TDRP) across a range of disciplines in the natural sciences show. A recent example from the *Journal of Virology* concerning the TDRP provides an excellent case in point. The authors of this paper interestingly prove that the "discrepancies [over the last decade or so] among viral [evolutionary] rate estimates that are calculated over different time frames" can be explained precisely by the time frame used by the researcher in a study.[71] In this case, the TDRP shows that viral evolutionary rates "are negatively correlated with the measurement timescales," such that studies examining virus evolution over a shorter time frame evidence a much higher rate of viral evolution than studies that adopt a longer time frame; quite unintuitively, viral evolution happens at a faster rate when looked at over shorter periods, and happens at a slower rate when examined over longer periods.[72] While the TDRP is forcing a reassessment of the evolutionary dates and

[70] Charles H. Wood, "Time, Cycles and Tempos in Social-Ecological Research and Environmental Policy," *Time & Society* 17, no. 2/3 (2008): 262, doi:10.1177/0961463x08093425.

[71] Pakorn Aiewsakun and Aris Katzourakis, "Time-Dependent Rate Phenomenon in Viruses," *Journal of Virology* 90, no. 16 (2016): 7192, doi:10.1128/jvi.00593-16.

[72] Aiewsakun and Katzourakis, "Time-Dependent Rate Phenomenon in Viruses," 7184. In this particular study, recognizing the impact of the TDRP leads the authors to challenge, reassess, and seemingly overcome the temporal distinction in the classification between "slow-evolving DNA viruses and fast-evolving RNA viruses" and the virological paradigm connected to this classification - a classification produced by inconsistent, varying time-perspectives. Moreover, this enabled the authors to bridge "the gap between ancient and extant viral evolutionary studies" - a great step forward in evolutionary microbiology and virology (Aiewsakun and Katzourakis, "Time-Dependent Rate Phenomenon in Viruses," 7184). Similar evidence of a nonlinear evolutionary rate has been identified by other scientists at physical and genetic level in horses, birds, and

temporalities of a number of specific species and organisms, it is also forcing natural scientists to reckon with their very conceptualization of evolution as a process operating at a constant, gradual rate.[73] As evolutionary phylogeneticist Sebastian Duchêne remarked: "'This changes the way we conceive of molecular evolution…It shows that there is no universal rate of evolution. Even the same organisms have rates that vary over time'."[74] The nature of the reassessment that these findings provoke calls to mind the dialectical biologist's Stephen J. Gould's conception of the temporality of the evolutionary process as one of 'punctuated equilibrium,'[75] which we will return to later.

Despite the difficulty of time-perspectives in the sciences, Martineau reports that "Interdisciplinary time studies have also sought to connect [the operative temporal logic in the] natural and social sciences in interesting ways. J.T. Fraser, for example, proposes a thought-provoking multidisciplinary theory of time, which seeks to integrate six fundamental levels of integrative temporalities, called the 'hierarchical theory of time'."[76] No doubt, this

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primates. The research into the TDRP is ongoing and, since it is forcing an enormous revision of the timeline of 'Life,' it is unlikely we will see the full extent of its impact in the immediate future (Carrie Arnold, "Evolution Runs Faster on Short Timescales," *Quanta Magazine*, March 1, 2019).

[73] It is worth noting that the view of evolution as a process operating at a constant rate parallels the liberal view of history as (the linear time of) progress at a constant rate. I would suggest that the origins and convergence of these two ideas might be traced to arch-classical liberal organicist thinkers like Herbert Spencer who conceived of society as an organism following precisely the same natural dictates (i.e., the evolutionary process) as any natural organism. I would also suggest that Stephen J. Gould's notion of punctuated equilibrium is a useful antidote here, at least to the belief that progress/evolution occurs at a constant rate. Interestingly, Louis Proyect claims that one of the most ecologically sensitive Soviet thinkers, Nicolai Bukharin, anticipated Gould's notion of punctuated equilibrium "long before the Marxist paleontologist considered it" in his *Philosophical Arabesques*, wherein he writes that "The dialectical interpretation of development thus includes both gradualness and leaps, in their transition from one into another and in their unity. The real historical process, whether in nature or in society, presupposes both gradualness and leaps" (Louis Proyect, "Review - Philosophical Arabesques," review of *Philosophical Arabesques* by Nicolai Bukharin, *Marxists.org*, October 30, 2011). This is indicative of the long-standing contributions made by Marxist theory to evolutionary theory and to theories of temporality and historical time.

[74] Quoted in Arnold, "Evolution Runs Faster on Short Timescales."

[75] York and Mancus provide an excellent summary of Gould's concept of punctuated equilibrium: "Gould…argues, based on the history of life on earth, that natural selection is the dominant force sculpting organisms to fit their environments, but contingent events, such as the impact of an extraterrestrial object on earth, can radically alter patterns, making history ultimately unpredictable, despite the operation of spatiotemporally invariant laws. Unique events can change the course of history, setting life on a different path." (Richard York and Philip Mancus, "Critical Human Ecology: Historical Materialism and Natural Laws," *Sociological Theory* 27, no. 2 (June 2009): 136.)

[76] Martineau, *Time, Capitalism, and Alienation*, 23-4.

type of work is to be encouraged. However, this issue - of inconsistent, varied, and incorrect time-perspectives, specifically in the social sciences - is, I will argue in more detail below, largely predicted on the various inconsistent and incorrect ways of conceptualizing and understanding the categories of, and most importantly the relation between, society and nature. Therefore, I wish to suggest that one of the most pressing challenges for both Environmental Philosophy and Political Ecology is the development of an understanding of interdisciplinary temporal disconnects, firstly, by addressing the muddied understandings of the categories of the social and the natural and their relationship, and secondly, by developing an ecological theory with a temporal-ecological component that enables researchers to accurately grasp the complex "diachronic...discordant...inchoate" temporalities of socio-ecological crises.[77] Only in this way will social and natural science be able to cooperate in their efforts to address climate collapse and the metabolic rift.

6. Beyond the Newtonian Worldview and Time Concept

In their now classic critique of modern science, with a focus on modern physics in particular, Ilya Prigogine and Isabelle Stengers ask a simple but important question: "Why was natural motion conceived of in the image of a rationalized machine?"[78] The answer that they offer, which does not originate with these thinkers and has been highlighted many times,[79] finds the origin of the mechanistic worldview developed according to this particular conception of motion in the work of Newton and the subsequent Newtonian paradigm in modern physics. The general problem of the time concept operative in modern science develops, according to Prigogine and Stengers, from the fact that "Classical science, the

[77] Malm, *The Progress of this Storm*, 11.

[78] Prigogine and Stengers, *Order Out of Chaos*, 47.

[79] For highly informative, historically grounded discussions of Newton and the role of Newtonian science in shaping modern conceptions of time see: Hessen, "The Social and Economic Roots of Newton's Principia," in *The Social And Economic Roots Of The Scientific Revolution: Texts by Boris Hessen and Henryk Grossmann*, ed. Gideon Freudenthal and Peter Mclaughlin (Boston: Springer, 2009), 41-102; Martineau, *Time, Capitalism, and Alienation*; Stahel, "Time Contradictions of Capitalism," 101-132; E.P. Thompson, "Time, Work-Discipline, and Industrial Capitalism," *Past & Present*, no. 38 (December, 1967): 56-97.

mythical science of a simple, passive world, belongs to the past, killed not by philosophical criticism or empiricist resignation but by the internal development of science itself."[80] Besides the overturning of the myth of a "simple, passive world" of mechanistic science by the development of the internal contradictions of science generally, but especially in physics, any notions of nature as entirely "law-abiding, docile, and predictable" have now been thoroughly refuted and replaced by a view of nature as "chaotic, unruly, and stochastic"; a view which has been largely vindicated by the material realities of climate collapse and ecological crises.[81] We should, however, strive to avoid overcorrection here by taking account of the fact that the challenge to the *strict determinism* of the mechanistic worldview does not deny that nature is still, to a degree, predictable. The interpenetration of ahistorical and historical forces in the development of human society is perhaps best captured by Gould's notion of 'punctuated equilibrium' which holds that "contingent events, such as the impact of an extraterrestrial object on earth, can radically alter patterns, making history ultimately unpredictable, despite the operation of spatiotemporally invariant laws. Unique events can change the course of history, setting life on a different path."[82] The stable, perfectly predictable world of classical science, especially that of classical Newtonian physics, which reaches its highest expression in Laplace's calculator,[83] has come undone; ours is a world "essentially and irreducibly open to novelty...with an irreducible element of unpredictability."[84]

While a more extended discussion of Newton's influence on modern notions of time will be offered below, for now I want to bring attention to two features of a related problem

[80] Prigogine and Stengers, *Order Out of Chaos*, 55.
[81] Prigogine and Stengers, *Order Out of Chaos*, 63.
[82] York and Mancus, "Critical Human Ecology: Historical Materialism and Natural Laws," 136.
[83] "The concept of strict determinism which is at the root of bourgeois physics is most simply expressed by Laplace, who imagined a calculator provided with accurate figures of the precise velocity, mass, and position of every particle in the universe at a given moment. From this he could predict the whole future course of the Universe" (Caudwell, *The Crisis in Physics*, 92).
[84] Stahel, "Time Contradictions of Capitalism," 103.

that exists for both social and natural sciences in the context of the warming world. The first part of this problem addresses our general conception of time, and the second revolves around the specific way that temporalities of nature and society are defined, understood, and related. The first aspect of this problem of time in science stems from our modern conception of time which, as mentioned above, emerges largely out of the work of Newton. During the transformation of the feudal organization of society into merchant capitalist society and then industrial capitalist society, the change in mode of production brought about (perhaps necessarily) a change in the conception of time.[85] In a foundational text in the historiography of science, Boris Hessen, while observing that Newton lived during a time "characterized by the emergence and development of merchant capital and manufacture," argues that science was in general preoccupied by "the physical problems presented by the development of transport, industry and mining…[that is,] all *purely mechanical problems*…[which] were primarily determined by the economic and technical problems that the rising bourgeoisie placed on the agenda."[86] Hessen's claim - that Newton's ideas were developed in response to and on the basis of the mechanical needs of the newly emerging bourgeois society in Europe - offers a way to begin to explain the shortcomings of Newton's work for our contemporary times: namely that "the rising bourgeoisie brought natural science into its service, into the

[85] Thompson, "Time, Work-Discipline, and Industrial Capitalism."

[86] Hessen, "The Social and Economic Roots of Newton's Principia," 44, 52-3. This is not to suggest that Hessen's argument is economically reductive. In fact, he is conscious to avoid this pitfall, remarking that: "The economic situation is the basis. But the development of theories and the individual work of a scientist are also affected by various superstructures, such as political forms of the class struggle and its results, the reflection of these battles in the minds of the participants—in political, juridical, and philosophical theories, religious beliefs and their subsequent development into dogmatic systems.
Therefore, when analysing the subjects addressed by physics we took the central, cardinal problems that attracted the greatest attention of scientists in that period. But the foregoing general analysis of the economic problems of the period is inadequate for understanding how Newton's work proceeded and developed and for explaining all the features of his work in physics and philosophy. We must analyse more fully Newton's period, the class struggle during the English Revolution, and the political, philosophical and religious theories as reflections of that struggle in the minds of the contemporaries" (Hessen, "The Social and Economic Roots of Newton's Principia," 62).

service of the developing productive forces."[87] On the basis of the recognition of the limitations of Newtonian mechanics as a worldview and the necessary transcendence of this paradigm forced by the internal development of science, many scholars are now taking up a temporal critique of Newton (generally in response to the temporal chaos of ecological limits and/or climate change) by critically investigating the conception of time and temporality produced by, and engrained in, his work and are finding that "the time concept that lies at the heart of Newtonian mechanics" - or what is typically called either *clock-time, abstract, chronological* or *mechanical time* - describes an "external, abstract and quantitative time, seen as a line along which events can be placed."[88] This time concept is a part of the Newtonian 'mechanistic worldview' which "portrayed the universe as perfectly ordered, made up of passive, separate objects, which are subjected to outside forces and perform perfectly reversible trajectories."[89] While the benefits of this time concept for the capitalist merchant and industrial social orders are made perfectly clear by the practical results that enabled merchants and industrialists to overcome the obstacles to 'transport, industry and mining,' the problem we now face in a world that daily passes further and further beyond the limits of the Newtonian paradigm is that attempts to temporally "confine and classify the catastrophic impacts of climate change have very little meaning when framed in [Newtonian] *Time.*"[90] The mechanistic, abstract, reified clock-time of the Newtonian world and the capital system is a hegemonic and alienating time concept that must be overcome in the socio-ecological transition, if this transition is to be successful.

The second aspect of this problem revolves around the way in which we are able to understand, temporally, the relationship between nature and society, which of course is

[87] Hessen, "The Social and Economic Roots of Newton's Principia," 56.
[88] Stahel, "Time Contradictions of Capitalism," 103-4.
[89] Stahel, "Time Contradictions of Capitalism," 104.
[90] Kolinjivadi, Almeida, and Martineau, "Can the planet be saved in Time?" 910. For the definition of "*Time,*" see footnote 3.

predicated on the first aspect of the problem, our conception of time itself. The critique of the limitations of the abstract, mechanical clock-time concept of Newtonian physics, implies the necessity of pointing a way towards an alternative time concept that enables us to theorize climate collapse and the generalized ecological crises more accurately and acutely. However, this immediately means tarrying with the fact that the Newtonian worldview "has not yet...been replaced by any other equivalent worldview," despite the fact that this worldview has been fairly comprehensively "undermined" by "Discoveries in such sciences as physics and ecology."[91] The question then becomes: where do we look for alternatives? I wish to suggest that some possible answers lie in the disciplines of Marxist Ecology and ecological thermoeconomics. In response to the thoroughly mechanistic tradition of capitalist Political Economy, and its reduction of economics to a "*timeless* kinematics,"[92] and, moreover, its "complete failure to incorporate as basic a phenomenon as entropy into its understanding of the process of production and reproduction…[such that] economics is incapable of making even the first few steps toward understanding nature's changing qualitative states," I suggest we might first turn to the ecological economics and thermoeconomics of Nicholas Georgescu-Roegen.[93] By synthesizing the principles of thermodynamics with economics, whilst also accounting for ecological limits and concerns, Georgescu-Roegen took the first step to overcoming the "*timeless* kinematics" of mechanistic Political Economy, and thus to incorporate not simply a conception of temporality into economic studies, but a robust conception of temporality that enables us to engage with and theorize "nature's changing qualitative states" in a dynamic model of production and reproduction. Additionally, the initiation of a critique of capitalist social time relations of clock-time by Marxist theorists and

[91] John Bellamy Foster, *Ecology Against Capitalism* (New York: Monthly Review Press, 2002), 53.
[92] Nicholas Georgescu-Roegen, "Energy and Economic Myths," *Southern Economic Journal* 41, no. 3 (January 1975): 348.
[93] Foster, *Ecology Against Capitalism*, 54.

political ecologists in the metabolic rift tradition has enabled us to begin to think about the necessity and form of alternative temporalities of socio-nature and their implications, and their relation to the socio-ecological metabolism of human society under conditions of climate crisis.[94] In the final chapter of this dissertation I will look to develop my contribution to this currently developing body of work.

As a brief final note in this preliminary discussion of the problem of time in science, it is important to add that the development of thermodynamic studies have pointed to and produced a notion of time and temporality known as 'systemic time,' developed out of Prigogine's 'far from equilibrium thermodynamics,' and which, in some cases, physics is already adopting.[95] In this way, although the mechanistic time concept of the Newtonian paradigm was initially adopted, propounded, and proliferated by the natural sciences and "exported to the social sciences (particularly economics)" such as to "lead [the latter] to search [for] an a-historical and universal knowledge," natural science is already beginning to move beyond this time concept and its limitations, while social science lags behind. Systemic time is not "a way to conceive time from a systemic perspective, but [refers] more fundamentally to the systemic features of reality itself and thus to a grounded time."[96] This systemic time concept, also called "thermodynamic time," is a "qualitative...process-related time" and "essentially systemic and internal, in contrast to the external and abstract time of the clock."[97] It is the concrete time of nature, of ecosystems, as opposed to the abstract ideal of Newton's Absolute time concept. By viewing nature and society as two interconnected

[94] See, for example, Peter Freund, "Capitalism, Time-Space, Environment, and Human Well-Being: Envisioning Ecosocialist Temporality and Spatiality," *Capitalism Nature Socialism* 21, no.2 (June 2010).
[95] Stahel, "Time Contradictions of Capitalism," 103.
[96] Stahel, "Time Contradictions of Capitalism," 103.
[97] Stahel, "Time Contradictions of Capitalism," 102-3.

complex thermodynamic systems, which is largely the position of Metabolic Rift Theory,[98] we can begin to theorize with a dialectical time concept that allows us to address not only the ways that the temporal logic of capital subordinates and negates the biospheric temporalities of nature, but enables us to develop Political Ecological theories on the basis of a scientifically accurate and sophisticated systemic understanding of the interrelation of social and natural temporalities *via* the process of socio-metabolic interaction and exchange. Without accounting for temporality in this way, as I will argue more fully in Chapter 7, our political theories of ecological transition are bound to fail.

7. Social Acceleration: A Prevalent Diagnosis of the Temporality of Capitalist Sociality

Before entering into a more detailed discussion of the temporal logic of the capitalist system and the history of capitalist social time relations, it will be beneficial to explicate a major theme and concern of time studies from the last few decades that is of direct relevance to the present work: social acceleration. One of the leading theorists of social acceleration, sociologist Hartmut Rosa, argues that there are three 'motors' driving the phenomenon: the economic motor, the structural motor, and the cultural motor.[99] For Rosa, there are three analytically and empirically distinct forms of acceleration - technological acceleration, acceleration of social change, and acceleration of the pace of (social) life - which correspond to the three motors above respectively. The connection between these three forms of acceleration essentially create an acceleration feedback loop whereby "the acceleration cycle' is a closed, self-propelling process" in the following form: technological acceleration increases the acceleration of social change; acceleration of social change in turn increases the

[98] See Paul Burkett, *Marxism and Ecological Economics: Toward a Red and Green Political Economy* (Leiden: Brill Academic Publishers, 2006).
[99] Rosa, "Social Acceleration."

acceleration of the pace of life; and the acceleration of the pace of life promotes technological acceleration (ostensibly to save time in everyday life), and so on and so forth.[100]

Rosa's central thesis - that modernity is driven by acceleration - is compellingly expounded and incorporates the major sociological theories of the 19th and 20th century: those of Marx, Weber, Simmel, and Durkheim. Yet Barbara Adam, perhaps the foremost scholar of contemporary time studies, takes issue with Rosa's decision to identify and highlight the concept of the domestication of nature in Marx as a central explanatory factor of the acceleration of modernity and, more importantly, contests Rosa's simultaneous neglect, in Adam's view, of the much more important concept of *commodification* in Marx's work - namely, of the commodification of time. In order to grasp the importance of Adam's critique to the present work, it will be very useful to quote from her critique of Rosa at length:

> With respect to Marx, however, the focus on domestication bypasses the far more important work on commodification, one of Marx's central contributions to understanding the modernist trend towards time compression. *While the domestication of nature is a process that extends to the beginning of agriculture, the commodification of nature and time are firmly tied to modernity and the organization of (re)production to the clock-time beat. Marx's principal point regarding commodification was that an empty, abstract, quantifiable, universally applicable time was a precondition for its use as an abstract exchange value on the one hand, and to the commodification of labor and nature on the other.* Only on the basis of this neutral measure could time take such a pivotal position in all economic exchange. *Not the variable time of seasons, aging, growth and decay, joy and pain, but the invariable, abstract time of the clock, where one hour is the same irrespective of context and emotion, is translatable into money. In Marx's analysis, clock time is the very expression of commodified time.*
>
> When time is money, the production of something of equal quality in a shorter time allows for a reduction in the price of the product, which increases its competitiveness. Equally, the faster an invention comes to market the better it is for a competitive edge over business rivals. To be first, to be faster than competitors, is crucial, and this applies whether the 'product' is a new invention, a garment, a news story, or a new drug. *Thus, when time is money, speed becomes an absolute and unassailable imperative for business.* At the same time, when speed is equated with efficiency, time compression and the intensification of processes seem inevitable. This argument is presented by Marx in volume one of Capital, where he argues that in a context of

[100] Rosa, "Social Acceleration," 11.

> competition, commodified labor time as abstract exchange value has to be intensified in order for employers to stay competitive and profitable.[101]

While succinctly refuting Rosa's focus on the domestication of nature in Marx as an *anachronistic* explanatory factor for the accelerating tendencies of modernity, this passage also provides excellent insight into the dynamics of both the temporal logic of capital, engendered by the accumulation imperative, (market) competition, and the commodification of time, and into the temporality of capitalist sociality - or, capitalist social time relations - and the disciplinary role played by clock-time in coordinating this form of social organization. As Adam makes clear, acceleration in social life - both individual and collective - is inherently tied to the particular, historically specific dynamics of the (temporal) logic of capital, which are expressed in capitalist sociality. Moreover, as she makes clear in this passage, organizing capitalism on the basis of "an empty, abstract, quantifiable, universally applicable time" was a necessary precondition for the commodification of nature, thus Adam deepens the ways in which we understand ecological crises to be bound up with the time and temporal logic of capital. Recognizing the distinctive role of the capital system as the mainspring of acceleration (or, in Adam's terms, compression) is a constitutive insight for the present work and will form the basis of a larger investigation into the temporal logic of capitalism and capitalist social time relations below, specifically as they relate to climate collapse, the temporal-ecological rift, and the production of Political Ecological theory.

8. The Temporal Irrationality of Capitalism in Everyday Life

Although the purpose of the present work is not to provide a subjective phenomenology of capitalist social time relations, it is worth offering some brief details and observations about the experience of time and temporality under contemporary capitalist society so as to highlight how fundamentally absurd and disorienting it can be to live

[101] Adam, "Comment on 'Social Acceleration' by Hartmut Rosa," 50. Emphasis is my own.

according to the disciplinary rhythms of abstract, reified mechanical capitalist clock-time. At least in the West, for example, we are able to see how capitalism has become detached from the temporality of the seasons through our forms of consumption. As a simple but informative example, we might consider the temporal disconnect between the availability of produce from the seasonality of the specific crop, which reflects capitalism's autonomy from the demands of natural, seasonal temporalities. Arising from this is perhaps the most general of observations concerning the alienation engendered by the movement, instigated by capitalism, from forms of life bound to nature's cyclical seasonal temporality to forms of life almost completely untethered from the natural rhythms of the world.[102] While much of human history witnessed forms of human social organization necessarily heed the dictates of the seasons when organizing social production and reproduction, capitalism takes no such orders. Rather, the homogenization of time through the abstraction of the mechanical clock has reduced the effects of fluctuating seasons largely to happenstance in the West, as opposed to central factors in the social organization of labor.[103] On the basis of homogenized time, capital is able to extract labor (and drive consumption for that matter) at a consistent rate and, therefore, need not suffer the consequences of reduced levels and rates of accumulation when seasons

[102] In the interests of clarity, I wish to emphasize that this statement is simply descriptive and should not be construed as a prescriptive romanticization of a 'more natural' past where humanity was 'more at one with' or more 'deeply connected to' nature. Rather, my intention here is merely to highlight a specific change brought about through the development of capitalism, not to promote some form of 'return' to an imagined idyllic pre-modern, pastoral form of society. Besides being undesirable for many reasons (which we do not have space to go into here), this return is also, of course, impossible. Since the only way to go is forward in time, I am more interested in the forms of organization of life and labor that we might develop in the future than I am in naive efforts to resuscitate a romanticized past. Moreover, in the extreme cases, the problems and tendencies of the idea of a 'return to nature' cannot be understated, particularly as they appear in various forms of (eco-)fascism, which have in some cases "envisioned a thoroughgoing ruralization of Germany and Europe, predicated on revitalizing yeoman peasantry, in order to ensure racial health and ecological sustainability" (Janet Biehl and Peter Staudenmaier, *Ecofascism Revisited: Lessons from the German Experience* (Norway: New Compass Press, 2011), 31). As the history of the 20th century has shown, we must always be on guard against fascist and racist ideologies, especially when they are concealed in the guise of ecological terminology. The necessity of this awareness assumes fresh relevance and heightened importance in our current situation of generalized ecological crisis, specifically with regards to the ecological refugee crisis that the continued operation of capitalism will almost certainly exacerbate and intensify without offering solutions.

[103] This is, of course, closely connected to the emergence of the global market and the West's offshoring of a great deal of agricultural labor via the exploitation of cheap labor and food sources around the world.

would have previously dictated a decrease in labor. This is most starkly true in the vast urban centers generated by capitalism in order to centralize - and therefore make it easier to discipline and control - labor. In this way, we see how capitalism has reorganized both space and time interdependently in order to meet the needs of the law of accumulation by separating itself from (in a sense, overcoming) the limitations imposed by the cyclical temporalities of nature.

One of the most striking examples of the irrational organization of time under capitalism can be found in Andre Gorz's essay "The Social Ideology of the Motorcar," in which the actual effects of the automobile, ostensibly a time-saving commodity designed to decrease the time spent on transport are explained, and the paradox of the automobile is revealed:

> a person on foot covers as many miles in an hour devoted to travel as a person in a car, but devotes 5 to 10 times less time in travel. Moral: The more widespread fast vehicles are within a society, the more time—beyond a certain point—people will spend and lose on travel. It's a mathematical fact...To make room for the cars, distances have increased. People live far from their work, far from school, far from the supermarket...In the final analysis, *the car wastes more time than it saves and creates more distance than it overcomes*.[104]

Although Gorz does not formulate his conclusion in these terms, this is another example of the 'rebound effect' or 'Jevons Paradox' - a paradox that plagues many of the 'innovations' brought about by capitalism due to the internal logic of capital itself - which describes "any circumstance where efficiency improves by X%, but resource consumption declines by something less than X% or increases"; in this case the efficiency improvement is the speed at which one can cover a given distance and the increased resource consumption is the greater

[104] André Gorz, "The Social Ideology of the Motorcar," in *Ecology as Politics*, trans. Patsy Vigderman and Jonathan Cloud (Boston: South End Press, 1980), 73-4. Emphasis is my own.

amount of time spent traveling (and also the increasing quantities of fuel consumed to power the car).[105]

Other examples of the irrationality of capitalist social time relations include the ways in which workers, through the flexibilization and intensification of labor, are laboring at 'all hours of the day' (e.g., night shift, split shift, etc.). This is in spite of the fact that, based on the insights into human internal biological time-systems studied in Chronobiology, there is a "intricate interplay between metabolism and the circadian timing system" in human bodies.[106] Once again, in the move to detach the social temporality of capitalism from the temporalities of nature, capitalism has organized time as though capital, and the labor it is dependent upon, function autonomously from any natural limitation, condition, or dictate, temporal or otherwise. Thus, the organization of labor under capitalism depends not only on detaching its broad social temporality from those of nature's seasons, but also on disconnecting the temporality of labor from the internal 'body clocks' of workers through the "*reorganization of everyday time*."[107] Alarmingly, for workers the "temporal dynamism of financial capital translates into newly condensed and pressurized work-time…[such that] workers *throughout the social hierarchy* experience…precarious body-time" which "involves the working body's constant exposure to the threat and actuality of harm in the midst of severe temporal flux, compression, and unpredictability."[108] This temporal restructuring of work has led scholars to report that "whether on the shop floors of de-regulated factories or in the burgeoning world of

[105] Richard York and Julius Alexander McGee, "Understanding the Jevons Paradox," *Environmental Sociology* 2, no.1 (December 2015): 2.

[106] "In mammals, physiology and behavior are subject to daily oscillations that are driven by an endogenous clock. The master clock (circadian pacemaker) resides in the suprachiasmatic nucleus (SCN) of the brain's hypothalamus. In the absence of external time cues, the SCN master clock generates cycles of approximately but not exactly 24 hours, and its phase must therefore be readjusted every day" (Ueli Schibler et al., "Chronobiology: Reducing Time," Science: American Association for the Advancement of Science 293, no. 5529 (July 2001): 437. http://www.jstor.org/stable/3084076.).

[107] Paul Apostolidis, "Theorizing Neoliberalism with Day Laborers: The Body-Time of Dangerous Work," Race and Ethnic Politics Colloquium, UCLA, March 2016: 32.

[108] Apostolidis, "Theorizing Neoliberalism with Day Laborers," 33.

online labor, more and more working people face 'risk on all sides'...traceable to the temporal-physical organization of work-processes, which in turn reflects…the impatient flows of finance capital that course beneath neoliberal employment restructuring."[109] An additional factor here is that, outside of work, through the domination of worker's bodies by the abstract temporality of capital, "some scientists found that the average sleeping time decreased by two hours since the nineteenth century and by 30 minutes since the 1970s," which quite obviously entails deleterious effects to worker's health.[110] Simply put, by alienating the human body from its natural biological temporalities, capital is able to extract a greater quantity of labor at the expense of workers' biophysical wellbeing.[111] Capitalist social time relations are hegemonic, over and against the temporalities of nature both writ large and on the smaller scale of human bodies. Reflecting on this point, Peter Freund warns that

> Of course, humans can be socially constituted to adapt to the demands of capitalist temporality (e.g., shift work), just as nature (e.g., land) can be adapted to the rhythms of capitalist industrial agriculture. However, such adaptations have long-range 'unhealthy' costs and require compensatory mechanisms to deal with temporal-spatial contradictions, such as disturbed sleep patterns to cope with a lack of sleep or using oil-based artificial fertilizer to boost depleted soil.[112]

I argue that the domination of nature and labor by capital, specifically the temporal forms of this domination, must be comprehensively addressed and understood if we are to be successful in addressing the ecological crises and metabolic rift brought about by the temporal logic of capital itself. This also entails addressing many aspects of the problem of time in the

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[109] Apostolidis, "Theorizing Neoliberalism with Day Laborers," 35. Earlier in the paper, Apostolidis explains that a major part of this risk relates to "job-related musculoskeletal disorders (WMSDs) [which are] due to 'monotonous and repetitive tasks' and 'speed-ups' that overtax workers' 'muscles, tendons, joints, and nerves'" (Apostolidis, "Theorizing Neoliberalism with Day Laborers," 35).

[110] Hartmut Rosa, *Social Acceleration: A New Theory of Modernity*, trans. Jonathan Trejo-Mathys (New York: Columbia University Press, 2013), 6.

[111] Although its forms have changed and, in some ways, intensified, the destruction of workers' bodies due to the exploitation of labor by capital is nothing new. For an account of this social violence (and in many cases social murder) in the time of Western industrial capitalism, see Frederick Engels, *The Condition of the Working Class in England: From Personal Observation and Authentic Sources* (London: Granada Publishing, 1981).

[112] Freund, "Capitalism, Time-Space, Environment, and Human Well-Being," 113.

warming world. The temporal contradictions of capital must be a central focus of both theory and practice in the coming decades as we struggle against the alienation and destruction wrought by capital against nature and labor.

9. Capitalism's Temporal-Ecological Rift: The Root of the Problem of Time in the Warming World

At the root of the crisis of time and temporality that I have been describing, and which is today brought into sharp relief by climate collapse and the metabolic rift, is the capital system; a totalizing system of social relations engendering a highly destructive, alienated form of socio-metabolic interchange with nature which, through ideological categories and a general mystification arising from alienation, has effectively obscured its role as the root cause of socio-economic and socio-ecological (metabolic) crises. The alienation of society from nature under capitalism, capital's metabolic rift, necessarily encompasses the alienation of the temporality of society from the temporality of nature under capitalism: capital's temporal-ecological rift. The many aspects of the problem of time in the warming world, which are made pressing and relevant by the rapidly worsening situation of climate collapse, derive from capital's temporal-ecological rift.

The mediating force of capitalist social time relations of alienated, abstract, socially necessary labor time has both reified time *as* merely abstract labor time and has subsumed historical time.[113] This, on the one hand, renders the temporality of capital as eminently natural and, accordingly, on the other, induces a great deal of confusion about the social determination of time by capitalism. Correspondingly, many contemporary scholars and scientists have not recognized the central role of capital, and more specifically the temporal logic of capital, in producing and accelerating the temporal-ecological rift and, subsequently, have failed to adequately account for it in their work. It is my intention, in what follows, to

[113] Mészáros, *The Challenge and Burden of Historical Time*.

elucidate (the ecologically destructive character of) the temporal logic of capital, so as to make clear the necessity of negating this logic if we are to cultivate future conditions suitable for the cooperative, sustainable development of human life and flourishing by a society of freely associated producers.

CHAPTER III

TIME AND CAPITAL: ON THE TEMPORAL LOGIC OF CAPITAL

1. On Time: Abstraction and Method

An historical materialist analysis of time requires, first of all, the basic recognition that "the unity of time and space is the unity of the basic general forms of the real world," and accordingly that when we discuss time we are discussing the *temporal dimension of reality*.[114] In unfolding the present work, we accept the material reality of temporality, which here refers to the sense of time-in-process, or the non-stagnant nature of the temporal dimension of reality.[115] We begin, therefore, by acknowledging the basic fact that the temporal dimension of reality and the spatial dimension of reality form a dialectical whole, and, thus, by affirming the materialist position that "the basic forms of all being are space and time."[116] This dialectical unity, however, can be analytically sundered by a process of abstraction, and so we must also affirm the necessarily abstract nature of discussions of time. In talking about 'time' in the present work, I am talking about an abstraction, albeit "*a rational abstraction*," rather than a metaphysical or even mystical one.[117] But what does it mean to say that an abstraction, in this case 'time,' is a rational one? Lenin explains:

> The abstraction of matter, of a law of nature, the abstraction of value, etc., in short all scientific (correct, serious, not absurd) abstractions reflect nature more deeply, truly and completely. From living perception to abstract thought, and from this to

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[114] Nikolaĭ Bukharin, *Philosophical Arabesques* (Delhi: Aakar Books, 2007), 72.

[115] In this sense, on a purely linguistic level, the term 'temporality' presents a more accurate description of the *experience* of time than the term 'time' itself does. It is in part due to the connection between the English linguistic convention of using 'time' rather than 'temporality' and the ideological hegemony of the notion of Absolute time, perpetuated through the social hegemony of capitalist mechanical clock-time, that some scholars argue that "time is in need of a de-reifying critique: [because it is] not a 'thing,' a natural object, or a neutral ('given,' 'ahistorical' and 'asocial') universal feature of human consciousness" (Martineau, *Time, Capitalism, and Alienation*, 5).

[116] Karl Marx and Frederick Engels, *Marx & Engels Collected Works Vol 25: Engels: Dialectics of Nature* (London: Lawrence & Wishart, 1987), 49.

[117] Karl Marx, *Grundrisse: Foundations of the Critique of Political Economy*, trans. Martin Nicolaus (New York: Penguin Books, 1993), 85.

> practice,—such is the dialectical path of cognition of truth, of cognition of objective reality.[118]

The analytical cleavage that occurs in the process of rational abstraction, therefore, is not a reductive abstraction that obfuscates the true nature of the world, or a denial of the dialectical nature of the "basic general forms of the world," but rather helps us grasp these forms with greater depth, accuracy, and comprehensiveness in order to advance our understanding towards a closer approximation of objective reality, of society and of nature, and their interrelation. In fact, the abstraction of time here captures the dialectical process of time under capitalism which makes possible a dialectical analysis "with an emphasis both on the tendency of capitalism to commodify time, and the irreducible substratum of 'multiple' concrete times that make up the social fabric."[119] On this basis, we can now say that the *rational abstraction of time* enables the development of, on the one hand, a historically specific understanding of the negative moment of capital's subsumption of various concrete social and ecological times and, on the other, the positive moment of capital's social production of its own form of abstract, alienated time and temporality; from this methodological foundation we may proceed with our considerations of a temporal analysis of capitalism.

I wish to briefly bring attention to an important, if often ignored, implication of the dialectical unity of the basic general forms of the real world, which is that "spatiotemporal framing is always overtly or covertly present in any form of inquiry."[120] This results in the dialectical unity of space and time being paid due attention in some cases, while in other

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[118] Vladimir Lenin, *V.I. Lenin Collected Works, Vol. 38* (Moscow: Progress Publishers, 1972), 171.

[119] Martineau, *Time, Capitalism, and Alienation*, 8.

[120] David Harvey, "The Dialectics of Spacetime," in *Dialectics for the New Century*, ed. Bertell Ollman and Tony Smith (New York: Palgrave Macmillan, 2008), 98. Stefano Bracaletti highlights this with regard to Marx's *Capital*, by explaining that "in *Capital* these [temporal] processes and dynamics remain 'hidden', so to speak, within the folds of the analysis of the production and circulation processes" (Stefano Bracaletti, "Temporality in Capital," in *The Government of Time*, ed. Vittorio Morfino and Peter D. Thomas (Leiden: Brill Academic Publishers, 2017), 78-116). This point is relevant for the discussion below.

cases it is simply presupposed and/or ignored.[121] However, since it is my intention in the present work to conduct a focused discussion dealing strictly with the temporal dimension of this dialectical unity by analyzing the temporal logic of capital and the nature of capitalist social time relations, particularly in their relation to the global socio-ecological crisis of the current moment, I will not undertake any sustained discussions of space or spacetime.[122]

In developing the theoretical orientation of the present project, I am greatly indebted to the works of many thinkers who have developed analyses of time and temporality under capitalism, but perhaps none more so than that of Jonathan Martineau in his *Time, Capitalism, and Alienation*, as it is from this excellent research that I take many cues in the development of the present work. On this note, it is important to stress that the present study, given its very similar theoretical orientation and object of analysis, begins by positing two related foundational theoretical commitments that are best expressed by Martineau. The first is a treatment of time as "a *social* phenomenon," as opposed to, for example, conceiving of

[121] David Harvey, for one, has been highly critical of the lack of attention paid to space and time in Marxist scholarship, decrying this "seemingly blind indifference to understanding the role of the basic concepts of space and time" as "One of the more frustrating aspects of Marxian approaches to dialectics" (Harvey, "The Dialectics of Spacetime," 98). The field of Marxian critical geography, however, to which Harvey belongs as the main representative, has, in recent years, done a fairly good job at bringing attention to this lacuna in Marxian theory and foregrounding the dialectical unity of space and time, to much success (so much so that Andreas Malm quips that, nowadays, given the "meteoric rise of critical geography...the star of David Harvey shines brighter than that of any Marxist historian" (Malm, *Fossil Capital*, 6). In my opinion, Marxist philosophers, particularly in the age of ecological breakdown, must recognize not only the importance of understanding the fundamental categories of time and space, but in connection with this must become cognizant of what Christopher Caudwell calls the "crisis in physics" (Caudwell, *The Crisis in Physics*). This crisis concerns the undialectical ontological dualism of the "closed world [that] is the aim of bourgeois physics" which is "artificially imposed by the special categories of the [bourgeois] society which generated [modern] philosophy" and which, given the development of the internal contradictions of the worldview of this bourgeois form of science, has veritably burst asunder and now makes way for a more dialectical materialist worldview (however, this is dialectical materialism *sans* Epicurus, Hegel, Marx and Engels etc., at this stage, per the bourgeois hangover in science in its current form) (Caudwell, *The Crisis in Physics*, 47). Failure to recognize the developments in contemporary science with regards to notions of space and time, particularly in the fields of complexity theory and systems theory, will necessarily result in an unscientific Marxism undeserving of the name Marxism at all; for, as Helena Sheehan asserts, Marxism "needs constantly to be revised in light of the most advanced science, the most up-to-date knowledge, of its time" (Helena M. Sheehan, "J D Bernal: philosophy, politics and the science of science," Journal of Physics 57 No. 1 (Feb 2007): 31).

[122] This delimitation is due to the scope of the present work rather than unacknowledged presuppositions, as I hope the acknowledgement of the dialectical unity of space and time in this paragraph shows. Moreover, by focusing on time and temporality, I hope to make a contribution that will be of use to those who do take up space and/or spacetime as their object in future studies.

time metaphysically, as with the Newtonian conception of Absolute time. Understanding time as a social phenomenon

> means that any idea or practice of time comprises a series of social determinations and mediations. Human lives and social life do not occur in time; rather they make and are *made* by time. Time is produced by and through social practices, and time systems, as well as the architecture of temporal relations, vary from one society or historical period to another. Since conceptions and practices of time are rooted in social practices, they require social and historical contextualisation. Time itself has a history.[123]

By beginning with a notion of time as a social phenomenon, not only are we able to avoid the metaphysical and/or cosmological quagmires than many non-materialist scholars of time and temporality inevitably fall into, but, more importantly, we are able to consider the socio-economic origin of the social time relations for a given system of production - in this case, capitalism.[124] Time is a socio-historical phenomenon and, as such, "Each historical epoch with its new forms of socio-economic expression is simultaneously restructuring its social relations of time."[125] Simply put, capitalism, as a system of commodity production and accumulation that generates its own historically distinct form of socio-metabolism and sociality,[126] necessarily produces a historically specific form of social time relations rooted in its specific mode of production.

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[123] Martineau, *Time, Capitalism, and Alienation*, 3-4.

[124] On this point, I adopt Mészáros position: "Naturally, our interest in this context is human historical time, and not some "metaphysical" or "cosmological" considerations of time. For us the time relations linked to the question of "cosmological contingency"—regarding, for instance, the possibility of other earth-like planets which might be capable of supporting advanced forms of life in far away solar systems: a well-known part of some on going astrophysical enquiry today—are totally irrelevant" (Mészáros, *The Challenge and Burden of Historical Time*, 36). Suffice it to say, the following analysis is rooted in this historical-materialist position.

[125] Barbara Adam, "The Gendered Time Politics of Globalization," *Feminist Review*, no. 70, Globalization, (2002): 14.

[126] In using this term, I am drawing on the following definition: "The creation [by tailoring space and time coordinates of activity to the principles of means-ends optimization] of a form-specific spatial and temporal social system of coordinates through the production of material structures and immaterial norms abstracts from traditional, pristine, and 'natural' spatial and temporal coordinates. This is the production of capitalist 'sociality,' that is, of a particular unified perception of time, space, cause, number and other basic categories of understanding." (Elmar Altvater, "Ecological and Economic Modalities of Time and Space," in *Is Capitalism Sustainable? Political Economy and the Politics of Ecology*, ed. Martin O'Connor (New York: The Guilford Press, 1994), 78.

To begin to clarify the historical specificity of capitalist social time relations, we can initially distinguish capitalism as an accumulative social system, as opposed to the non-accumulative social formations that antedate capitalism.[127] On the one hand, non-accumulative "societies were engaged mainly in agricultural and craft production and integrated with natural, cyclical rhythms," whereas capital, as an accumulative social order, organizes abstract, alienated social time relations for purposes of over-production and expansion through accumulation.[128] More precisely, capitalism, as an accumulative regime *par excellence*, engages in a highly destructive and violent process of reorganizing space and time because "time has to be compressed and intensified in order to become as productive as possible…[and] space has to be shaped according to the needs of circulation and reproduction."[129] Besides this broad preliminary historical distinction, much about the historically specific and alienated temporality generated by the capitalist mode of production and the process of capital accumulation remains to be analyzed; this is the task I take up below.

The second theoretical commitment serves to determine the mode of time treated in the analysis of the present study, through which I seek to advance a dialectical

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[127] This distinction comes from Marx who, correcting Adam Smith, remarks that accumulation is not only "the result of the capitalist mode of production but its point of departure." This "primitive accumulation…appears as primitive because it forms the pre-history of capital" (Marx, *Capital, Volume 1*, 873). More specifically, with regards to *capitalist* accumulation, we should be aware that capitalism's "own distorted existence means that [accumulation] has to be done in certain ways. It is easier for the system to grow by producing depleted uranium shells to be used in imperialist wars or by expanding agribusiness devoted to producing luxury crops to be consumed by the relatively well-to-do in the rich countries than it is to protect the integrity of the environment or to provide food for those actually in need" (Foster, Clark, and York, *The Ecological Rift*, 204). In other words, the problem is not simply the fact that accumulation takes place, but the form which accumulation takes under capitalism, such that "To reduce the whole environmental problem to the issue of scale - however much that constitutes the first step in addressing the problem - is to underestimate the systemic obstacles like the conflict between use value and exchange value built into the structure of the existing system" (Foster, Clark, and York, *The Ecological Rift*, 204).

[128] John Bellamy Foster, et al., "Henri Lefebvre's Marxian ecological critique: recovering a foundational contribution to environmental sociology." *Environmental Sociology* 6, no. 1 (2020): 36.

[129] Massimiliano Tomba, "Time" in *The SAGE Handbook of Marxism Volume 1*, ed. Beverley Skeggs et al., (Los Angeles: SAGE, 2022), 503.

> synthetic account of social time in which human groups reproduce themselves, and develop conceptions and practices of time, in a way in which 'natural' time is always already socially mediated in human experience, 'social' time always encompasses a multiplicity of 'natural' and 'individual' temporal phenomena, and 'subjective' time is mediated by the simultaneously social and natural experience and constitution of human beings.[130]

It is only upon the basis of a dialectical, synthetic account of time, as described in the above passage, that incorporates both social and natural dimensions of temporality, and the respective mediations of these time concepts, that any analysis attempting to deal with the temporal dimensions of humanity's socio-metabolic interaction with nature may be successful. It would be reductive, for example, to present a study of subjective time by focusing only on individual psychological temporality while failing to recognize how the individual's time concept is determined by various social and natural temporalities and by history. Therefore, I will be seeking to develop an understanding of the temporality of capital that captures the dialectical complexity of the multiplicitous time concepts that a strong synthetic account of social time encompasses.

Here it is also important, due to the overlap of approach and scholarly concerns, to briefly distinguish between Martineau's particular object of focus and this study. Although in his introduction Martineau identifies the focus of his text as the "relations between the social organization of the metabolic activities of human societies, and their conceptions and practices of time," throughout the text this focus tends less towards a discussion of metabolic interaction and exchange with nature, as it is conceived of in Metabolic Rift Theory, and more towards the *strictly social* (rather than natural or ecological) implications of capitalist social time relations. The subtle distinction lies in the fact that, for Martineau, 'metabolic activities' designates human social productive activity (that is, labor in general), rather than designating the dialectical interconnection of nature and a historically specific mode of production - in

[130] Martineau, *Time, Capitalism, and Alienation*, 4.

fairness, Martineau does make this clear.[131] The latter definition, which approximates the meaning of 'metabolic activity' as used in Metabolic Rift Theory, will be the operative definition of 'metabolism' or 'metabolic activities' in the present work. In contrast to Martineau, this work will focus on the relation of capitalist social time relations (and the temporal logic of capital that gives rise to these relations) as they determine the socio-metabolic interchange of capitalist society and nature, and, additionally, on the temporal logics and notions of temporality expressed by certain political ecological theories *in and through* their proposed political solutions to ecological cries. It is in this sense that the current work, although in many ways drawing upon theoretical foundations outlined by Martineau, is distinct.

2. A Brief Note about the Categories of Time and Space in the History of Marxist Scholarship

How have Marxists sought to contend with and incorporate the categories of time and space in their analyses, and has enough critical attention been given to these categories throughout the history of Marxist scholarship?[132] As was mentioned above, Marxist critical geography has done much in recent years to develop our understanding of the relation of capital to space, in many ways by building upon the attempt to understand this relation, albeit sometimes implicitly, in 20th century studies of 19th and 20th century capitalist imperialism

[131] Martineau, 4. As Martineau explains, his "particular study examines the relationship between time and capitalism: it seeks to delineate some of the characteristics of capitalism's mode of social time and to examine how processes of capitalist value formation and appropriation affect and/or construct a historically specific relationship between an 'abstract' time-form (known as clock-time) and 'concrete' times" (4). Given this, his use of 'metabolic activities' seems to be an attempt to overcome the ideological distinction of productive and reproductive times, rather than a specific attempt to introduce ecological concerns to his work.

[132] Although it is not my intention here to provide a full and detailed review of Marxist studies of categories of space, time, and spacetime because the scope does not permit such a review, it is helpful in the unfolding of the work to present at least a brief picture of this history, in part to show that there has been an extensive focus on space (perhaps to the exclusion of time), and in part to show that the perception of this history is contested by those involved in it. Ultimately, however, this history shows that there is still work to be done and much more to be said by Marxists regarding time, space, and spacetime under the capital system.

and colonialism by thinkers like Luxemburg[133] and Lenin who dealt with what might be considered *extensive accumulation*; that is to say, "the system's growth towards an outside through dispossession, commodification and appropriation of labor time, social space and objects (as means of production or of consumption) that were not incorporated in capitalist social relations."[134] As we see here, this form of accumulation corresponds primarily to the spatial form of domination, exploitation, and accumulation, which in turn corresponds primarily to the imperialist and colonial phase of capital's development in the 19th and 20th centuries.[135] As such, given the nature of the history of the 19th and the earlier decades of the 20th century, and the continually expanding spatial frontiers of capitalist accumulation during this time, it would seem that space has, rightfully, been the dominant category of Marxist investigations into the nature and logic of capital and its accumulation dynamics. Even as we progressed into the 21st century and the time of unprecedentedly accelerated/accelerating technological development, Frederic Jameson characterized the era of postmodernity as a period of socio-temporal synchronicity wherein "our daily life, our psychic experience, our cultural languages, are...dominated by categories of space rather than by categories of time."[136] The result of this synchronicity is that "postmodern generations are dispossessed

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[133] For Luxemburg, "extensive forms [of accumulation] were considered to predominate over intensive forms, this was the cornerstone of her theory of imperialism and eventual capitalist crisis and breakdown" (Eric Pineault, "Growth and Overaccumulation in Advanced Capitalism: Some Critical Reflections on the Political Economy and Ecological Economics of Degrowth," *DFG-Kolleg Postwachstumsgesellschaften*, no. 5 (2016): 5).

[134] Pineault, 4. In order to avoid a rather obvious criticism that extensive forms of accumulation dominate "labor time" as well as "social space and objects" equally, and therefore time and space equally, it is necessary to point out that, in this quote, it would be more accurate to render "labor time" as 'labor power,' since, as Marx notes, the capitalist does not buy labor that has already been used to produce something - as this would mean buying the commodities that have been produced, that is, objectified labor power - but rather purchases *as yet unspent* labor power *in order* to produce commodities at a cost that makes possible the extraction of surplus value. "Labor time" in this quote refers to the labor power of people outside of capitalist relations of production which is to be made into a commodity (i.e., to be made to be purchasable on the market) through the mechanisms and machinations of imperial and colonial domination.

[135] Pineault presciently notes that extensive accumulation can also refer to "investment in the expansion of existing productive capacity" and adds "When discussing the effect of extensive accumulation on the exploitation of labour, Marx used the expression 'formal subsumption' meaning that the exploitative relation concerns primarily the outer form of the labour process without changing its content" (Pineault, 4).

[136] Fredric Jameson, *Postmodernism, or, The Cultural Logic of Late Capitalism* (New York: Verso, 1991), 16.

(without even knowing it) of any differential sense of that deep time" and left to inhabit an ahistorical perpetual present replete with spatial theories of globalization.[137] While capital spent the 19th and 20th centuries extending its domination over the physical space of the earth, it has come, in the 21st century, per Jameson, to dispense with any meaningful sense of historical time and to extend its domination over both representative and ideological space too.

In a sense, it is easy to understand why space has taken such a central role in Marxist analyses of these last two centuries: capital was, at an empirically observable level, *materially expanding within and dominating global space* through colonialism and imperialism, and continuing the process, identified and thoroughly described by Engels in *The Condition of the Working Class in England,* of the dispossession and centralization of wage-laborers in newly emerging cities and suburbs, while also forging a tightly interconnected global market through conquest and destruction that left no stone unturned in the hunt for new commodities, markets, and opportunities to generate surplus value.[138] Moreover, and so for quite obvious reasons, much of the attention of the emerging field of ecological-Marxism focused on the capitalist spatial domination of nature as a physical, extensive environment - many scholars in this field rightly heeding Marx and Engels' focus on the spatial division of town and country and the metabolic alienation engendered by this specific contradiction.

Despite the apparent prominence of space as the most fruitful critical category in Marxist scholarship in the 20th and 21st centuries, a brief evaluation of the attention paid to the categories of time, space, and spacetime in the history of Marxism does not present us with such a straightforward hierarchy of critical categories. Take, as examples, the following

[137] Fredric Jameson, "The End of Temporality," *Critical Inquiry* 29, no. 4 (Summer 2003): 699.
[138] Frederick Engels, *The Condition of the Working Class in England: From Personal Observation and Authentic Sources* (London: Granada Publishing, 1981).

five claims, all from eminent Marxists, about the respective importance and place of the categories of time and space in the history of Marxist scholarship: (i) "One of the more frustrating aspects of Marxian approaches to dialectics is *the seemingly blind indifference to understanding the role of the basic concepts of space and time*"[139]; (ii) "Lefebvre was concerned with correcting what he saw as *Marxism's over-emphasis of the temporal dimension - and concomitant under-emphasis on the spatial*"[140]; (iii) "Over the past decades, *critical theory has moved towards space, away from time as the long-favoured dimension*, the classical vessel of structure, causation, rupture and possibility. Within historical materialism, this 'spatial turn' has generated the meteoric rise of critical geography"[141]; (iv) "Moreover, although the literature on social time has indeed raised *the question of the commodification of time, historical-materialist studies of this question were, until very recently, rather scarce*, save for the pioneering work of Marx himself and the important subsequent theoretical work of Lukács"[142]; and (v) "The tyranny of time in capitalist society is a central dimension of the Marxian categorical analysis."[143, 144] In other words, the whole gamut of possible perspectives on the relative importance or problematic ignorance of the categories of space and time in Marxism are represented from inside the tradition. We see here, in one case, an exasperated condemnation of the supposed complete lack of attention paid to the dialectics of space, time, and spacetime in Marxism; in another, the claims that Marxism has over-emphasized the temporal and under-emphasized the spatial[145]; in another case, the claim that Marxism has

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[139] Harvey, "The Dialectics of Spacetime," 98.

[140] Stuart Elden, "Rhythmanalysis: An Introduction," in *Rhythmanalysis: Space, Time and Everyday Life* by Henri Lefebvre, trans. Stuart Elden (London: Bloomsbury Academic, 2019), 3.

[141] Malm, *Fossil Capital*, 6.

[142] Martineau, *Time, Capitalism and Alienation*, 7.

[143] Moishe Postone, *Time, Labor, and Social Domination: A Reinterpretation of Marx's Critical Theory* (Cambridge: Cambridge University Press, 2003), 214.

[144] All emphasis in these five quotes is my own.

[145] Typically, this claim is found when the temporal is treated as, reduced to, or confused with the historical, which is of course, due to the material and conceptual overlap between time and history, a common, understandable, and perhaps occasionally even justifiable, categorical confusion.

always been more concerned with time and less concerned with space, but with the caveat that this is currently changing; and, in yet another case, we see the claim that time always has been and must always be central to any Marxian analysis. Whatever the case may be, Marxism, as a perpetually developing method of analysis seeking always to incorporate the cutting-edge of modern science, will (must) always have more to say about space, time, and spacetime because the relation of capital to these categories is also undergoing perpetual development as capital seeks out new frontiers, both spatial and temporal, for new markets, new commodities, and new forms of accumulation.[146] In the present work, I show that time has not been excluded from analyses and, in fact, that there have been many works developed around a temporal critique of capital, which help advance our understanding of the capital system as one that operates on both the spatial and temporal dimensions of the reality from which it emerges. Now, we will begin a description and examination of the *temporal logic of capital* and *capitalist temporality/social time relations* as they are expressed in and through the processes of direct production, simple circulation, reproduction, and accumulation of the capitalist mode of production, with a view to the form of the relation between the temporal logic of capital and the temporal-ecological rift.

3. The Temporal Logic of Capital

What is our object when we speak of the relation of time and capital, and what does examination of this object, this *relation*, tell us as we attempt to grasp more precisely the relationship of the capital system to nature? To answer this question, we must develop an understanding of the ways in which capital reduces, subsumes, transforms, produces, and reorganizes time for its own accumulative ends: we must concern ourselves with the temporal

[146] For an extensive history of the relation of Marxism and natural science, see Helena Sheehan, *Marxism and the Philosophy of Science: A Critical History, The First Hundred Years* (New York: Verso, 2017). Here, Sheehan explains that Marxism, particularly through Engels during its formative years, warns "not only against a one-sided, and therefore distorted emphasis on natural science over philosophy, but also against the opposite" (Sheehan, *Marxism and the Philosophy of Science*, 43).

dimension of the logic of capital - or *the temporal logic of capital*. Our question then becomes: what does an analysis of the temporal logic of capital and capitalist social time relations capture and reveal about the systemic dynamics which have produced the metabolic rift and are presently driving climate collapse?

The logic of capital, as is well known, has been most extensively unfolded by Marx in *Capital*. From the beginning of his analysis of the commodity as the individual unit, the germ, of the entire capital system, Marx unfolds the categories of use and exchange-value, commodity production and fetishism, surplus value, capitalist private property, the accumulation imperative, the principle of competition, capitalist class relations, and the formation of the global market, which constitute the most fundamental economic components of the structure of the capital system. Marx's analysis of the primary categories of the capital system, specifically in *Capital Volume 1*, in short, demystifies and reveals the internal logic of the system.[147]

The temporal logic of capital determines how capital organizes and re/produces social time (the temporality of capitalist sociality and capitalist social time relations); the ways in which capital shapes and utilizes time in order to generate and extract surplus value (abstract time, socially necessary labor time, and the control of the length of the working day through both automation and temporal disciplining of labor); the ways that capital operates *in and through* time (the contradiction and contrast between the (logico-ideal) objectives of its temporal logic and the social time relations/temporality it can attain in material reality over and against the objective conditions/limitations of its existence, i.e. labor and nature); and, of most importance for current purposes, the "relations between the social organization of the metabolic activities of human societies, and their conceptions and practices of time" (the

[147] Marx, *Capital Volume 1*. It is unnecessary to repeat Marx's arguments about the structure and logic of capital in great detail (for this, see *Capital*), but it is necessary to acknowledge that they form a major part of the groundwork on which this project stands.

domination of the temporal logic of capital over human socio-metabolic interchange with nature).[148] Although the capital system - like everything else in the universe given the "basic general forms of the real world" - exists *in and through* time, from where does the temporal logic of capital derive? For guidance as to where we might look to answer these questions, we will heed Massimiliano Tomba's appraisal: "*Capital* is a treatise on time, not only on stolen time, but also on its transformation and ontologisation."[149] Therefore, we turn now to *Capital*.

The analysis in the present work draws predominantly from *Capital Volume 1* because in this volume Marx considers capital at a level of abstraction that is congruent with the task at hand: namely, an analysis of the *temporal logic* of capital. While *Capital Volume 2* and *Volume 3* are concerned, for example, with concrete problems such as the "turnover [time] of capital," the temporality of the "reconstitution of the social product," and the varying temporalities of the "set of forms capital assumes in the process of circulation such as commercial capital and credit capital," the analysis presented here is directly concerned with the determination of the temporal logic of the capital system by the form of *capital in general* and its expression in "the linear and abstract temporality of the process of immediate production" and the cyclical temporality of the process of simple circulation as examined by Marx in *Volume 1*.[150] Although this level of abstraction may seem limited due to its exclusion

[148] Martineau, *Time, Capitalism, and Alienation*, 4.

[149] Tomba, *Marx's Temporalities*, 137.

[150] Bracaletti, "Temporality in Capital," 77-78. All laws and logics, Marx reminds us, are "modified in [their] working by many circumstances" (*Capital Volume 1*, 789). Many factors, including the variety of barriers and forms of pre-capitalist organization that capital encounters and contends with as it emerges in a specific location will greatly influence the development of capitalism as it emerges and begins to subsume a given society. In this regard, we can consider how "The operation of formal subsumption - referring to the encounter of capitalism and received practices at hand [-] appeared first in the appropriation of labor practices belonging to a prior mode of production, which invariably meant taking on the baggage of older forms of exploitation and resituating them alongside and within newer capitalist demands to create value" (Harry Harootunian, *Marx After Marx: History and Time in the Expansion of Capital* (New York: Columbia University Press, 2017), 12-3). It is for this reason that, despite the immutability and consistency of the temporal logic of capital, the subjective temporal experience of workers can vary across historical situations - for example, it is clear that comparing the temporal experience of a 21st Western worker laboring under a flexible, just-in-time system, to that of a 20th century

of the many important temporal problems of *Volume 2* and *Volume 3* such as the turnover of aggregate social capital and the realization of value on the global market, it is important to recognize that any analysis of these more concrete problems, in keeping with Marx's method, must begin from an analysis of the cellular, germinal form of capital *and its logic*. The analysis must begin here precisely because it is through the processual operation of the temporal logic of capital over and against the material conditions and limitations of capital's existence (i.e., labor and nature) that these larger, global problems emerge. In addition, as our attention is directed primarily toward the *systemic dynamics* of capital that drive ecological collapse, the appropriate level of abstraction for our analysis is the logical form and operation of capital that constitute and determine the dynamics of the system. For this reason, the present work aims to analyze the temporal logic of capital in general (i.e., capital in the abstract), and therefore will not be able to take up other problems of the temporality of capital mentioned above.[151]

The logic of capital in general is best distilled by Marx in *Capital Volume 1*, "Chapter 4 The General Formula for Capital" wherein Marx examines "the circulation of commodities [which] is the starting-point of capital," or simple circulation, through which capitalism's historically specific value form emerges.[152] The temporal logic of capital is bound up with, and therefore can be derived from, the logic of capital, because it simply signifies the

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worker laboring under a Fordist system, to that of an enslaved person in the 18th century laboring under conditions of chattel slavery, would show great variance. What we have here, then, is a view of the uneven and combined *temporal* development of capital. In light of this, the institution of World Standard Time, established in the latter half of the 19th century, can be understood as a continuation of capitalism's process of temporal homogenization, both formally and experientially. Thus, although we can recognize the variance of subjective temporal experience, in remaking the world in its own image capital is nonetheless engaged in a project of subsuming and/or reducing all concrete times to abstract labor time. The degree to which this is achieved in a given society is reflected in the subjective temporal experience of the worker. While it is certainly an interesting object for future studies, due to reasons of scope, I do not have the opportunity to enter into a full analysis of the historical variance of subjective temporal experience here.

[151] For an excellent and nuanced examination of the many problems of the temporality of capital developed in *Capital Volume 2* and *Volume 3*, see Stefano Bracletti's wonderful essay "Temporality in Capital" in *The Government of Time*.

[152] Marx, *Capital Volume 1*, 247-57.

temporal aspect of this broader logic. Thus, it is from Marx's analysis and presentation of the "general formula for capital" (i.e. the logical form of capital in general) from which we can deduce not only the logic of capital in its most elementary form, but its specifically temporal aspect - its temporal logic and related temporality.[153] It is in this sense that Moishe Postone is correct in stating that "time in capitalist society is a central dimension of the Marxian categorical analysis," since the temporal aspect of the logic of capital underpins the historical development of the entire capital system.[154]

In "Chapter 4," signaling the importance of this part of his analysis, Marx expends a great deal of effort meticulously describing the specific nature and processes of capital *in circulation* - the nature of capital *in general* - through both analytic formulas which express the movement of capital in circulation (e.g. M-C-M`),[155] and through his quite brilliant use of metaphor and allegory (e.g. his metaphorical portrayal of capital, as the relation between value and surplus-value, as formally corresponding to the relation of God the Father and God the Son in Christianity).[156] In this early chapter of *Capital*, Marx presents an argument that is indispensable to his whole analysis of the self-propelling development of capital and which is shown to be foundational to any attempt to understand the capital system: that "M-C-M` is in fact therefore the general formula for capital, in the form in which it appears directly in the sphere of circulation."[157] Now, recalling Marx's description of the "sphere of circulation" as

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[153] Marx, *Capital Volume 1*, 247.

[154] Postone, *Time, Labor and Social Domination*, 214.

[155] "The complete form of this process is therefore M-C-M`, where M` = M + ΔM, i.e. the original sum advanced plus an increment. This increment or excess over the original value I call 'surplus value'. The value originally advanced, therefore, not only remains intact while in circulation, but increases its magnitude, adds to itself a surplus-value, or is valorized. And this movement converts it into capital." (Marx, *Capital*, 251-2)

[156] "But there is more to come: instead of simply representing the relations of commodities, it now enters into a private relationship with itself, as it were. It differentiates itself as original value from itself as surplus-value, just as God the Father differentiates himself from God the Son, although both are of the same age and form, in fact one single person; for only by the surplus-value of £10 does the £100 originally advanced become capital, and as soon as this has happened, as soon as the son has been created and, through the son, the father, their difference vanishes again. And both become one, £110" (Marx, *Capital Volume 1*, 256).

[157] Marx, *Capital Volume 1*, 257.

"the starting-point for capital," we see that not only is the formula M-C-M` the formula for capital *in general*, but that it is the *movement*, the *process* of capital this formula expresses that represents the temporal logic of capital.

In order to draw out the specificities of the temporal logic of capital, Marx contrasts the circulation of capital, or what he calls "buying in order to sell" (M-C-M`), with simple circulation, or "selling in order to buy" (C-M-C), such that he can show how

> In simple circulation, the value of commodities attained at the most a form independent of their use-values, i.e., the form of money. *But now, in the circulation M-C-M, value suddenly presents itself as a self-moving substance which passes through a process of its own*, and for which commodities and money are both mere forms. But there is more to come: instead of simply representing the relations of commodities, *it now enters into a private relationship with itself*, as it were...*Value therefore now becomes value in process, money in process, and, as such, capital. It comes out of circulation, enters into it again, preserves and multiplies itself within circulation, emerges from it with an increased size, and starts the same cycle again and again*.[158]

Importantly, and as Marx makes eminently clear in his description of capital *in general* as capital *in process* or *capital in motion*, capital is depicted as a substance that cannot be conceptualized *but on the basis of time*, since one simply cannot conceive of motion without time. It is this fact that has led some scholars to declare, not incorrectly, that "the logic of capital is essentially temporal."[159] Capital in general, as *capital in motion*, has a temporal

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[158] Marx, *Capital Volume 1*, 256. Emphasis is my own.

[159] Stahel, "Time Contradictions of Capitalism," 101. Although this claim forms the basis of Stahel's argument, and while I do not disagree with his analysis of capital, I see a benefit of preserving the distinction between the 'logic of capital' and the 'temporal logic of capital' because the former, I believe, as a broader category, captures the complexity of the processes of capital through a more expansive scope, and includes, for example, the dialectics of space (e.g., the logic of extensive accumulation) and spacetime. In addition to this, I would contend that Stahel operates in his paper, despite the certitude of the claim given here, with a broader conception of the logic of capital that is distinct from the temporal logic of capital. This can be seen, for example, in the following quote: "We are aware that the spatial and the temporal aspects are intimately interwoven, constituting a dialectical whole where one dimension only exists in relation and by means of the other. However, for analytical purposes, we will separate them in order to argue that while capital has an inherent tendency to expand in spatial terms (geographically, increasingly extending throughout the globe, as well as socially and ecologically, encompassing more and more social, cultural, political and biospherical domains under its rules), this expansion is subordinated to the temporal logic of its ends: the accumulation of capital itself." (Stahel, "Time Contradictions of Capitalism," 101). Stahel presents this schema on the basis of a distinction he makes between the 'logic of capital' and the 'processes of capital' as in this quote: "we can say that essential means of expansion of capitalism as a spatio-temporal process lies in its spatial dimension, while the essence of its ends and logic (the expansion and accumulation of capital itself) is given by its temporal dimension" (Stahel, "Time

basis - indeed, it is fundamentally temporal - which is made explicit when Marx states that it is "this movement [in circulation that] converts [value] into capital" (*Capital* 252). Continuing to develop his analysis of the nature and processes of capital in motion, Marx describes the "occult ability" of values process of "self-valorization" engendered by capital in circulation

> In truth, however, *value is here the subject of a process* in which, while constantly assuming the form in turn of money and commodities, *it changes its own magnitude, throws off surplus-value from itself considered as original value, and thus valorizes itself independently*. *For the movement in the course of which it adds surplus-value is its own movement, its valorization is therefore self-valorization. By virtue of being value, it has acquired the occult ability to add value to itself.* It brings forth living offspring, or at least lays golden eggs.[160]

These passages reveal a great deal about the nature of capital in process, and therefore, by highlighting the motion that is the most basic mode of existence of capital in general, provide a series of insights that express and clarify the temporal logic of capital. In the following, building on the analyses offered by Marx, I describe and analyze three important aspects of the temporal logic of capital: (a) *the necessity of the perpetual cycle* (ceaseless and limitless movement); (b) *the exponentially increasing magnitude of the infinite circulation of capital* (infinite growth); and (c) *capital as the "automatic subject" of the process of self-valorization* (the untethered, self-propelling, anti-ecological temporality of capital).[161] While the distinction made between these three aspects is merely analytic, and in reality they are dialectically bound up within the processes of the temporal logic of capital, I argue that by considering each aspect separately we can develop a sharper understanding of the temporal

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Contradictions of Capitalism," 102). While I agree that the logic (and therefore the temporal logic also) of capital derive from capital's accumulation imperative, in my analytical schema I allow for the existence of, for example, a spatial logic of capital (also derived from the accumulation imperative) that is distinct from the temporal logic yet bound up with it in the broader category of the 'logic of capital.' Despite the analytic differences between my own and Stahel's approach, I find his work to be of an extremely high quality and am grateful for the part his insights have played in the formation and development of the present work.

[160] Marx, *Capital Volume 1*, 255. Emphasis is my own.

[161] Marx, *Capital Volume 1*, 255.

logic and the logic of capital, and therefore more rigorously comprehend the functioning of the contemporary capital system. I will now develop a description of the three main aspects of the temporal logic of capital.

3.1 The Necessity of the Perpetual Cycle (Ceaseless and Limitless Movement)

The first aspect concerns what Marx describes as the "constantly renewed movement" of capital in circulation: "the circulation of money as capital is an end in itself, *for the valorization of value takes place only within this constantly renewed movement. The movement of capital is therefore limitless.*"[162] The first important point with regards to this aspect of the temporal logic of capital is that the *perpetual* cycle of capital circulation (and also, therefore, accumulation) must be *continuous*, permitting no breaks, no stoppages, no pauses of any kind. In the extreme, a long enough interruption of the perpetual cycle of capital could portend a death sentence for the system itself. Any interruption of the perpetual cycle constitutes a violation of the nature of capital in general and, therefore, from the perspective of the system, must be unremittingly prevented and avoided; this can be illustrated well by a recent pertinent historical example. It is the *necessary continuity* of capital circulation that generated and forced such a difficult decision for the political representatives of the capital system in the West during the initial stages of the 2020 Coronavirus pandemic: the pragmatic, common-sense responses of virologists, biological scientists, and health experts around the world to the global spread of the virus - to shut down, lock down, and stop all non-essential social activity, especially the glut of non-essential economic activity - were in contradiction with the imperatives of the representatives of capital who must do all they can, in keeping with the political dictates of the temporal logic of the system, to maintain the *perpetual*

[162] Marx, *Capital Volume 1*, 253. Emphasis is my own.

operation of business, trade, and *doux commerce* (i.e. of capital) at any cost.[163] These representatives understand very well - if not in Marxist terms - that any hindrance to the "constantly renewed movement" of capital in circulation is deleterious to the system as a whole. In fact, so powerful is the force of compulsion descending from the temporal logic of capital that decisions to go into lockdown represented something of a world-historical moment: "Never before had the business-as-usual of late capitalism been so utterly suspended."[164] Implementations of lockdowns - and the concomitant slowdown or pausing of capital circulation - constituted such a shock to the capital system during the pandemic, by interrupting its necessarily perpetual cycle, that a majority of the responsive actions of the system's political representatives to lockdown conditions were geared towards easing the difficulties afflicting the system itself, as opposed to easing the toll of severe illness, trauma, and mass-death on the human sufferers of the ravages of the pandemic.[165]

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[163] The phrase 'Doux Commerce' refers to Albert Hirschman's "'doux-commerce' ('sweetness of commerce') thesis, which, he argued, was conventional wisdom in the mid eighteenth century" (Jessica Whyte, *The Morals of the Market: Human Rights and the Rise of Neoliberalism* (New York: Verso, 2019), 14-5). To explain the doux-commerce thesis, Hirschman quotes Montesquieu's maxim, "'Commerce...polishes and softens (adoucit) barbarian ways as we can see every day,'" and, explaining this view, notes that "The image of the trader as a doux, peaceful, inoffensive fellow may have drawn some strength from comparing him with the looting armies and murderous pirates of the time," while critically remarking that "the persistent use of the term la doux commerce strikes us as a strange aberration for an age when the slave trade was at its peak and when trade in general was still a hazardous, adventurous, and often violent business" (Albert O. Hirschman, *The Passions and the Interests: Political Arguments for Capitalism before Its Triumph* (New Jersey: Princeton University Press, 1977), 60-2). Although the 'doux-commerce thesis' was a general dogma bolstering an emergent capitalist order in the early and mid-18th century, "A century later the term was duly ridiculed by Marx who, in accounting for the primitive accumulation of capital, recounts some of the more violent episodes in the history of European commercial expansion and then exclaims sarcastically: 'Das ist der *doux commerce*!'" [This is sweet commerce!], adding in a footnote that: "The term became apparently a private joke between Marx and Engels" (Hirschman, *The Passions and the Interests*, 62).

[164] Malm, *Corona, Climate, Chronic Emergency*, 5.

[165] This has been particularly obvious throughout the Covid-19 pandemic, perhaps most so in the arch-capitalist nation states of the USA and UK. The differential in state-provided care offered to the private sector rather than the public sector can be roughly quantified by comparing the vast public monies bailouts received by corporations and businesses in both countries during the pandemic to the scant financial support received by workers and their households. In fact, the public monies sent to individual workers (with citizenship status) during the pandemic were quite overtly intended to be used to pay rent, and can thus be understood less as genuine financial support for citizen-workers and more so as bailouts for private landlords and the rentier sector of the economy. As one group of scholars recently observed: "This recent legacy of supporting the private sector at the expense of the public sector has been perversely notable during the pandemic, with larger corporations conspicuously the only constituency not being asked to take a financial hit by the more right-wing states"

The second important point with regards to this aspect of the temporal logic of capital is that, in the "constantly renewed movement" of capital in circulation, the *"movement of capital is...limitless*."[166] On the one hand, this is the logical counterpart of the necessity of *perpetual* movement, since any limit to this movement would, of course, violate its perpetuity. In other words, in order to be perpetual, it must be unlimited; if the movement was limited, it could not be perpetual, since this would of course imply a stopping point, a limit. On the other hand, the limitlessness of the circulation of capital is tightly bound up with the second aspect of the temporal logic of capital - that of infinite growth - because it is the unlimited nature of circulation which makes formally possible *the exponentially increasing magnitude of accumulation*. Thus, the overlap between the perpetual circulation and the ever-increasing magnitude of capital, through the logical relation of the limitlessness of capital in circulation to both of these aspects, generates a positive feedback loop of sorts, which we recognize as infinite growth; that is, the second aspect of the temporal logic of capital.

3.2 The Exponentially Increasing Magnitude of the Infinite Circulation of Capital (Infinite Growth)

For the perpetuation of the capital system, the constant movement of capital in circulation must not only be perpetual, but it must also be *exponential*, that is *ceaselessly expanding*. In more familiar terms, we would say that capitalism is necessarily a system of perpetual growth. This feature of the capital system leads Stahel, for example, to argue that the temporal logic of capital is "marked by a continuous and progressive temporality, *the time of the expanding capital*."[167] In fact, when we hear capitalism described as a 'growth based economy' or a 'system that produces economic growth,' or other such honorific, mystifying

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(Andreas Chatzidakis, et al., *The Care Manifesto: The Politics of Interdependence* (New York: Verso, 2020), 15).

[166] Marx, *Capital Volume 1*, 253.

[167] Stahel, "Time Contradictions of Capitalism," 101. Emphasis is my own.

euphemisms that invoke growth,[168] it is precisely this ceaseless expansion through the perpetual and exponential valorization of value (captured and represented by the formula M-C-M`) that is being invoked, typically in a positive, celebratory tone. As discussed, this aspect of the temporal logic of capital - *the exponentially increasing magnitude of the infinite circulation of capital* - is logically coupled with the perpetuity of the renewed movement of capital in circulation, and it is this coupling that produces capital's "uncontrollable expansive tendency that 'shatters and subordinates whatever resists it' – both humanity and nature," i.e., capital's process of infinite growth.[169]

The "time of expanding capital" is marked, then, not only by the limitless movement of capital in circulation, but also importantly by the *acceleration* of capital in circulation. This aspect of the nature of capital in general, as described by Marx, leads Elmar Altvater to argue that "To shorten the circulation time of capital is a principle inherent in capitalist development, as a way of increasing the rate of accumulation."[170] Thus, we can say that *the compression of circulation time of capital* is equivalent to *the acceleration of capital in circulation*, and thus the temporal logic of capital constitutes what can be described as an *expansive, accelerating temporal logic*. In one sense, this is what Marx elucidates when he argues that capital in circulation "passes through a process of its own" since the inherent tendency to accelerate circulation, coupled with the limitless movement of accelerating circulation, means that the temporal logic of capital in general is self-referential - it sets out its own course of development constituted by limitless movement and acceleration, which appears in practice as the compression of circulation time, and, once begun, cannot be

[168] And with this invocation of growth, the concomitant evocation of 'prosperity', 'higher standards of living', 'progress', 'development', 'innovation', 'advancement', etc. These connotations are, of course, merely ideological platitudes repeated by the representatives of the system in order to secure its preservation and continuation in spite of the immense destruction and immiseration generated by a process represented by that ever-innocent, always-positive term 'growth.'

[169] Lefebvre, *Critique of Everyday Life*, as quoted in Foster et al., "Henri Lefebvre's Marxian Ecological Critique," 37.

[170] Altvater, "Ecological and Economic Modalities of Time and Space," 77.

derailed from this track without endangering its very existence (i.e. continual processual movement) altogether.[171]

In the process of circulation represented by the formula M-C-M`, value "now enters into a private relationship with itself, as it were."[172] Of course, the acceleration of capital cannot be achieved by capital in-and-of-itself in the process of circulation, but requires, on the one hand, a specific form of sociality - capitalist sociality - which engenders specific social time relations, and, on the other hand, the actions of human subjects which correspond with the logical dictates of the system. This relationship, between the temporal logic of capital and the material social conditions and human actions that correspond to the dictates of this logic, is a dialectical one since the accelerating temporal logic gives rise to specific forms of material conditions and compulsion of human actions, and the material conditions and human actions perpetuate the temporal logic of acceleration - the process of acceleration of capital in circulation is mutually constitutive of the specificities of capitalist sociality (i.e. the material social conditions and human actions). Though they may be unaware of the Marxist analysis of this phenomenon, any individual seeking to generate profit through the valorization of value understands that, under the conditions of capitalism, (i) "the production of something of equal quality in a shorter time allows for a reduction in the price of the product, which increases its competitiveness," (ii) that "the faster an invention comes to market the better it is for a competitive edge over business rivals," and (iii) that "To be first, to be faster than competitors, is crucial, and this applies whether the 'product' is a new invention, a garment, a news story, or a new drug" etc.[173] It is precisely this that is meant by the argument that the temporal logic of capital determines specific forms of human behavior and material social

[171] This is where the point of analytic overlap lies between (b) the exponentially increasing magnitude of the infinite circulation of capital (infinite growth) and (c) capital as the "automatic subject" of the process of self-valorization (the untethered, self-propelling, anti-ecological temporality of capital).
[172] Marx, *Capital Volume 1*, 256.
[173] Barbara Adam, "Comment on 'Social Acceleration' by Hartmut Rosa," in *Constellations* 10, no.1 (2003): 50.

conditions, and why Marx can claim, at least in Volume 1 of *Capital*, that "individuals are dealt with only in so far as they are the personifications of economic categories."[174] Later he adds that the "conscious bearer of this movement" of capital, the capitalist, functions "as capital personified and endowed with consciousness and a will."[175] In other words, the temporal logic of capital is revealed in the fact that for capitalists "speed becomes an absolute and unassailable imperative for business," and, moreover, the necessity of speed in a capitalist market situation drives the accelerating circulation of capital.[176] The temporal logic of capital, as expressed in the exponentially increasing magnitude of the infinite circulation of capital, produces a "social principle that endeavors to reduce time intervals by submitting the quantity and quality of space to the principle of acceleration."[177] Therefore, we can see that this aspect of the temporal logic of capital generates a specific form of social ordering which involves "tailoring space and time coordinates of activity" to, in the case of capitalism, the accumulation imperative.[178] This amounts to saying that the capital system, given the implications of the temporal logic of capital, *requires its own mode of time and temporality*. Without delving too much into the history of abstract time and the hegemony of mechanical clock-time and their relationship at this point (as this is a task I will take up in more detail below), I must offer a few brief remarks regarding the role and importance of abstract, socially-necessary labor time, or commodified time, as measured by abstract mechanical

[174] Marx, "Preface To The First Edition," in *Capital Volume 1*, 92.
[175] Marx, *Capital Volume 1*, 254.
[176] Adam, "Comment on 'Social Acceleration' by Hartmut Rosa," 50. For the reasons laid out here, among the innumerable studies of the phenomenon generally described as the 'acceleration of modern life,' those which downplay or even completely ignore the role of the capital system in this phenomenon may be seductive in their pronouncements or even poetic in their analyses, yet offer, in the last analysis, little explanatory power and thus are ultimately useless to any emancipatory politic.
[177] Altvater, "Ecological and Economic Modalities of Time and Space," 78.
[178] Altvater, "Ecological and Economic Modalities of Time and Space," 78.

clock-time, as an extensive-instantiation of the abstract temporality of the logic of capital, to the accumulation dynamics of the capitalism.[179]

By returning to the originary kernel of Marx's analysis of the capital system, we see that the mystifying relation between use-value and exchange-value contained in and expressed by the commodity form also expresses a schism at the heart of capitalist temporality. This fracture imposed by the commodity form is accounted for succinctly by Tomba, who writes that "Schematically, we can say that use value expresses the quality of concrete labor supplied in view of the production of objects suitable for human needs…[while exchange-] value corresponds to abstract labor, labor without a specific quality, if nothing other than to be supplied in view of valorizing value."[180] Reconstituting this formulation with a greater focus on the temporal implications, Postone writes that "the magnitude of [exchange-] value is a function of the expenditure of abstract labor time, whereas material wealth is measured in terms of the quantity and quality of products created."[181] On the one hand, use-value is measured by the ability of the product of concrete human labor to satisfy historically determined human needs, i.e. qualitatively; on the other, exchange-value is measured according to the expenditure of abstract human labor time constituted as socially necessary labor time, i.e. abstractly quantitative. Thus, to clarify the somewhat general statement that 'capitalism requires its own mode of time and temporality,' we can now say that the operative value-form of the capital system, exchange-value, as expressed by the cellular unit of the system, the commodity, requires measurement as abstract, socially-necessary labor time in order to become universalized, thus enabling the global spatial

[179] Following Stahel, I use the term 'mechanical' "not only because this abstract time was originally measured by a mechanical device (the mechanical clock, but it makes no difference whether it is measured by electronic or atomic means, as presently), but more fundamentally because it refers to the time concept which lies at the heart of Newtonian mechanics, which shaped modern science paradigmatically" (Stahel, "Time Contradictions of Capitalism," 103).

[180] Tomba, "Time," 492.

[181] Postone, *Time, Labor, and Social Domination*, 193.

expansion of the system, and that this form of temporal measurement requires and is expressed in an abstract mode of time.[182] That the "historical origins of the conception of abstract time should be seen in terms of the constitution of the social reality of such time with the spread of the commodity-determined form of social relations"[183] leads our investigation to a specific historical moment: that of "the disintegration of the feudal system and…the emergence and development of merchant capital and manufacture" - also, and not coincidentally, the time of Newton.[184]

Newton's conception of Absolute time - "Absolute, true and mathematical time, of itself, and from its own nature flows equably without regard to anything external"[185] - was a major theoretical development that formed the basis of a surge of scientific discovery which can be understood as a response to the "purely mechanical problems" of the particular historical period, which were "primarily determined by the economic and technical problems that the rising bourgeoisie placed on the agenda."[186] Newton's mechanistic universe was (and still is) the worldview of the bourgeoisie and of bourgeois science, whose class interests required practical solutions to the obstacles that inhibited the development of industry, manufacture, communication, trade, navigation, transportation, raw material extraction, etc. - in short, of the development of the productive and distributive forces of capitalism. However, perhaps the most important requirement for the merchants and emerging bourgeoisie, and therefore also for the capital system more generally, in light of the fact that "development of merchant capital destroyed the isolation of the medieval town and the village commune,

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[182] "In capitalism, abstract temporal measure rather than concrete material quantity is the measure of social wealth" (Postone, *Time, Labor, and Social Domination*, 194).
[183] Postone, *Time, Labor, and Social Domination*, 202.
[184] Boris Hessen, "The Social and Economic Roots of Newton's Principia," in *The Social And Economic Roots Of The Scientific Revolution: Texts by Boris Hessen and Henryk Grossmann*, ed. Gideon Freudenthal and Peter Mclaughlin (Boston: Springer, 2009), 44.
[185] Isaac Newton, *Newton's Principia: The Mathematical Principles of Natural Philosophy*, trans. Andrew Motte (New York: Daniel Adee, 1846), 77.
[186] Hessen, "Roots of Newton's Principia," 52-3.

immensely extended the geographical horizon, and considerably accelerated the pace of life," was the need for "a more accurate measurement of time, especially in light of the ever accelerating pace of exchange."[187] Thus, the development of the mechanical clock should not be treated as a historical accident or a purely technological development, but must be understood, on the one hand, "with reference to a sociocultural process that it, in turn, strongly reinforced" and, on the other, as a necessary feature of the course of historical development of capitalism in imposing its mode of social domination.[188] The path to temporal-hegemony of abstract time as instantiated and measured by the mechanical clock is a long and complex one,[189] but what is important to grasp here is that, as capitalism developed, it required new social time relations that would make possible the abstraction and commodification of time in order to make labor and other commodities equivalent as exchange-values. As Adam explains, "empty, abstract, quantifiable, universally applicable time was a precondition for its use as an abstract exchange value on the one hand, and to the commodification of labor and nature on the other."[190] This exemplifies the importance of grasping the historical development of the social time relations during the period of transition from feudalism to capitalism, the period of the emergence of the capitalist mode of production, for an accurate understanding of the dynamics of a global capital system and,

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[187] Hessen, "Roots of Newton's Principia," 45-6.

[188] Postone, *Time, Labor, and Social Domination,* 203.

[189] And one which I will focus on in greater detail below, but for now see: Postone, *Time, Labor, and Social Domination*; Hessen, "The Roots of Newton's Principia"; Martineau *Time, Capitalism, and Alienation*; David S. Landes, *Revolution in Time: Clocks and the Making of the Modern World* (Cambridge: Belknap Press, 1983). However, to offer a small point of clarification at this point, Martineau does well to note the following: "What exactly is entailed by the expression 'rise to social hegemony'? Does it describe a process in which other times are extinguished or negated by clock-time? Does it mean that clock-time eradicates the multiplicity of social times? On this count, the answer is no. 'Hegemonic,' here, does not mean 'sole' or 'only'. It rather means that capitalism's tendency to abstract from concrete times and to reduce them to a common denominator, thus alienating and subsuming the multiple concrete times which make up the social fabric, is precisely that: a tendency ingrained in processes of capitalist valorisation. This hegemonic form of social time is thus embedded in the formation and appropriation of capitalist value, and tends to alienate and subsume concrete times, in a process that entails a logic of domination and resistance. In other words, clock-time's 'hegemony' means that it tends to dominate and subordinate other time relations, i.e. it becomes the dominant ordering of time, but always in a contested relation with other temporalities" (*Time, Capitalism, and Alienation,* 126).

[190] Adam, "Comment on 'Social Acceleration' by Hartmut Rosa," 50.

especially for our purposes here, for a clear understanding of the historically specific metabolic relation between capitalism and nature.

3.3 Capital as the "Automatic Subject" of the Process of Self-Valorization[191]

The final aspect of the temporal logic of capital which I will describe here has not been entirely absent from the discussion of the previous two aspects, although it has yet to be explicitly analyzed.[192] Insofar as it is impossible to consider (a) perpetual movement of capital in circulation without also considering (b) the exponentially increasing magnitude of capital in circulation, it is also impossible to consider (c) capital as the automatic subject of the circulation process without also accounting for both aspect (a) and (b); such is the nature of a dialectical account. With regard to this analytic connection, it was noted above that the main overlap between (b) and (c) can be identified in the self-referential logical relation between the necessary acceleration of capital in circulation and the self-valorization of capital in circulation. Therefore, we shall begin our description here.

The self-referential nature of the logic of capital can be observed, very clearly, in capital's perennial processual movement (i.e. M-C-M`) whereby capital, although changing the form in which it is represented, from money to commodities to money, over and over again, remains in "a private relationship with itself, as it were."[193] In other words, the processes through which capital *as* capital *must* proceed in order to maintain its character *as* capital are merely internally relational - only recognizing and operating on the basis of the internal relation between capital in different forms, i.e. the dialectical relation between the

[191] Of course, this description of capital is not meant to imply that capital operates in isolation from human labor or human subjects. Rather, the subjects who carry on the logical processes of capital are to be understood merely "as capital personified and endowed with consciousness and a will" (Marx, *Capital Volume 1*, 254). The extent to which capital *is* untethered from, or rather the extent to which capital *can be* untethered from, the objective conditions of its existence, and the subsequent (ecological) implications of this, will be the central focus of the following section.

[192] This is because, to reiterate, the aspects identified and described here are merely analytically separated, and in reality form a dialectical whole as capital in general.

[193] Marx, *Capital Volume 1*, 256.

movement of capital in general and the composite movement of specific capitals (e.g. industrial, financial, etc.) within and through their respective branches of production. From its internally related vantage point, capital in general recognizes no external relations, even those upon which it is ultimately dependent: for example, labor and nature. The self-referential (temporal) logic of capital in general leads Marx to depict capital as "a self-moving substance which passes through a process of its own."[194] The logic of capital is an *internal* logic which need not account for anything outside of itself since capital's whole (logical) existence is bound up and laid out in and by itself immanently. In light of this, we come to understand the incredible degree of insight about the logic and nature of capital that is expressed in Marx's metaphor: capital "differentiates itself as original value from itself as surplus-value, just as God the Father differentiates himself from God the Son, although both are of the same age and form, in fact one single person."[195] As with the different forms of the Christian God, the different forms of capital are internally logically constituted, immanently self-related. How, then, are we to understand this description of capital as logically self-referential, and what does it reveal about the temporal logic of capital in general?

In *Capital Volume 1*, Marx describes capital in general as the "automatic subject" of the process of self-valorization. Interestingly, Marx is not the first to describe capital in such terms, a fact of which he is aware, as can be seen in a footnote citation of Swiss economist Sismondi's description of capital as "permanent self-multiplying value."[196] Although the (temporal) logic of capital had been identified by the bourgeois economists, they had failed to treat it with the critical import that Marx was to introduce in his analysis. To grasp Marx's critique of the logic of capital, it will be helpful to return to an extremely important passage

[194] Marx, *Capital Volume 1*, 256.
[195] Marx, *Capital Volume 1*, 256.
[196] Sismondi as quoted in Marx, *Capital Volume 1*, 255-6.

from *Capital,* in which Marx clearly lays out his understanding of capital as the self-propelling subject/agent of its own processual movement:

> In truth, however, *value is here the subject of a process* in which, while constantly assuming the form in turn of money and commodities, *it changes its own magnitude, throws off surplus-value from itself considered as original value, and thus valorizes itself independently*. *For the movement in the course of which it adds surplus-value is its own movement, its valorization is therefore self-valorization. By virtue of being value, it has acquired the occult ability to add value to itself.* It brings forth living offspring, or at least lays golden eggs.[197]

As a system of self-referentiality, therefore, the temporal logic of capital, expressed in the movement of capital in circulation which is "its own movement," operates *as though* it were independent of any external constraints or conditions, namely labor or nature.[198] The source of this outward independence of capital can be uncovered by again turning to Marx's analysis of the cell of the capital system, the commodity form.[199] Much as the commodity form engenders an inversion of use-value and exchange-value, the instantiation of value as the hegemonic social mediation produces an inversion of the social activities of humans and capital in general through which the latter assumes a position as "the subject" of its own process, the former of course becoming objectified in the same process.[200] In other words, expanding on Marx's analysis of the commodity form, "the definite social relation between men themselves…assumes here, for them, the fantastic form of a relation between things," that is commodities and money *as* capital, in the process of exchange, and therefore capital in

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[197] Marx, *Capital Volume 1*, 255. Emphasis is my own.

[198] Marx, *Capital Volume 1*, 255.

[199] This method of approaching the temporal logic/temporality of capital is also taken up by the current foremost scholar of capitalist temporality, Massimiliano Tomba, who makes the following observation: "If, with Marx, the starting point for developing a criticism of the capitalist mode of production is the commodity and its dual nature – value and use value – this same incipit must also be the starting point for an analysis of capitalist temporality" (Tomba, "Time," 492).

[200] While in "Chapter 1" of *Capital* Marx describes the "enigmatic" and "mystical character of the commodity" which can only be explained by analogies to the human creations in the "the misty realm of religion," here, in "Chapter 4" he describes the "occult ability" of capital in general "to add value to itself" (Marx, *Capital Volume 1*, 164-5; 255). The cognate language that Marx employs signals the correspondence between his object of analysis - i.e., the commodity and capital in general.

general becomes the dominant subject [*übergreifendes Subjekt*] of social processes.[201] Hence, with the expansive development of commodity production, propelled by the ongoing process of originary accumulation, capital becomes the dominant social relation in human society. It is from this position, as the automatic subject of the process of circulation, that capital expresses its "occult ability to add value to itself" and attains its (logical) independence from external conditions and processes.[202] The infinitely moving and accelerating processes determined by temporal logic of capital thus operate independently, untethered and detached from anything that exists outside of itself, and therefore capital avails itself of any objective limitation or boundary to its process of accumulation.[203]

Through its logic, we can now say, capital expresses a false or bad infinity. Engel's incorporation of Hegel's "critique of 'bad infinity'" in the former's "conception of the dialectics of nature and history," is particularly relevant here.[204] "What Hegel called 'bad infinity,'" John Bellamy Foster writes, is "the principle of infinite merely quantitative and linear expansion, excluding qualitative transformation."[205] For Hegel, an abstract infinity that represents simply infinite quantitative expansion (e.g. 1+1+1+1…) is "intellectually self-defeating, and essentially meaningless."[206] Engels, taking up Hegel's Idealist critique, but grounding his materialist dialectics of nature in his broader "ecological worldview,"[207] claimed that, "Infinity is a contradiction, and is full of contradictions," and not merely in the

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[201] Marx, *Capital Volume 1*, 165.

[202] Marx, *Capital Volume 1*, 255.

[203] It is clear, in light of this sentence, how aspects (a), (b), and (c) of the temporal logic of capital are only analytically distinct and are ontically coexistent and inseparable.

[204] Foster, *The Return of Nature*, 268. While Hegel's notion and critique of 'bad infinity' is clearly very relevant to aspects (a), (b), and (c) of the temporal logic of capital in their own right, I have decided to discuss it here, in this latter stage of the analysis, so as to convey its relevance to the temporal logic of capital in general (i.e., all three aspects taken together).

[205] Foster, *The Return of Nature*, 230. The full quote reads: "What Hegel called 'bad infinity,' the principle of infinite merely quantitative and linear expansion, excluding qualitative transformation asserted itself more and more in the capitalist world, which was increasingly in conflict with the very principles of change, placing humanity at odds with the natural world, history, and its own existence" (Foster, *The Return of Nature*, 230).

[206] Foster, *The Return of Nature*, 230.

[207] Foster, *The Return of Nature*, 268.

abstract.[208] For Engels, Hegel's critique of 'bad infinity,' which is represented as a "straight line, extending infinitely in both directions, and thus without limits," when brought to bear on matter dialectically, comprises "the epitome of what is now seen as an unecological view."[209] On this point, Engel's position can be explained, on the one hand, by the fact that he had an expansive knowledge of (and, it must be said, an acute sensibility to) the environmental implications of human productive activity,[210] and, more importantly, on the other, by the fact that, already in 1882, Engels was aware of the finitude of the Earth System.[211] Commenting in *Dialectics of Nature* on the notion of 'bad infinity,' he notes that "it is not infinite: the end of the earth's lifetime can already be foreseen."[212] Thus, for Engels, the "general formula for capital," M-C-M`, in virtue of it being a material example of a 'bad infinity' of merely additive, quantitative expansion, constitutes the pure form of *the ecological contradiction* at the very center of the capital system.[213] In light of this, it is clear that "Capital's self-reproduction is thus inherently self-undermining… [because] *Its false infinity regularly runs up against finitude - and this is a central feature of its crises*."[214] The "general formula for capital," capital's expansive and accelerating 'bad infinity,' therefore represents the general formula for metabolic rift.

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[208] Marx and Engels, *Marx & Engels Collected Works Volume 25*, 48.

[209] Foster, Clark, and York, *The Ecological Rift*, 521n52.

[210] For more detail on Engels ecological worldview, see Engels *Dialectics of Nature* and John Bellamy Foster's "The Return of Engels" in *The Return of Nature*, 358-416. For examples of the ecological component of Engels thought, take the following passages: "For in nature nothing takes place in isolation. Everything affects every other thing and *vice versa*" and "In relation to nature, as to society, the present mode of production is predominantly concerned only about the first, tangible success; and then surprise is expressed that the more remote effect of actions directed to this end turn out to be of quite a different, mainly even of quite an opposite character" (Frederick Engels, *Dialectics of Nature*, trans. Clemens Dutt (New York: International Publishers, 1960), 289, 296).

[211] Granted, he does not use this contemporary parlance.

[212] Engels, *Dialectics of Nature*, 248.

[213] Marx, *Capital Volume 1*, 257.

[214] David McNally, "The Dual Form of Labour in Capitalist Society and the Struggle over Meaning: Comments on Postone," in *Historical Materialism* 12, no. 3 (November 2004), 204. Emphasis is my own.

While the formula for capital represents, in abstract, the growth of the capital system through its self-imposed movement, which *is* the generation of surplus value, it also represents, materially, the appropriation, exploitation, and transformation of the natural world into an "immense collection of commodities," and all the ecologically pollutive, destructive, and violent consequences which are to follow this process.[215] Humanity's socio-metabolic exchange with nature, and all the qualitatively different forms of socio-ecological interaction this relation entails, is reduced and submitted to the quantitative, additive dictates of the 'bad infinity' that is the logic of the capital system. We can surmise that should the 'bad infinity' of the M-C-M` formula continue infinitely (i.e., politically, this is called 'business as usual'), as its logical form entails, it will eventually come into contradiction with the objective limitations of variable capital, that is the material reproduction of labor,[216] and with the limitations of the conditions of production, that is, the limitations of our finite Earth System. Precisely this is happening today as the capital system, all the while continuing to accelerate and expand, immensely overshoots all known Earth System planetary boundaries at a historically unprecedented rate. The 'bad infinity' of the general formula for capital, M-C-M`, the irrepressible motor of our social system is, as Foster remarks, "placing humanity at odds with the natural world, history, and its own existence."[217] But here we might be inclined to ask: can the capital system be curtailed, controlled, and managed so as to prevent the running-up against these limits? To answer this question, we turn again to Marx and his appropriation of Hegel.

In his *Science of Logic,* Hegel introduces an important dialectical distinction between boundary [*Grenze*] and barrier [*Schranke*], in which the former is understood as *a real,*

[215] Marx, *Capital Volume 1*, 125.

[216] It is important to acknowledge that while the M` in the general formula for capital represents the appropriation of surplus value and so is the product of the originary contradiction between capital and labor, what I am arguing here is that the processes which this contradictory relationship gives rise to will eventually result in the inability of labor to materially reproduce itself.

[217] Foster, *The Return of Nature*, 230.

objective limitation, and the latter as *an obstacle to be overcome*. Taking up this distinction in the context of the processes and logic of capital, Marx writes that

> capital is the endless and limitless drive to go beyond its limiting barrier. Every boundary [*Grenze*] is and has to be a barrier [*Schranke*] for it. Else it would cease to be capital - money as self-reproductive. If ever it perceived a certain boundary not as a barrier, but became comfortable within it as a boundary, it would itself have declined from exchange value to use value, from the general form of wealth to a specific, substantial mode of the same. Capital as such creates a specific surplus value because it cannot create an infinite one all at once; but it is the constant movement to create more of the same. The qualitative boundary of the surplus value appears to it as a mere natural barrier, as a necessity which it constantly tries to violate and beyond which it constantly seeks to go.[218]

By the self-referential dictates of its own logic, capital, Marx contends, is not only incapable of respecting or deferring to the objectivity of boundaries imposed by the material conditions of its existence, but actively seeks to transforms these limiting boundaries into mere barriers, so that it may violate and overcome them in order to generate surplus value in perpetuity. It becomes clear that capital "seeks to annihilate the very material presuppositions of its own reproduction."[219] From the perspective of capital in general, anything that imposes limitations on the perpetual and accelerating generation of surplus value must be subsumed, swept aside, or destroyed. Moreover, Marx comments that, for capital, "The barrier appears as an accident which has to be conquered."[220] It is therefore appropriate to say that, from the perspective of capital, any barrier to expansive accumulation constitutes a deviation from the true objective conditions of capital's existence - that is, the self-referential logical ideal of capitals own existence as the dominant subject without any external constraints, prohibitions, or obstacles.

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[218] Marx, *Grundrisse*, 334-5. In a footnote, Marx adds: "The barrier appears as an accident which has to be conquered. This is apparent on even the most superficial inspection. If capital increases from 100 to 1,000, then 1,000 is now the starting point of departure, from which the increase has to begin; the tenfold multiplication, by 1,000%, counts for nothing; profit and interest themselves become capital in turn. *What appeared as surplus value now appears as simple presupposition etc*., as included in *its simple composition"* (Marx, *Grundrisse*, 335).

[219] McNally, "The Dual Form of Labour," 204.

[220] Marx, *Grundrisse*, 355.

Maintaining this crucial point, while deepening the argument, in *Capital Volume 3*, Marx writes:

> Capitalist production constantly strives to overcome these immanent barriers, but it overcomes them only by means that set up the barriers afresh and on a more powerful scale.
> The *true barrier* to capitalist production is *capital itself*. It is that capital and its self-valorization appear as the starting and finishing point, as the motive and purpose of production; production is production only for *capital*, and not the reverse, i.e., the means of production are not simply means for a steadily expanding pattern of life for the *society* of producers. The barriers within which the maintenance and valorization of the capital-value has necessarily to move - and this in turn depends on the dispossession and impoverishment of the great mass of the producers - therefore come constantly into contradiction with the methods of production that capital must apply to its purpose and which set its course towards an unlimited expansion of production, to production as an end in itself, to an unrestricted development of the social productive powers of labour.[221]

Labor and nature (i.e. the actual objective conditions of the existence of capital), then, for capital, are simply that "which has to be conquered" or, in other words, disciplined according to the requirements of the capital accumulation regime and converted into surplus value.[222] This brings us to the famous contradiction at the heart of the logic of capital: the objective conditions of the existence of capital, labor and nature, are treated as impediments to its process of valorization, and therefore must be overcome for capital to fulfill its valorization potential. Marx famously expressed this point as such: "Capitalist production, therefore, only develops…by simultaneously undermining the original sources of all wealth - the soil and the worker."[223] This leads to the conclusion that the (temporal) logic of capital is antagonistically and contradictorily opposed to its own conditions of possibility, labor and nature, and therefore, proceeding from this contradiction, it is evident that the temporal logic of capital and also the temporality of capitalist sociality are alienated. The temporal hegemony of the

[221] Marx, *Capital Volume 3*, 358.
[222] Marx, *Capital Volume 1*, 335.
[223] Marx, *Capital Volume 1*, 638.

reified, mechanical clock-time regime of modern capitalism is an alienated temporal hegemony.

Despite pretensions to *autonomy* via the alienation of its own objective conditions, (which we must distinguish from the *automaticity* of its logic and processes of valorization), it should remain clear that the logico-historical process in which capital has been engaged - the 'conquering' of the objective, material limitations of labor and nature - is ultimately an exercise in futility. "Labour and nature," Andreas Malm writes, "possess an ineradicable *autonomy* from capital. Both are ontologically prior to it, antedate its appearance on earth…and however hard various ruling classes have subsequently sought to control them…that autonomy persists."[224] Capital, fundamentally and ontologically, is dependent upon labor and nature. This is a fact, the terms of which, despite the best efforts of the representatives of capital, cannot be inverted. In this regard, Marx is careful to emphasize that there are particular aspects of reality, in this case the arrow of time as posited by the laws of entropy, that capital cannot overcome and to which it must, therefore, defer. When Marx writes that "Capital as such creates a specific surplus value because it cannot create an infinite one all at once; but it is the constant movement to create more of the same," he is highlighting precisely the materially temporal boundedness of the processes of capital, against the ideal of the logic of capital to exist outside time and space.[225] Capital, in other words, being bounded by time, can only valorize in the present moment, and cannot supersede or subsume its temporal limitations by instantaneously generating an infinite, atemporal surplus. Specifically, capital is bound to the entropic time of nature; capital, as a human creation, must exist

[224] Malm, *The Progress of this Storm*, 197.
[225] Marx, *Capital Volume 1*, 334.

according to the arrow of entropic time to which humans, likewise a part of nature, are also bound.[226]

Having now described in detail the contradiction produced by the temporal logic of capital between the objective-material conditions and boundaries of capital and the inveterate yet ultimately futile attempts of capital to 'conquer' and overcome these boundaries, we can begin to examine how capital proceeds on the basis of this contradiction. This brings our analysis to the concrete question of the temporality of capitalist sociality and the social time relations in capitalism. What is the character, we must now ask, of the temporality and social time relations that the temporal logic of capital gives rise to and, moreover, what does this tell us about capitalist socio-metabolic (re)production and its relation to, and effect upon, nature?

[226] "However trivial it may seem to mention it, nature cannot exist without time and space: the disregarding of space and time does away with nature, and since human beings are themselves natural beings, their mode of existence is thereby undermined" (Elmar Altvater, *The Future of the Market: An Essay on the Regulation of Money and Nature after the Collapse of 'Actually Existing Socialism'*, trans. Patrick Camiller (New York: Verso, 1993), 200).

CHAPTER IV

CAPITALIST TEMPORALITY: FEATURES, HISTORY, PROBLEMS

1. Introduction: Capitalist Temporality

In the following, I aim to provide an outline of some of the central features of capitalist temporality in general, which I understand as the socio-material expression of the temporal logic of capital through historically determinate relations of production, social organization, and institutional structuring which give rise to the specific social time relations of capitalist society and its socio-metabolic temporality. Because the concept operates at a high level of abstraction, when discussing capitalist temporality in general, it is important to acknowledge that, due to the contradiction between the logico-ideal expressed in and through the temporal logic of capital and the heterogeneity of material conditions capitalism encounters as it emerges and develops in and against a broad set of varying biogeophysical and socio-political conditions, relations, and spaces around the world, capitalist temporality does, in many ways, differ from place to place; we can say, in other words, that in becoming global hegemon capitalism underwent a process of uneven and combined temporal development.[227] Despite this, it is still possible to offer some observations and analyses of capitalist temporality *in general* because, notwithstanding the heterogeneous material conditions of capitals, the temporal logic of capital is a homogenous and ubiquitous feature of the emergence and development of capitalism.[228] To paraphrase Levins and Lewontin: capitalisms are logically similar, this makes analysis possible; capitalisms are materially

[227] For an excellent discussion of some of the specificities of capitalist temporality in differing biogeophysical and geopolitical spaces see Harootunian, *Marx After Marx: History and Time in the Expansion of Capital*. Given that the present work is concerned with capitalist temporality in general, there is not sufficient space for a full exploration of the specific differences of various capitalist temporalities in the current analysis.

[228] Quite obviously, this is evidenced in the fact that the capital system has never been anything other than a grow-or-die system - and never could have been, nor can be.

different, this makes analysis necessary.[229] In the following section, I will focus on the ways in which capitalisms, in the expression of capital's temporal logic *as* capitalist temporality, are logically similar in order to describe three features of capitalist temporality in general, that is, features of capitalist temporality that are common to all capitalisms.

2. The Short-Termism of Capital's Restricted Systemic Temporal Horizon

Capitalism, as the preceding analysis has shown, is an extremely temporally limited, short-termist system which, operating in an accelerating-expansive manner, strives to produce surplus value as quickly as possible at all times; as a grow-or-die system of unrelenting urgency in the generation of value, capitalism cannot slow down or rest in the present and cannot (p)reserve for the future.[230] This - *the short-termism of capital's restricted systemic temporal horizon* - is the first feature of capitalist temporality in general. We see this expressed at the level of the individual, by the fact that the capitalist "knows that the struggle for existence in business is waged round the timetemple, and who knows that he who has the shortest cuts in the end will survive."[231] As has been well documented, speed and acceleration are cardinal virtues at every level and stage of capitalist economic activity. Likewise Engels attests to this, stating that "The individual capitalists, who dominate production and exchange, are able to concern themselves only with the most immediate useful effect of their actions."[232] They are not, he adds, at all concerned with any of the more temporally remote social effects of their actions such as "what becomes of the commodity afterwards or who are its

[229] "Things are similar: this makes science possible. Things are different: this makes science necessary" (Richard Levins and Richard Lewontin, "Dialectics and Reductionism in Ecology," *Synthese* 43 (1980): 57).
[230] As such, it is unsurprising to find that capitalists, as personifications of the (temporal) logic of the system, do "not think of the future, only of the immediate profit," or that, in times of crisis, even those multinationals, corporations, and banks considered to be 'too big to fail' require taxpayer funded bailouts because they have not sufficiently prepared for such a possible future despite the inevitably of crisis under capitalism (Anton Pannekoek, "The Destruction of Nature" in *Zeitungskorrespondenz* 75 (10 July 1909). Translator unknown).
[231] John MacLean, "Time-saving and Karl Marx," *Justice* (14 December 1907), https://www.marxists.org/archive/maclean/works/1907-tsm.htm.
[232] Engels, *Dialectics of Nature*, 295.

purchasers."[233] In terms of the capitalist's relation to nature, "The same thing applies to the natural [i.e. ecological] effects of the same actions."[234] However, more important for our current discussion, and more problematic in relation to the material bases of capital, labor and nature, is the short-termism of the *systemic* temporal horizon of capitalism, from which the limited subjective temporal horizons of the capitalist arise, and about which Mészáros insightfully remarks that

> In relation to capital's mode of social metabolic control - which cannot contemplate the possibility of a future unless the projected future is envisaged as a direct extension of past and present determinations - there cannot be any such thing as "the longer run." The apologists of capital are fond of quoting the Keynesian wisdom according to which "in the long run we are all dead," as if that kind of frivolous dismissal of concern with the future could settle the matter. The truth, however, is that because of its *necessary nihilation of the future* the capital system is locked into the vicious circle of the short run, although its ideologists try to misrepresent such vice as an unsurpassable virtue. This is the reason why capital is incompatible with any meaningful attempt at comprehensive *planning*, even when the need for it is quite overwhelming in the troubled relations of global capitalist enterprises.[235]

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[233] Engels, *Dialectics of Nature*, 295. An important, although hardly redeeming, qualification should be added to this: under contemporary conditions of production, the capitalist does oftentimes take an interest in what becomes of the commodity after it has been sold. The capitalist's interest is in arranging the production process so as to accelerate (or shorten, depending on how one views it) the lifecycle of the commodity, in order to increase the rate at which the commodity becomes used up, defunct, or redundant, and therefore increasing the rate at which it must be repurchased/replaced. This phenomenon has been well documented across a gamut of commodities from light bulbs and pantyhose to smart phones, batteries, and household appliances, under the concept of 'planned obsolescence.' Temporally, then, the capitalist takes a perniciously cunning interest in accelerating the general formula for capital (M-C-M`), in accordance with the temporal logic of this formula itself, by accelerating the rate at which the process of this formula must be completed and repeated. Of course, this has led to a frightening increase in the quantity of waste produced by capitalist societies, particularly those highly-developed, Western economies now powered in a major way by consumerism, particularly of technological consumption. No doubt this phenomenon contributes to the anxiety that arises from the feeling of being "doomed to be forever running out of time" due to the accelerated/ing pace of life in modern society (Richard Gault, "In and Out of Time," *Environmental Values* 4, no. 2 (May 1995): 153). For Jean Baudrillard this can be explained by the fact that, in an age of "fantastic conspicuousness of con-sumption and abundance," we now "live by object time," a disoriented sense of time stemming from an inversion of the relation between the time of a human life and the time of the lifecycle of a commodity which contributes to "a funda-mental mutation in the ecology of the human species": "We live by object time: by this I mean that *we live at the pace of objects, live to the rhythm of their ceaseless succession*. Today, it is we who watch them as they are born, grow to maturity and die, whereas in all previous civilizations it was timeless objects, instruments or monuments which outlived the generations of human beings" (Jean Baudrillard, *The Consumer Society: Myths and Structures* (London: SAGE Publications, 1998), 25, emphasis is my own).

[234] Engels, *Dialectics of Nature*, 295.

[235] István Mészáros, *The Necessity of Social Control* (New York: Monthly Review Press, 2015), 64.

Due to the structural dynamics determined by its temporal logic, capitalism's systemic temporal-perspective is closed off to any future other than the perpetuation of its process of expansive accumulation. Capitalist temporality in general, then, is characterized by a fixity on the most immediate possibilities for valorization, the acceleration that goes along with this, and a concerning inability to contend with or plan for any sense of a future beyond the most immediate. In the warming world, however, the irrationality of capital's *systemic* temporality is most precisely exemplified, I argue alongside Anton Pannekoek, by considering the relation between capital's destructive appropriation of the natural world and the short-term temporal horizon with which this accords, alongside the corresponding suppression of any genuine thought of, concern for, or action over the (long-term) future:

> For capitalism all natural resources are nothing but gold. The more quickly it exploits them, the more the flow of gold accelerates…This is an economy which does not think of the future but lives only in the immediate present…Capitalism is a headless economy which cannot regulate its acts by an understanding of their consequences.[236]

Importantly Pannekoek, as is characteristic of socialist ecological critique, recognizes that the environmental problem is rooted *not* in the natural necessity of humanity's appropriation of nature and the fact that "to live…we have to use and consume [natural resources]," but rather he stresses that the problem is specifically "the way capitalism makes use of" natural resources - that is, in order "to make the most profit possible without even thinking for a single moment of the general interest, that of humanity."[237,238] Leaving aside the discussion of

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[236] Pannekoek, "The Destruction of Nature."

[237] Pannekoek, "The Destruction of Nature."

[238] It is a noteworthy historical point that Pannekoek published this pamphlet in 1909, fully sixty-three years before bourgeois society, with the publication of the Club of Rome's *The Limits to Growth* report, began to take notice of the deteriorating environment situation that socialist/anti-capitalist scholars had already identified (Donella H. Meadows, et al., *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe Books, 1972)). I wish to stress here the passivity of the phrase 'to take notice,' for this certainly does not mean bourgeois society generally 'accepted,' or 'initiated remedial or transformative action on the basis of,' the environmental situation. Rather, the *Report* was heavily criticized or entirely rejected by many preeminent representatives of bourgeois capitalist society. Take the following example: Wilfred Beckerman, one of the most influential neoliberal economists at that time, was to go "through the motions of a man bent on doing a thorough hatchet job" in his review of the Club of Rome's *Report* (EJ

capital's subsumption of non-economic values for now, Pannekoek makes clear that the temporal horizon of capital is concerned only with immediate and accelerating valorization of value and that this extremely limited systemic temporal-perspective is constituted in and through the very logic of the system. According to the fundamental precepts of the system, the exploitation of nature (and labor, for that matter) must undergo perpetual acceleration leading to a most unsustainable situation. He emphasizes that the long-term repercussions of the valorization of value for nature and labor are factors that in no way presently affect, limit, or curtail the operation of the system, and instead, as I have argued in Chapter 2, these objective conditions are posited by capital as mere barriers to be overcome, as merely relative to the absolute of capital. This contributes to the perpetuation of a 'business-as-usual' situation in which not only are current economic activities that will certainly produce extreme negative future consequences conducted uninterrupted and with relative impunity, but

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Mishan, "Reviewed Work: In Defence of Economic Growth by Wilfred Beckerman," *Journal of Political Economy* 83, no.4 (1973), 876). Mishan, a colleague of Beckerman at the London School of Economics, in his morally indignant criticism of Beckerman's review, writes: "Again, to take a couple of examples, we are told on page 123 that 'the total quantity of sulphur oxide emitted in the air in Britain has been falling since 1962.' But how can such a statement be squared with the figures given in table 2.4 of the National Survey of Air Pollution, 1961-71 (vol. 1) of total SO2 emissions of 5.72 million tones [sic] in 1962 and 5.95 million tones in 1970? And four pages later Beckerman alleges that the environmental impact of pollutants emitted from high chimneys 'is often virtually zero'" (Mishan, 875). The last sentence produces, quite understandably, profound incredulity in contemporary readers. In another example of rejection of the notion of limits to growth by the foremost representatives of capital, Beckerman's deceitful and discredited review was drawn-on extensively by Friedrich Hayek in his (Swedish Central Bank-sponsored) Nobel Prize in Economics acceptance speech in order to argue in favor of maintaining neoliberal economies in which market mechanisms are the sole regulating force in all human activity, including our metabolic interchange with nature (Friedrich Hayek, "The Pretence of Knowledge," in *The Essence of Hayek*, ed. Chiaki Nishiyama and Kurt R Leube (Stanford: Hoover International Press, 1984)). On the back of this rejection of the very idea of limits to growth, Hayek was to assert, quite astoundingly it should be said given that two years had passed since the publication of the *Report*, that "There is no danger whatever that, in any foreseeable future with which we can be concerned, the population of the world as a whole will outgrow its raw material resources, and every reason to assume that inherent [market] forces will stop such a process long before that could happen" (Friedrich Hayek, *The Fatal Conceit: The Errors of Socialism* (London: Routledge, 1988), 125). Current global freshwater shortages and the many anticipated future resource shortages expose the willful, ideologically-driven ignorance of these two positions and serve to emphasize the arrant ridiculousness of the apologetics that representatives of the system engage in to preserve and bolster the functioning of the system, enshrining the continued valorization of value. Thus, it is clear that the representatives of capital, acting in coherence with the dictates of the logic of capital, will adopt anti-scientific attitudes, even when that science is couched in the language of quite tepid liberalism, as is the case with Club of Rome's *Report*, in order to prevent limitations or restrictions being placed on the functioning of the system. This is important to note because there are strong parallels to this form of apologetics for, and ideologically-driven ignorance of, the ecological consequences of economic growth, as we shall see later, in Ecological Modernization Theory in Political Ecological.

"Remarkably little preparation is made for a generation, century or further ahead. So problems like the greenhouse effect, desertification, the hazard of nuclear waste, are ignored because their consequences will be experienced well beyond any normal planning horizon."[239] In a disturbing paradox, despite a host of developments in modern science that enable us to understand the long-term ecological impacts and consequences of our present actions with more accuracy and detail than ever before in human history,[240] the dictates of the temporal logic of capital and the correlated short-termism of our now-global socio-temporality close off the possibility, from within the present system, of any transformative socio-economic or socio-ecological action that might alleviate, and perhaps prevent, impending deleterious consequences produced by the historical activity of capital. The more we come to know about the long-term consequences and effects of our actions, the less we seem able to act to positively affect this future; the more capital develops knowledge of future consequences, the more it confines action to the perpetual present of the accelerating expansion of capital. This paradox effectively illustrates the irrationality of capitalist temporality in general, particularly when considered in the context of our rapidly warming world.

By severely restricting the systemic temporal-perspective according to which human socio-metabolic activity is organized, capitalism essentially blinds itself to a future which, it now seems fairly likely, will include the demise and ruin of the capital system because of its reckless destruction of its own conditions of possibility, i.e., a nature which can accommodate human labor(-power), society, and life. "In relation to nature, as to society," Engels observes,

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[239] Gault, "In and Out of Time," 151. While Gault's conclusion is largely correct here, his unconvincing attribution of the "loss of a proper sense of time" solely to "the rise of modern science and technology" coupled with his aversion to treat capitalism critically (he does not use the word capitalism in this paper) and lack of recognition of the social embeddedness of science and technology means he must rely on vague notions such as a 'normal planning horizon,' by which, we can surmise, he essentially means something like a rational planning horizon in contrast to the temporal horizon of capitalism which, irrationally, precludes any possibility of planning beyond the immediate horizon of the valorization of value.

[240] "And, in fact, with every day that passes we are learning to understand these laws [of nature] more correctly, and getting to know both the more immediate and the more remote consequences of out interference with the traditional course of nature" (Engels, *The Dialectics of Nature*, 292-3).

"the present mode of production is predominantly concerned only about the first, tangible success; and then surprise is expressed that the more remote effects of actions directed to this end turn out to be of quite a different, mainly even of quite an opposite character."[241] Considered in the more explicitly ecological terms of natural resource usage, it is clear that a "rational social order will have to use the available natural resources in such a way that what is consumed is replaced at the same time," yet, with regards to nature, capitalism acts like a "closed economy which consumes part of its seed corn [and] impoverishes itself more and more…[until it] must inevitably fail."[242] This occurs precisely because the short-term systemic horizon of capitalism, which is inherently tied to the temporal logic of capital, means that "the temporal range of economic calculations and the price movements resulting from these calculations diverge sharply from resource times and waste-disposal time."[243] The supply of labor-power, perhaps the most important resource for capital's continued reproduction, is not necessarily in jeopardy of being consumed at an unsustainable rate and exhausted, but is certainly in danger of being rendered unable to reproduce itself due to capital's destruction of very conditions that make possible the reproduction of labor-power, of human life. In the warming world, this is how the contradiction between capital and labor and the contradiction between capital and nature, the first and second contradictions of capital respectively, converge. Concisely metaphorizing the situation, Ashley Dawson observes that "By fecklessly consuming the environment, capitalism is figuratively sawing off the tree branch it is sitting on" - here, the branch can stand for nature, labor, or both.[244] Evidently, then, as with the bad infinity of the temporal logic of capital, the most basic general feature of

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[241] Engels, *Dialectics of Nature*, 296.

[242] Pannekoek, "The Destruction of Nature."

[243] Altvater, "Ecological and Economic Modalities of Time and Space," 86. Altvater provides a startling example of this temporal incongruity: "The planning horizon of nuclear power companies, for example, is at most several decades. The half-life period of radioactive waste, however, is some 100,000 years. Economics is, in effect, the science of the '*avant le déluge*.' On its banner could be written, '*Après moi, le déluge*'" (Altvater, "Ecological and Economic Modalities of Time and Space," 86).

[244] Ashley Dawson, *Extinction: A Radical History* (New York: OR Books, 2016), 52.

capitalist temporality this logic gives rise to - that is, the short-termist, immediate fixation on the valorization of value and the corresponding disregard of more temporally remote concerns and consequences of this activity - is contrary to what could be considered an ecological socio-temporality, since this would require planned social reproductive activity in accordance with the (reproductive) temporalities of the natural world. In fact, capitalist temporality, as the socio-material expression of the 'bad infinity' of the temporal logic of capital, is *necessarily* anti-ecological, regardless of the specific biogeophysical, socio-political conditions under which it emerges and develops. This is evidenced not only by the global ecological crises currently developing which are the cumulative outcome of the historical activity of capital, but also in the fact that there is nowhere in the world, where capitalism exists, where nature has not been ravaged in the pursuit of value. In terms of its temporality, then, an 'ecological capitalism' is ultimately a contradiction in terms.

3. Capital's Abstract Temporality as Socio-Temporal Hegemon

The second feature of capitalist temporality in general simultaneously concerns the historical ascension of abstract time, eventually in the form of socially necessary labor time, and its material expression in mechanical clock-time, to socio-temporal hegemony, and the concomitant processual reduction and subsumption of concrete social and ecological temporalities to the abstract time of capital. To understand this feature of capitalist temporality, however, we must account for the foundational developments in the historical emergence and development of abstract time. Therefore, we must consider the transition from feudalism to capitalism or, more precisely, the transition, drawing on historian Jacques Le Goff's categories, from the hegemonic mode of time in Western feudalism - Church's time - to the new mode of time of the emerging mercantile social formation - merchant's time. This transition prefigured the rise of capital's specific form of abstract temporality to socio-temporal hegemony and so its historical importance should not be underestimated. In fact,

"The conflict, then, between the Church's time and the merchant's time," Le Goff observes, "takes its place as one of the major events in the mental history of these centuries at the heart of the Middle Ages, when the ideology of the modern world was being formed under pressure from deteriorating economic structures and practices."[245] This socio-temporal hegemonic transition meant major qualitative and technological changes in the temporal organization and disciplining of labor, in social relations of production and social time relations, and in humanity's metabolic interchange with nature, and included the move from 'activity as the measure of time' to 'time as the measure of activity'; the chronometrical development and subsequent social proliferation of the mechanical clock and clock-time; and the world-historical development of Isaac Newton's Absolute time concept. In the following, I will provide an overview of this process to historically orient and contextualize my discussion of capitalist temporality in general.

3.1 The Origins of Clock-Time in the Transition from Feudalism to Capitalism

Contestation over modes of time and socio-temporal organization during the disintegration of feudalism and the growth of mercantilism and the urban labor market was a major event in the historical class struggle that has determined the temporality of our contemporary social time and socio-metabolic relations. Social time relations are always closely bound up with relations of domination and power,[246] evidenced, for example, in the fact that feudal social time relations were largely controlled by the Church until the "communal clock [became] an instrument of the economic, social, and political domination wielded by the merchants who ran the commune," and so the struggle over time was important in determining not just the social time relations, but the broader socio-political

[245] Jacques Le Goff, *Time, Work, & Culture in the Middle Ages*, trans. Arthur Goldhammer (Chicago: The University of Chicago Press, 1980), 30.

[246] Additionally, one can consider that "In ancient societies, there is an intimate relationship between priests, the production of an agricultural surplus, and time-telling" (Martineau, *Time, Capitalism, and Alienation*, 31).

complexion of an emerging modern Europe.[247] The particular moment of struggle we are interested in here, that between the Church and the bourgeoisie and merchants over the mode of, forms of organization of, and authorized uses of time and temporality, was highly socially complex. Not only did it involve various class interests, developments in the social relations of production, breakthroughs in time-keeping technology, and the burgeoning of a radical new bourgeois worldview, but the transition from Church's to merchant's time occurred processually over several centuries both in various urban centers and rural areas around Europe without centralized organization, which eventually led to a veritable patchwork of various 'times' throughout the continent.[248] Moreover, the struggle involved moments of both resistance and cooperation between the competing ecclesiastical, feudal, the newly economically-empowered, and the laboring classes. This struggle was an important part of the social evolution of the West (one which has culminated in the present global socio-temporal hegemony of capitalist temporality) because throwing off the economically restrictive yoke of theological time was a requisite development for the emergence of the abstract mode of time necessary for the functioning of a commodified labor market of dispossessed laborers, capitalist relations of production, and, eventually, the fully-fledged capitalist mode of labor that was to arise through industrialism. To understand capitalist temporality in general, therefore, we must understand the history of the class struggle over time from which it emerged.

During Western feudalism, when the Catholic Church, as the dominant socio-cultural institution, shaped the patterns and rhythms of daily life, and strong religious belief was

[247] Le Goff, *Time, Work, & Culture in the Middle Ages*, 35.

[248] "An indication of this may be found in the diversity of the zero hours of the new clocks: sometimes noon, sometimes midnight, which is not a very serious difference, but more frequently sunrise or sunset - such was the difficulty of freeing preindustrial time from natural time. In his *Voyage en Italie*, Montaigne, like many other travelers before him in the fifteenth and sixteenth centuries, noted what confusion and disorder were caused by the changing origin of time from one city to the next" (Le Goff, *Time, Work, & Culture in the Middle Ages*, 49).

practically ubiquitous among Western peoples, time belonged to God.[249] Contrary to Benjamin Franklin's famous secular edict that 'time is money' - an utterance only conceivable under the particular historical conditions of abstract temporality and commodified labor - in the early Medieval centuries, time was not be equated with money and, moreover, the fact that time belonged to God meant that its possible uses were highly restricted. Church's time was God's time and was therefore sacred, prohibited from being "an object of lucre": "'Time is a gift of God and therefore cannot be sold.'"[250] On the basis of the Church's authority over time, it was forbidden, for example, for time to be profaned through particular forms of economic activity, and these practices were identified with the sin of usury. However, the Church's prohibitive control of feudal social time relations was an unacceptable obstacle for the growing mercantilist and bourgeois classes, which, for the sake of economic development, required the opportunity to turn time into money *through* the sale of the merchant's time, and through the purchase of labor time, so as to make commercial and productive activity not just economically viable, but increasingly profitable.[251] In this struggle over time, the merchant and bourgeois classes required two different but interrelated moments of transformation of the social time relations: first, time had to be freed from its strict adjudication and regulation by the Church, and second, they required an entirely new mode of time that could be more precisely divided and more accurately tracked and measured - these requirements would instigate the development of abstract time, a vital precondition of the emergence of capitalism.

Through the socio-temporal dominance of Church time, and the monastery as "the seat of a regular life," non-laboring activity was largely organized around the rhythms of the

[249] Lewis Mumford, *Technics and Civilization* (London: Routledge & Kegan Paul Ltd, 1955), 12-14.
[250] Le Goff, *Time, Work, & Culture in the Middle Ages*, 30, 51.
[251] "For the merchant, time is a prime opportunity for profit, since whoever has money counts on being able to profit from the expectation of reimbursement by someone who has none immediately available, inasmuch as the merchant's activity is based on assumptions of which time is the very foundation" (Le Goff, *Time, Work, & Culture in the Middle Ages*, 29-30).

rituals of worship and prayer, later known as the "canonical hours,"[252] which were regulated and proclaimed by the sounds of Church bells, while labor was organized around "differing notations of time provided by different work-situations and their relation to 'natural' rhythms."[253] Precipitating the temporal-ordering of the coming clock-time society, under these conditions "the monasteries…helped to give human enterprise the regular collective beat and rhythm of the machine."[254] Presently, the main unit of time in the organization of rural and urban labor was the work 'day,' which altered with the variable natural temporalities of specific activities; for example, "the patterning of social time in the seaport follows upon the rhythms of the sea…the compulsion is nature's own."[255] Le Goff argues that the temporal limitations of these social relations of production, because they were bound up with concrete, variable natural temporalities, served to constrain both the pace of life and the economic appetites and behaviors of Medieval society:

> On the whole, labor time was still the time of an economy dominated by agrarian rhythms, free of haste, careless of exactitude, unconcerned by productivity - and of a society created in the image of that economy, *sober and modest*, without enormous appetites, undemanding, and incapable of quantitative efforts.[256]

The nature of these relations and conditions can be explained, in one sense, by the natural necessity of the rhythms of nature in relation to the particular laboring activity; in another, by the fact that accumulation was not the organizing principle of the relations of production, as is the case with capitalism; and in another, by the limitations of time-keeping technology in this

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[252] Mumford, *Technics and Civilization*, 13.

[253] Thompson, "Time, Work-Discipline, and Industrial Capitalism," 59. Thompson explains: "Clearly hunters must employ certain hours of the night to set their snares. Fishing and seafaring people must integrate their lives with the tides" (Thompson, "Time, Work-Discipline, and Industrial Capitalism," 59).

[254] Mumford, *Technics and Civilization*, 13-4.

[255] Thompson, "Time, Work-Discipline, and Industrial Capitalism," 60. The "unit of labor time in the medieval West was the day. At first, this meant the rural working day…[and then] the urban working day was defined with reference to variable natural time, from sunrise until sunset, which was marked off in an approximate way by religious time, the *horae canonicae*, borrowed from Roman antiquity" (Le Goff, *Time, Work, & Culture in the Middle Ages*, 44).

[256] Le Goff, *Time, Work, & Culture in the Middle Ages*, 44.

period. Yet the demands of the growing merchant and bourgeois classes for "a better measure of labor," which was soon to be found in the "*certain* hours spoken of by the bourgeois," remained and intensified.[257]

As mercantilism and the conditions of rural and urban labor continued to develop, the ideological battle between Church's time and merchant's time wore on. The Church, although mired in theoretical disagreement about the nature of time, eventually recognized the expanding power of the merchant and bourgeoisie classes, and thus the necessity of making concessions to their economic interests with regards to the practical temporal requirements of the new economic conditions.[258] Ultimately, then, the ideological battle for time was won by the ascendant classes against the entrenched: "The taboo of time with which the Middle Ages had confronted the merchant was lifted at the dawn of the Renaissance. The time which used to belong to God alone was thereafter the property of man."[259] In this, the initial temporal transformation required by the merchant and bourgeois classes - the freeing of time from the strict adjudication and regulation by the Church - was essentially achieved, partly due to cooperation by the Church. But what of the second: how did an entirely new mode of time arise?[260]

Identifying the schedules of monks as one of the first impulses toward the strict, regular ordering of time, Lewis Mumford argues that "the new mechanical conception of time

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[257] Le Goff, *Time, Work, & Culture in the Middle Ages*, 48.

[258] "The Church no doubt tried to lighten ship when conditions changed. In the first place, it accepted and soon came to encourage the historic evolution of economic and professional structures. But the theoretical elaboration of this adaptation at the canonical and theological level proceeded slowly and with great difficulty" (Le Goff, *Time, Work, & Culture in the Middle Ages*, 30).

[259] Le Goff, *Time, Work, & Culture in the Middle Ages*, 51.

[260] N.B. the sequential structure of this discussion - i.e., the discussion of the freeing of time from the Church's adjudication and regulation *followed by* the discussion of the development of the 'new time' - is not intended to reflect the chronological order of these events in reality, but is meant for ease of comprehension. Rather, the ideological overcoming of Church's time and the development of a new time were tightly interwoven, co-constitutive, historical events.

arose in part out of the routine of the monastery."[261] More concretely, however, after the freeing of time from its divine fetters, the new economic conditions play a central role. Establishing and sedimenting commercial trade networks, and in this process developing and proliferating the use of the 'tools' of mercantilism, i.e. "accounting sheets, travel diaries, manuals of commercial practice, and the letters of exchange," and coordinating the organization of a dispossessed rural and a growing urban labor force, for example in the production of textiles, demanded a stricter, more predictable measurement of time to ensure economic viability and success in these commercial and productive endeavors.[262] Because the continuing development of merchant capital resulted in the destruction of "the isolation of the medieval town and the village commune, immensely extended the geographical horizon, and considerably accelerated the pace of life," it required "improved means of communication, *a more accurate measurement of time, especially in light of the ever accelerating pace of exchange,* and *precise tools of calculation and measurement*."[263] In light of this, Le Goff, among many others, concludes that "the new time owed its inception primarily to the needs of a bourgeoisie of employers whose concern, in view of the crisis, was to improve the measurement of labor time - the source of their profits."[264]

Of course, achieving a more predictable, trackable, manageable, and specific measure of labor time required a means of accurately measuring time, which brings our inquiry to developments made in chronometry around this period. The development of the mechanical clock, which occurred in the 13th century, can be seen as the culmination of the long history of developments in timekeeping, beginning with ancient time-keeping devices such as the sundial and clepsydra. The clock, however, in terms of meeting the requirements of the

[261] Mumford, *Technics and Civilization*, 13-4.
[262] Le Goff, *Time, Work, & Culture in the Middle Ages*, 35.
[263] Hessen, "Roots of Newton's Principia," 45-6. Emphasis is my own.
[264] Le Goff, *Time, Work, & Culture in the Middle Ages*, 49.

ascendant classes, was a substantial improvement on other timekeeping instruments because "The clouds that could paralyze the sundial, [or] the freezing that could stop the water clock on a winter night, were no longer obstacles to time-keeping: summer or winter, day or night, one was aware of the measured clank of the clock."[265] Thus, with the mechanical clock and its representation of abstract time, one of the central difficulties of timekeeping activity up until this point - i.e. the inherent dependency of timekeeping practices upon variable natural phenomena - had been largely overcome. Broadly speaking, the requirements of the bourgeoisie and merchants gave impetus to the social proliferation of clock-time. More specifically, Martineau, following Robert Brenner's view of the transition from feudalism to capitalism as originally occurring in the transitional phase of English feudal agrarianism to agrarian capitalism, and the dispossession of peasants and reconstitution of wage-labor relations this entailed, to argue, contrary to Le Goff, who represents the spread of clock-time as a mostly urban affair on the European continent, that

> Clock-time spread, in towns but also in rural settings, throughout the transitional phase of agrarian capitalism in England, without yet rising to a hegemonic position in these specific social time relations. Indeed, clock-time is not merely an urban phenomenon in early modern England, but can also be found in rural settings. Even before the Industrial Revolution, clocks were found not only in urban centres, but also at 'the outer margins of anything we might call the English 'urban system'.[266]

Despite the ongoing theological (and secular) debates about the nature of time, clock-time was spreading widely throughout society, both in urban centers and in rural areas. E.P. Thompson attests to this, claiming that "From the fourteenth century onwards church clocks and public clocks were erected in the cities and large market towns" and, moreover, that "The majority of English parishes must have possessed church clocks by the end of the sixteenth

[265] Mumford, *Technics and Civilization*, 14.
[266] Martineau, *Time, Capitalism, and Alienation*, 92.

century."[267] Moreover, by the end of the 16th century, "the small domestic clock had been introduced in England and Holland," thus bringing clock-time and clock-timekeeping practices into the familial home.[268] The widespread social acceptance and proliferation of clocks and clock-time was thus under way in European societies, precipitating the temporal basis and organization of the then-gestating capitalist system.

As the feudal period came towards its end at this time, the abstract economic time of the merchants and bourgeoisie became increasingly entrenched in social relations and the social infrastructure. The social *necessity* of clock-time, however, can be said to have largely arisen through the conditions created from the enclosures of the commons in England. Again invoking Brenner's position, Martineau argues that the separation of the laboring classes from the land through enclosures, that is the end of "the open field system and its legal and customary encoding of the time of labour according to agrarian and seasonal cycles," contributed to the spread of abstract time in the organization of labor and so clock-time "increasingly becomes a formal system in which certain practices are inscribed."[269] "With the formation of a labour market, abstract time acquires a growing social ascendancy. In turn, the spread of abstract time runs parallel to the growth of the labour market."[270] "Already, the 'infernal rhythms' can be felt."[271] In the period between the late 16th and early 18th century, when the "sophistication of an abstract clock-time system occurred progressively," the social role of clock-time continued to increase in importance with regards to the organization of labor and society, until it gradually became hegemonic in social time relations in the 17th and early 18th centuries, immediately before the onset of industrialism.[272]

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[267] Thompson, "Time, Work-Discipline, and Industrial Capitalism," 63.
[268] Mumford, *Technics and Civilization*, 16.
[269] Martineau, *Time, Capitalism, and Alienation*, 94.
[270] Martineau, *Time, Capitalism, and Alienation*, 125.
[271] Le Goff, *Time, Work, & Culture in the Middle Ages*, 36.
[272] Martineau, *Time, Capitalism, and Alienation*, 93-4.

The contradiction between the limitations of Church's time and the inherent requirements of mercantilism and the bourgeoisie-directed organization of labor which led to the uptake of clock-time, also entailed the development of a new way of dividing time based on a smaller, more precise, more manipulable measurement than the work 'day.' After the end of the 16th century, when clock-time was developing,

> Decisive progress toward 'certain hours' clearly came only with the invention and spread of mechanical clocks and the escapement system, which at last made it possible for the hour to achieve its mathematical sense, the twenty-fourth part of the day…From Normandy to Lombardy, the sixty-minute hour was firmly established; at the dawn of the preindustrial era, it replaced the day as the fundamental unit of labor time.[273]

Thus the requirements of the merchant and bourgeois classes had been met, and a "more precisely measured time, the time of the hour and the clock, became one of man's primary tools," not only in economic activity, but in the other spheres of life.[274] In the main, though, it was the economic sphere that was most thoroughly transformed since one of the foremost consequences of the uptake of abstract time was that it was the first movement towards the homogenization of the measure of labor time *in the abstract*. Although the process was only completed with the full development of capitalism in the industrial era, this initial movement enabled the coordination of a basic unit of measure for labor time (which of course is intimately connected with capitalism's specific value form) that propelled the expansion of market relations and the commodification of labor throughout European societies. In other words, the historical "institutionalisation of clock-time assuredly goes hand in hand with the consolidation of market relations."[275] Another of the central consequences of the shift from the 'day' to the 'hour' was that activity would no longer be the measure of time, and now time

[273] Le Goff, *Time, Work, & Culture in the Middle Ages*, 48-9.
[274] Le Goff, *Time, Work, & Culture in the Middle Ages*, 51.
[275] Martineau, *Time, Capitalism, and Alienation*, 130.

would become the measure of the activity.[276] This development was a crucial step, reflective of capitalism's tendency toward abstraction, in this case of time,[277] that enabled the capital system to assert its particular form of abstract, impersonal, economically determined social control. On the one hand, in relation to Church's time, this meant a drastic shift in the temporal horizon of human action since "Time-keeping passed into time-serving and time-accounting and time-rationing…[and] As this took place, Eternity ceased gradually to serve as the measure and focus of human actions"; rather, fungible units of time, namely the hour, became the main measure of human activity - the secularization of time was thus complete.[278] On the other hand, in relation to the developing economic conditions of pre-industrial Europe, by being rendered abstract, "Time took on the character of an enclosed space: it could be divided, it could be filled up, it could even be expanded by the invention of labor-saving instruments."[279] With this, time had become a resource, a commodity not to be frivolously wasted, but productively, and ideally profitably, spent. Anticipating its strict organization under capitalism according to metrics of productivity for purposes of accumulation, this early form of abstract time induced a new form of time-consciousness specifically attuned to the productive utilization of smaller time units. Thus, this historical transformation from Church's time to clock-time constitutes a major aspect of the "process of secularization of the basis and context of human activity: labor time, and the conditions of intellectual and economic

[276] E.P. Thompson provides several interesting historical examples of activity as the measure of time: "Among the Nandi an occupational definition of time evolved covering not only each hour, but half hours of the day - at 5-30 in the morning the oxen have gone to the grazing-ground, at 6 the sheep have been unfastened, at 6-30 the sun has grown, at 7 it has become warm, at 7-30 the goats have gone to the grazing-ground, etc. - an uncommonly well-regulated economy, in a similar way terms evolve for the measurement of time intervals. In Madagascar time might be measured by "a rice-cooking" (about half an hour) or "the frying of a locust" (a moment). The Cross River natives were reported as saying "the man dies in less than the time in which maize is not yet completely roasted" (less than fifteen minutes)" (Thompson, "Time, Work-Discipline, and Industrial Capitalism," 58).

[277] The "compression of, and abstraction away from, real space and time is, nonetheless, the aim of capital" (Altvater, "Ecological and Economic Modalities of Time and Space," 77).

[278] Mumford, *Technics and Civilization*, 14.

[279] Mumford, *Technics and Civilization*, 17.

production."[280] The novel socio-temporal organization that coalesced at the end of the pre-industrial era, centered around the abstract time of the mechanical clock, revolutionized social relations and was an essential precondition for the emergence of the capitalist mode of production and its socio-metabolic relations.

While the groundwork for capitalism's socio-temporal hegemony of abstract, alienated clock-time had been laid by the merchants and early bourgeoisie, one major shift still to occur in the transition to capitalist temporality had to do with the fact that although "the merchant's time was measurable, and even mechanized, it was nevertheless also discontinuous, punctuated by halts and periods of inactivity, subject to quickenings and slowings of its pace."[281] Contrary to mercantilism, for capitalism to function according to its own internal logic, time had to become continuous. The transition from merchant's time to the abstract time of capitalism in the 17th century - given the dictates of the temporal logic of capital - therefore involved a shift from the discontinuous time of mercantile activity and the emergence of the continuous (i.e. perpetually expanding) time of capital, and central to this process was a new time-concept developed on the basis of conditions whereby "Abstract time [had become] the new medium of existence."[282] Thus, the historical path was cleared for the development of Isaac Newton's concept of Absolute time.

3.2 Newton's Absolute Time Concept: Abstract Time and the Mechanistic Worldview

Unlike analyses of Newton as a historical outlier, an inexplicable genius, or of his work as impossible to account for without reference to divine inspiration,[283] the analysis

[280] Le Goff, *Time, Work, & Culture in the Middle Ages*, 30.
[281] Le Goff, *Time, Work, & Culture in the Middle Ages*, 37.
[282] Mumford, *Technics and Civilization*, 17.
[283] The classic example of this perspective is best expressed in Alexander Pope's famous epitaph for Newton: "Nature and nature's laws lay hid in night; God said 'Let Newton be!' and all was light." Additionally, the inscription on Newton's grave reads, "Hic depositum est, quod mortale fuit Isaaci Newtoni" or "Here lies that which was mortal of Isaac Newton." Interestingly, while Pope's epitaph "was not allowed to be put on the monument in [Westminster] Abbey," inscribed instead are the words: "Here is buried Isaac Newton, Knight, who by a strength of mind almost divine…he vindicated by his philosophy the majesty of God mighty and

presented here, which will be predominantly concerned with the concept of Absolute time, will address the historical continuity and connections between the ascension of abstract time in the transition from feudalism to capitalism and the bourgeoisie as the hegemonic class in early capitalism, and Newton's work. As Martineau correctly notes, "The case of Newton's concept of time illustrates the important relationship between his ideas and the material and temporal realities in which they were formulated."[284] In this vein of analysis, Boris Hessen provides the most complete (if not, certainly the most ambitious) account of the historical conditions out of which Newton's work arises, specifically the *Principia*. Hessen argues that Newton's project was essentially determined by the "*purely mechanical problems*" of the mercantile and bourgeois classes in their initial general establishment and gradual (yet, in this period, rapid) expansion of capitalism, particularly in areas of "transport, industry, and mining."[285] In order to historically situate Newton's project, Hessen outlines a historical schema regarding the major periods in the development of private property, through which he tracks the consubstantial development of capitalism and (bourgeois) science: "The first period is that of feudalism. The second period begins with the disintegration of the feudal system and is characterized by the emergence and development of merchant capital and manufacture."[286] "Newton's activities," Hessen continues, "fall within the second period in the history of the

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good…Mortals rejoice that there has existed such and so great an ornament of the human race!" The chosen words, while failing to emulate the poetry of Pope's dedication, certainly accord with his sentiments regarding Newton's transcendent, semi-divine status. ("Sir Isaac Newton," Westminster Abbey, accessed April 26, 2022, https://www.westminster-abbey.org/abbey-commemorations/commemorations/sir-isaac-newton.)

[284] Martineau, *Time, Capitalism, and Alienation*, 96.

[285] Hessen, "Roots of Newton's Principia," 52. However, Hessen is not economically reductive in the sense of what might be called a 'vulgar' Marxism. He states that "It would, however, be a gross oversimplification to derive every problem studied by various physicists, and every task they solved, directly from economics and technology…this [historical materialist conception of science] does not mean that the economic factor is the sole determining factor…The economic situation is the basis. But the development of theories and the individual work of a scientist are also affected by various superstructures, such as political forms of the class struggle and its results, the reflection of these battles in the minds of the participants—in political, juridical, and philosophical theories, religious beliefs and their subsequent development into dogmatic systems." (Hessen, "Roots of Newton's Principia," 61-2).

[286] Hessen, "Roots of Newton's Principia," 44. For reference: "The third period in the history of the development of private property is that of industrial capitalism" (Hessen, "Roots of Newton's Principia," 44).

development of private property," and therefore we pick up here where the preceding discussion of abstract clock-time left off; that is around the 17th and 18th centuries, the beginning of the capitalist epoch.[287] During this period, in the lead up to the emergence of industrial capital, "the sophistication of an abstract clock-time system occurred progressively" and, with the application of the pendulum to clock-time mechanisms in 1656,[288] attained its highest degree of precision in the pre-digital era. The clock in this period, at the outset of modern technics, had taken on important symbolic social meaning and had become "both the outstanding fact and the typical symbol of the machine."[289] In addition to this, Newton's social position, as an English man well educated in mathematics, physics, and philosophy, who worked in the academy and politics for much of his life, meant he moved in professional and social circles in which "clock-time conceptions and practices [were] the most widespread" at that time.[290] On the basis of this convergence of social, personal and professional circumstances, it is clear that "Newton's powerful and influential conception of time *expresses social changes brought about by the spread of clock-time* and the emergence of agrarian capitalism, and even *prefigures the development of capitalist social time relations*."[291] In fact, Newton himself attributes his development of the concept of Absolute time, at least in part, to the developments in the abstract time of the mechanical clock, acknowledging that "The necessity of which equation, for determining the [Absolute] times of a phænomenon, is evinced as well from the experiments of the pendulum clock."[292] Therefore, let us now examine the content and philosophico-political implications of

[287] Hessen, "Roots of Newton's Principia," 44.
[288] Developed by Dutch mathematician and scientist Christiaan Huygens, one of the outstanding figures of the Scientific revolution, in 1656.
[289] Mumford, *Technics and Civilization*, 14.
[290] Martineau, *Time, Capitalism, and Alienation*, 96.
[291] Martineau, *Time, Capitalism, and Alienation*, 93-4, 96. Emphasis is my own.
[292] Newton, *Newton's Principia*, 79.

Newton's universe and its Absolute time concept in relation to the development of capitalist temporality.

Newton's universe is the outstanding example of a mechanistic philosophical worldview due to its conceptual and mathematical elegance, its all-encompassing theoretical grandiosity, reflected clearly in its enduring impact on almost all human theoretical endeavors post-Newton, and of course for its practical, empirical successes.[293] The universe Newton describes in his work is an absolutely mathematically ordered one; it is precise and clean, and the workings of nature can be reduced to mathematical formulae in order to be explained. The order that Newton attributes to nature derives from the law-abiding essence of matter, which in turn is a product of the intention behind God's act of creation and initial endowment of motion, or 'original impulse.' Despite being mechanistic in function, Newton's system is metaphysical in origin; "Newton's theological views were by no means a mere appendage to his system."[294] Once divinely established and given motion by God, Newton's universe operates automatically, in the fashion of an exact, precise machine - the finest example of

[293] The following critique is offered on the basis of the recognition that, although there are issues with Newtonianism, it has undoubtedly had an enormous positive impact on the development of human society.

[294] Hessen, "Roots of Newton's Principia," 68. Although for reasons of scope I cannot engage in a full critique of the theological import in Newton's work here, we should note that the mechanistic order which Newton imputes to the universe (and which modern physics has largely rejected - see Chapter 2, especially "Beyond the Newtonian Worldview and Time Concept") has a divine origin. On different occasions Newton writes, for example, that "there is a Being who made all things and has all things in his power, and who is therefore to be feared" and "God made and governs the world invisibly" (Isaac Newton, *Newton's Philosophy of Nature: Selections from His Writings*, ed. H.S. Thayer (New York: Hafner Publishing Company, 1960), 66). While many other examples of Newton's theological perspective and grounding could be provided, we will confine ourselves to only these two. On this point, Engels remarks that in Newton's time "Science was still deeply enmeshed in theology. Everywhere it sought and found its ultimate resort in an impulse from outside that was not to be explained from nature itself." (Engels, *Dialectics of Nature*, 7). Yet, from a materialist perspective, Newton's system is more sophisticated than most other theological causal arguments because "Newton's atomistic scheme gives a basis for deleting God from the Universe as a causal influence once it is treated [i.e. once God, as the prime mover, has given the world motion]. The laws of God then become qualities of matter…Nature becomes a machine…[and] Newtonian physics excludes God from Nature, but not from Reality, because it makes Nature only a part of Reality as a result of its particulate conception of matter" (Caudwell, *The Crisis in Physics*, 5-6). Importantly, it is this dualistic conception of nature and reality on which Newton founds his arguments for the objective reality of Absolute time and space: relative (or, relational) time and space correspond to (subjective) nature, which Newton considers to be bound up with common prejudices and therefore "vulgar," and Absolute time and space correspond to (objective) reality, which Newton considers to be independent of change (Stephen Toulmin, "Criticism in the History of Science: Newton on Absolute Space, Time, and Motion, I," *The Philosophical Review* 68, no. 1 (January 1959): 8).

such motion, in Newton's time, being the mechanical clock - with God playing little to no further role in its order or operation.[295] Newton's universe *per se* is a mechanistic system wherein the atomistic collection of isolated, self-contained 'bodies' of which it is composed move along their own vectors without interruption (unless acted upon by another object). Nature is represented as machine-like in a "law-abiding, docile, and predictable" world.[296] As is true of all mechanistic worldviews, nature is essentially ahistorical: its order is immutable, and there is no conception of a historical development of nature either as a whole or of its parts. Moreover, the Newtonian worldview posits the "universe as perfectly ordered, made-up by passive, separate objects, which are subjected to outside forces and perform perfectly reversible trajectories."[297] With regards to both the erasure of history and the development of the Absolute time concept, the concept of reversibility plays a significant role in Newton's system since it amounts to a serious and problematic lacunae, which we have come to recognize due to developments in thermodynamics, in terms of the conservation and conversion of energy and the entropy law. While it is true that Newton cannot fairly have been expected to incorporate the law of entropy in his system (since it was not discovered until after his death), we must still consider the fact that the Newtonian system, including its shortcomings and lacunae such as this, has been the basis of the development of the majority of modern sciences. The extent of the influence of Newtonianism is revealed when we consider that "Newtonian mechanics…shaped modern science paradigmatically…not only in

[295] Although we cannot enter a full analysis of the matter here, the connections between the symbolic and social meaning and importance of the clock in this period and Newton's (and other) mechanistic systems should not be hastily dismissed and, especially in this context, we should consider Christopher Caudwell's prescient diagnosis that the bourgeoisie "had come to know Nature via the machine, hence the laws of Nature came to [them] to seem identical with the laws of a machine" (Caudwell, *The Crisis in Physics*, 36-7). Consider also that almost a century after Newton's death, the philosopher William Paley would famously inaugurate the 'Watchmaker analogy' in which he described nature and the universe as a machine so finely and intricately designed - like a watch - that it could only be explained by the existence of a creator - a watchmaker. The watch, after being created, wound up, and set off, then runs according to its own mechanism, without further involvement of the watchmaker.

[296] Prigogine and Stengers, *Order Out of Chaos*, 63. For a brief but insightful note on the extent of predictability imputed to Newton's universe by some of his followers, see Chapter 2, footnote 79 on Laplace's calculator.

[297] Stahel, "Time Contradictions of Capitalism," 103.

physics and the other so-called natural sciences, but also in the so-called social sciences and particularly, as Georgescu-Roegen already showed, economics."[298] While many disciplines in modern science have corrected course by adjusting their theories to accord with the new knowledge of the thermodynamic features of the universe, the same cannot be said for social sciences, particularly capitalist Political Economy, where the Newtonian Absolute time concept still plays a central theoretical and practical role.

In his *Principia*, Newton explained his time concept as such: "Absolute, true and mathematical time, of itself, and from its own nature flows equably without regard to anything external."[299] By this definition, "Newton can be taken as believing in the existence of a fundamental frame of reference in nature, something not consisting of material objects but having nevertheless an 'objective existence' of a nonmaterial or immaterial character."[300] Although an abstract mode of time was already being used for the organization of production, marketization of labor, and distribution of the merchants, and was increasing in prevalence with the spread of the mechanical clock (yet as we have seen only to a certain extent in Europe), Newton's particular conception of abstract time was much more metaphysically and theoretically rigorous than that of the clock. The abstract time posited by the clock itself was simply that: the mutable, human-created abstract time of a timekeeping device brought into existence by the clock-maker.[301] The "confusion and disorder" Montaigne experienced due to "the changing origin of time from one city to the next" while traveling across Italy in the 15th

[298] Stahel, "Time Contradictions of Capitalism," 102.

[299] Newton, *Newton's Principia: The Mathematical Principles of Natural Philosophy*, 77.

[300] Toulmin, "Criticism in the History of Science: Newton on Absolute Space, Time, and Motion, I," 8. In order to fairly represent Toulmin, we should note that while he presents this as the most prevalent interpretation of Newton's concepts of Absolute time and space, in this particular paper he is disagreeing with it. He questions readings that impute an 'objective existence' to Absolute space and time (although the focus of his discussion is heavily weighted towards space), and instead argues for a reading that, while acknowledging their practical applications, treats them as ideal mathematical constructs, similar to the ideal shapes of geometry.

[301] Recall Newton's remark that it was the "experiments of the pendulum clock" that directed him to the task of producing the formulae for a concept of Absolute time.

and 16th centuries attests to the social origin of this particular form of abstract time.[302] The Absolute time concept at the heart of Newtonian mechanics, however, had the effect of raising time to its highest possible degree of abstraction. Whereas before abstract clock-time remained *in or a part of* nature given that it was inherently existentially tied to an artifact, that is it was produced by the mechanical clock and thus only partially abstracted, with the development of Newton's Absolute time concept, abstract time became entirely removed from nature and completely abstracted from material origin. This time concept, therefore, expresses a form of time that is *external* to the material realm of reality, nature; the concept therefore induced an inversion which meant that no longer did time arise from motion in nature, or from the gears of the clock, but, instead, on the basis of this time concept, nature came to exist *in time*, that is in a non- or immaterial framework of 'true and mathematical' time. Previously abstract clock-time as the product of the clock remained to some extent within the reach of human action, however with the development of Absolute time and its inversion of the relation between time and nature, human social action now also came to exist *in time*. Hence, human labor could now be measured *against* a uniform flow of time that exists externally to it and 'flows equably' 'from its own nature' - one of the preconditions of the quantification of capital's value form. Martineau confirms the implications of Newton's Absolute time concept:

> With Newton, the 'absolutism' of abstract time is given a strong impulse. It is ascribed full authority, it answers to no 'relative' or 'common' notion of it, it is completely independent of events, objects and the environment. Moreover, it cannot be changed, it cannot be challenged, it is out of the reach of any human or social force. Newton installed an absolute entity, a time independent of human timing practices and relative – or concrete – times. He substituted an abstraction to the social being of time. He postulated a time whose parts are ordered in an 'immutable' way, a time 'in' which 'all things are placed'. The social basis of time is here deemed 'relative', whereas 'true' time is independent of humans, it is absolute, objective, 'natural'.[303]

[302] Le Goff, *Time, Work, & Culture in the Middle Ages*, 49
[303] Martineau, *Time, Capitalism, and Alienation*, 100.

Thus, the Absolute time concept expressed a degree of temporal abstraction that, in a major way, contributed to the rupture of the relation between humans and nature in capitalism. Precisely because it is a form of abstract time that cannot be altered, effected, or remade, only observed and adhered to in activity, this concept set time over against nature and humanity, and thoroughly alienated it from the material and social realms. As we shall see in more detail below, this time concept was, and still is, the central ideological component of the temporal-ecological rift generated by capitalist society. Addressing this point more generally, Caudwell argues that "The categories of Time and Space regarded as *absolute* categories, express [the] attempt to remove the bourgeois from active relation with the object. If the object, Nature, can be completely isolated from the subject, [Humanity], it can be expressed in terms of itself" and is therefore represented as isolated from the knowing subject[304]; he adds, derisively, that "this closed world…is the inevitable presupposition of mechanism."[305] Tracing the relation of mechanistic physics and the capitalist mode of production, Franz Borkenau argued that "the practical and technical aspect of this development, namely, the emergence of *abstract labor* in the manufacturing process, had to accompany the theoretical system, that is, the formulation of the concept of *abstract matter* in mechanistic philosophy and science. The two are inseparable."[306] For Borkenau, "'only the application of capitalist methods in the labor process makes possible the observation of nature according to quantitative methods.'"[307] With Newton's Absolute time concept, then, the time concept at the heart of the most influential expression of the mechanistic physics and its accompanying worldview, several important simultaneous developments occur that, on the one hand, facilitate capital's subsumption of the

[304] On this point, he incisively remarks: "This contradiction - a self-sufficient Nature, and yet one contemplated by Man - is the contradiction which drives on the development of physics." (Caudwell, *The Crisis in Physics*, 46).
[305] Caudwell, *The Crisis in Physics*, 47. (Quote edited to remove unnecessarily gendered language.)
[306] William Leiss, *The Domination of Nature* (Boston: Beacon Press, 1974), 91.
[307] Franz Borkenau, *Der Übergang vom feudalen zum bürgerlichen Weltbild: Studien zur Geschichte der Philosophie Manufaktur-period* (Paris: Félix Alcan, 1934), quoted in Leiss, *The Domination of Nature*, 91.

concrete temporalities of nature and society and, on the other, "[prefigure] the development of capitalist social time relations."[308] Let us now enumerate and examine these.

3.3 Post-Newtonian Characteristics of Capitalism's Abstract Temporality and its Rise to Socio-Temporal Hegemony

The first development made possible by Absolute time was that the social shift from 'activity as the measure of time' to 'time as the measure of activity' could now be extensively completed. This is most clearly reflected in that abstract time is no more simply the abstract time *of the clock*, but in the fact that clock-time becomes an *expression of the uniform flow of Absolute time*. The clock now operates as a sort of medium for the expression of 'a time' that is external to it, and activity is measured against this 'true and mathematical' form of time. This inversion is intimately tied to the changes in the organization of production under early capitalism and specifically the emergence of the capitalist form of wage-labor, since surplus value is generated from the appropriation of a worker's labor-time beyond that which is required for their physical and social reproduction. Thus, the workday would no longer be set in terms of the completion of tasks (activity) but would be set in terms of number of hours (time). It is for this reason that "we should not say that one man's hour is worth another man's hour, but rather that one man during an hour is worth just as much as another man during an hour," Marx writes, adding that now "Time is everything, man is nothing; he is at the most time's carcase. Quality no longer matters. Quantity alone decides everything; hour for hour; day for day."[309] The framework for the organization of labor in capitalism, in other words, is now fundamentally that of abstract, external temporality, in the form of Absolute time, and all qualitative temporal considerations rendered meaningless. Keeping in mind the way that abstract time in capitalist temporality comes to dominate both its objective conditions of

[308] Martineau, *Time, Capitalism, and Alienation*, 93-4, 96. Emphasis is my own.
[309] Karl Marx, *The Poverty of Philosophy: Answer to the Philosophy of Poverty by M. Proudhon*, trans. The Institute of Marxism-Leninism (Moscow: Progress Publishers, 1955), 22.

existence, labor and nature, an important ecological qualification, which is particularly relevant here, must be added to Marx's point: "Not only 'man' (humans) but nature is 'nothing,' and the maintenance of the natural conditions are not a concern, since nature is seen by the capitalist as a free gift."[310] While labor, as we have seen, had been here and there organized according to abstract clock-time since around the 14th century, with the emergence of capitalism in the 16th/17th century clock-time became not only much more widespread and important in the organization of labor, but, with the shift to time as measure of activity brought about in large part by the clock, it became possible for this form of time to function as the universal measure of value, expressed as abstract, quantitative, socially necessary labor time. On the one hand, this had the effect of "*reducing human beings to a reified condition* (whereby *they* are brought to a common denominator with, and become replaceable by, 'locomotives' and other machines"; and, on the other, meant that "The only modality of time in which capital can be interested is *exploitable labor time*," expressed as socially necessary labor time.[311] While affirming the relationship between abstract time and clock-time that I have described above, Tomba here explicates the nature of the relationship between abstract labor and abstract time

> On the one hand, the inversion between use value and value, and thus between concrete labor and abstract labor, places the temporality of the latter as dominant. Qualitative differences are canceled in the abstraction of exchange between equivalents. Quality is subsumed in quantity. The abstract nature of labor is derived from the exchange of equivalents. And since capital, starting from the commodification of human labor, tends to commodify every kind of relationship, in this perspective it becomes possible to understand abstract time as a totalizing concept, which not only tends to subsume any other concrete temporality but also becomes the temporalizing principle of time as clock-time.[312]

[310] Freund, "Capitalism, Time-Space, Environment, and Human Well-Being," 120.
[311] Mészáros, *The Challenge and Burden of Historical Time*, 47, 24.
[312] Tomba, "Time," 494.

Precisely due to the fact that socially necessary labor time is not constant but varies across societies according to the differing levels of development of the means of production, in order to function as a universal equivalent, measurements of wealth in capitalist societies must be pegged to a uniform, constant standard of measurement, i.e., abstract clock-time. This abstract temporality, which Absolute time can be said to have in a certain sense perfected by raising to its highest degree of abstraction, is key to the specific form of impersonal domination inaugurated by the capitalist mode of production (as opposed to the interpersonal forms of domination that characterize the feudal mode of production) since the organization of labor is now subject to the external domination of Absolute time represented by the clock, and is therefore (ideologically at least) detached from the social and political realms. This point also pertains to the formation of capital's socio-metabolic interchange with nature since, as Kolinjivadi et al., drawing on Wood,[313] argue "such a universal conception of *Time*, calibrated to ensure predictability and control, serves as both precursor to and a product of the imposition of 'science and technology on the tempos of the biological, physical and social worlds'."[314] We will return to this in more detail in Chapter 5.

Second, contrary to the simple abstract time of the clock, which could in some cases be discontinuous as we have seen in the case of the merchant's form of abstract clock-time, Newton's Absolute time is uniform and *flows continuously*. This is a crucial development in the emergence of capitalism and for the formation of capitalist temporality because, as was discussed in Chapter 3, the ceaseless and limitless movement of capital in its perpetual cycle of valorization, dictated by the temporal logic of capital, could only be realized on the basis of a 'time' that would flow not only uniformly, but continuously, without interruption or pause. Absolute time, then, we can say, provides the temporal grounds by which the logic of capital

[313] Wood, "Time, Cycles and Tempos in Social-Ecological Research and Environmental Policy," *Time & Society* 17, no. 2/3 (2008).
[314] Kolinjivadi et al., "Can the planet be saved in Time?" 909. For a definition of *Time* see Chapter 2 footnote 3.

would come to function. This highlights the importance of the social spread of clock-time in the rise of capitalism; with the disintegration of feudalism, capitalism was not inevitable nor entirely determined, but was made possible by various determinate historical conditions, one of the most important being the process of development of abstract clock and then Absolute time. The former, simple clock-time, facilitated the coagulation of capitalist social relations during the dissolution of feudalism and the latter, Absolute time, helped to crystallize capitalist social time relations in Europe during the industrial period. Moreover, the universally uniform, continuous flow of Absolute time, external to nature and therefore detached from the impingements, constraints, and variety of concrete social and ecological times, also made possible the centralized synchronization of abstract time. "As capitalist social-property relations came to exert their sway over parts of Western Europe and the United States during the eighteenth and nineteenth centuries, abstract time rose to hegemony in the form of clock-time," with "The institutionalisation of World Standard Time in the nineteenth century [epitomizing] this process."[315] Historically, the standardization of abstract time happens at both a micro and a macro level, mostly during the 19th century. At the micro, nation state level, England introduces a national, centrally synchronized standard time by imposing upon the diverse local abstract clock-times Greenwich Mean Time (GMT), expressly for the purpose of organizing the most important method of transportation of commodities during capital's industrial expansion, the railroad: "Britain took the first step towards standard time in 1847 when the British Railway Clearing House called for each company to harmonise local times into one standard, Greenwich Mean Time (GMT)."[316] At

[315] Martineau, *Time, Capitalism, and Alienation*, 126.

[316] Martineau, *Time, Capitalism, and Alienation*, 127. Martineau adds that "Local times were soon subsumed under standard GMT, despite 'considerable psychological and social resistance' from local communities wanting to preserve their local times from 'railway-time aggression'" (Martineau, *Time, Capitalism, and Alienation*, 127).

the macro, international level, capitalism's imperial and colonial phases were integral to the coordination of a synchronized global standard time:

> It took six hundred years to revolutionize the temporal orientation of Europe. *It took only one-third of that time to extend the temporal revolution to countries and cultures across the globe.* In the sixteenth, seventeenth, and eighteenth centuries, European armies colonized the territories of the planet. *In the nineteenth and twentieth centuries, European and American industry colonized the time frame of much of the rest of the world*.[317]

The process, then, of producing a standardized global temporal orientation by which capital could operate to its fullest extent and power did not, as many may presume, happen spontaneously or simply occur as a matter of course with the end of feudalism, but was instead for most societies across the globe imposed from outside through the process of subsumption which brought an increasing number of countries under the sway of the rhythm and tempo of capital and its now-global market. In fact, from the initial emergence of the clock and its relation to the brutal and violent dispossession of peasants through clearances and enclosures and the concomitant organization of intensely exploitative labor, to the global conquest of clock-time established through the ruthless and belligerent subjugation of the non-capitalist world by imperial and colonial capitalist powers, the history of the rise to hegemony of abstract time has been bloodstained and intimately tied to capitalism's processes of abstraction, domination, and valorization. Capital's imperial and colonial expansion from the 16th through 19th centuries led to the universalization of abstract clock-time, and eventually resulted in the major European capitalist powers cooperating, toward the end of the 19th century, to organize World Standard Time.[318] Truly, abstract clock-time had become

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[317] Jeremy Rifkin, *Time Wars: The Primary Conflict in Human History* (New York: Henry Holt and Company, 1987), 137, quoted in Martineau, *Time, Capitalism, and Alienation*, 127. Emphasis is my own.

[318] Martineau provides a finely detailed picture of the event which was the culmination of this historical process: "In 1884, 25 countries were represented at the International Meridian Conference in Washington, which was held at the request of then US president, Chester A. Arthur. Building on the idea of a World Standard Time, which engineer Sandford Fleming (the Canadian delegate at the conference) had been advocating since 1879 and which suggested that the Earth be divided into 24 equal time zones each of fifteen degrees of longitude, the conference participants agreed on establishing Greenwich as the zero meridian of an emerging

hegemonic, and as the hegemonic socio-temporality completely subsumed any and all local, concrete social and ecological times. With regard to this process of temporal subsumption and the rise of abstract clock-time to socio-temporal hegemony, and succinctly encapsulating many of the arguments I have presented thus far, Mészáros remarks:

> Capital's historically unique mode of social metabolic reproduction must degrade time because the most fundamental objective determination of its own form of human interchange is the irrepressible drive to continued self-expansion, defined by the intrinsic characteristics of this mode of societal interchange as necessary *capital-expansion*, achievable in commodity society only through the exploitation of labor-time. *Thus capital must become blind to all dimensions of time other than that of maximally exploitable surplus-labor and the corresponding labor-time*.
> This is why all possible value and meaning potentially arising from historically created relations must be obliterated from capital's equations, other than those directly linked to the systemic imperative of capital-accumulation.[319]

Through an incredibly complex and multifaceted historical process, capital has effectively eliminated all concrete social and ecological times, and abstract clock-time has become the substratum of capitalist social time relations and therefore also the form of temporal regulation of its metabolic interchange with nature, reduced to abstract socially necessary labor time. I will return to this point below.

Third, Absolute time, expressed as of socially necessary labor time, the time of capital, is a *purely quantitative* form of time - "Quantity alone decides everything" - which, through a process of reduction, completely dispenses with all qualitative temporal

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World Standard Time system. They also determined the exact length of the day, divided the Earth into 24 zones, one hour apart, and agreed on a precise beginning to the universal day. This abstract time-system was inscribed in the very landscape of the planet, as time-zone delimiting lines were drawn that cut through multiple histories of culturally and materially embedded concrete local time-systems. World Standard Time was not adopted and implemented overnight, but the process was launched and other countries would eventually join in. Although within ten years many countries such as Belgium, Austria-Hungary, Italy, Japan, the US and Britain had adopted World Standard Time, the process of complete standardisation of the globe took a while. France took some time to join, especially due to its refusal to accept an English prime meridian, but once it did, it aimed at becoming the world leader in World Standard Time institutions. In 1912, Raymond Poincaré lobbied for Paris to host the International Conference on Time, which decided on a universal system of determining time and of maintaining accurate time signals around the world. On 1 July 1913, the Eiffel Tower emitted the first time signal to be transmitted around the world, which makes 'the beginning of *world time*' an event that is actually datable. From then on, local time systems would come under the sway of World Standard Time" (Martineau, *Time, Capitalism, and Alienation*, 129).

[319] Mészáros, *The Challenge and Burden of Historical Time*, 35. Second emphasis is my own.

considerations - "Quality no longer matters" - including all concrete social, socio-economic, and socio-ecological times.[320] We can trace this feature of capitalist temporality in general quite directly to the temporal logic of capital which, as the alienated logic of capital's expansion and growth, must, even to the point of destroying its objective conditions of existence, be concerned only with the quantitative time of exploitable labor power, the time of surplus value, for the sake of the exponentially increasing magnitude of the infinite circulation of capital. Of course, the reduction of time to quantity is partially begun with the emergence of the abstract time of the clock but can only be fully completed with the expansion of capital, and the increased influence of its practical reductionism, with the aid of the concept of Absolute time. Reduced to pure quantity, with the deleterious ecological effects that certainly follow the reduction of all concrete ecological times, abstract time, in the first place, makes possible capitalism's system of universal equivalence, and in the second, makes possible the commodification of time, labor, and nature:

> Marx's principal point regarding commodification was that an empty, abstract, quantifiable, universally applicable time was a precondition for its use as an abstract exchange value on the one hand, and to the commodification of labor and nature on the other. Only on the basis of this neutral measure could time take such a pivotal position in all economic exchange. Not the variable time of seasons, aging, growth and decay, joy and pain, but the invariable, abstract time of the clock, where one hour is the same irrespective of context and emotion, is translatable into money. In Marx's analysis, clock time is the very expression of commodified time.[321]

When reduced to pure quantity, time could become the substrate of capitalism's system of universal equivalence (such that we now quite commonly hear that 'time is money') because, in terms of the calculation and measure of value in capital's system of commodity exchange, abstract time formally corresponds to the categories of abstract labor and exchange-value. At the level of the commodity, we see that the "objectified time in commodities…is not

[320] Marx, *The Poverty of Philosophy*, 22.
[321] Adam, "Comment on 'Social Acceleration' by Hartmut Rosa," 50.

considered as the specifically qualitative time of the manufacturer's skill, but as abstract time."[322] The quantity of abstract labor that produces a commodity, and by which its exchange-value is determined, is represented in terms of abstract time. Under the conditions of the capitalist mode of production, all qualitative elements of human labor, of the commodity (i.e., its use-value), and of time itself, are reduced to the purely quantitative because the expansion of the system depends on the perpetual quantitative increase of value. This serves to highlight the role of "capital's underlying practical reductionism," a broad tendency which in the case of abstract capitalist temporality produces the "alienating subordination of human beings to the rule of *quantity and time* under capital's prevailing imperatives."[323]

Capitalism's reductionism is essential in establishing what Mészáros calls capitalism's economically determined "*time accountancy*: the only kind of - extremely dehumanizing - accountancy compatible with capital's social order."[324] This concept captures the dialectical relation between purely quantitative abstract time, abstract labor, and exchange-value for capital's valorization of value and expansive structural dynamics by highlighting how capital's determination of value emerges from the synthesis of these categories. In other words, without abstract time, capital's specific value form certainly could not be what it is today, and perhaps could not function at all because it would not be able to impose, on the basis of abstract time, the universal equivalence on which it is able to found its system of exchange. The temporal effect of this abstract, reductive time accountancy system is the "reduction of 'Historical Time' (T) to 'dynamic time' (t)" where 'time t' represents the time of "purely mechanical phenomena (or, phenomena described only in mechanical

[322] Tomba, "Time," 493. Tomba adds: "Hence the emergence of clock-time in the hegemonic position in the hierarchy of various temporalities." (Tomba, "Time," 493).
[323] Mészáros, *The Challenge and Burden of Historical Time*, 46.
[324] Mészáros, *The Challenge and Burden of Historical Time*, 46.

dimensions)...[which] do not have a history, properly speaking."[325] Mechanism, as we shall see in more detail below, emerges in bourgeois physics and is taken up wholly and uncritically by bourgeois political economy[326], and through this convergence, capitalist economists come to disregard the historical qualitative change that economic activity entails, particularly in relation to the natural environment. On this point, Georgescu-Roegen remarks that, according to bourgeois political economy, "if events alter the demand and supply propensities, the economic world always returns to its previous conditions as soon as these events fade out. An inflation, a catastrophic drought, or a stock-exchange crash leaves absolutely no mark on the economy. Complete reversibility is the general rule, just as in mechanics."[327] Capitalism's time accountancy also serves to determine, in accordance with the logic of capital, the system's destructive appropriation and exploitation of both nature and labor which, Mészáros argues, cannot function in any manner other than it does currently, which is to say it drives towards the destruction of both the natural world and workers while accelerating the expansion of value. "With time being money in capital's ceaseless pursuit of ever-more surplus value for itself, capital has no time for modes of temporality other than its own clocks, deadlines, and turnover rates…The '24/7' rhythms and routines of all life come under the sway of capitalistic cadences. Everyone [and everything, including nature] marches and dances to capital's beat around the clock."[328] Turning from capital's structural determinations to the bourgeois theories which seek to affirm and reproduce them, we shall find that there are two major reductive theoretical undertakings which mirror and justify capital's practical reductionism, one in bourgeois physics, the other in bourgeois political

[325] Altvater, "Ecological and Economic Modalities of Time and Space," 80-1.

[326] "Even an economist of Frank H. Knight's philosophical finesse not long ago referred to mechanics as 'the sister science' of economics" (Knight quoted in Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process* (Massachusetts: Harvard University Press, 1971), 3).

[327] Georgescu-Roegen, "Energy and Economic Myths," 348.

[328] Adrian Johnston, "Real Reduction: The Antinomy of Georg Lukacs," streamed live on YouTube on February 2, 2022, at Philosophy and the Rise of Fascism - Symposium on Lukács's Destruction of Reason (Day Two), video, 1:57:45, https://www.youtube.com/watch?v=RsP51XHFlqs.

economy. Connected by the latter's adoption of the mechanistic worldview developed by the former, both are important in relation to the current discussion because they compose the theoretical basis by which capitalist society represents and constructs its socio-metabolic relations with nature.

3.4 Abstract Time, Reductionism, and the Physics-Political Economy Matrix: The Theoretical Bases of Capitalism's Socio-Metabolism

Modern physics, that is to say the physics inaugurated by Galileo and Francis Bacon, the physics that emerged in tandem with and in service to capitalism, and of which Newton is perhaps the most famed and revered representative, is constructed upon the contradiction between subject and object, cast in terms of mind and matter, respectively. For physicists, this externally imposed ontological disunity of subject and object, the veritable hallmark of bourgeois theory, consists of the contemplative, external subjective observer, the mind of the physicist, and the objective substance of investigation, the bare matter of nature, which can be known through the contemplation of the external subject, but which does not in any way determine the subject or their observations. "This contradiction - a self-sufficient Nature, and yet one contemplated by [Humanity] - is the contradiction which drives on the development of physics."[329] In this disunity a one way relation derived from the "bourgeois theory of the machine" which is "based on the part [the bourgeoisie] play in relation to the machine in concrete living" is expressed - that is, an ownership relation, the reflection of the foundational structuring relation of capitalist social-property relations. Accordingly, the contradiction corresponds to the main class division in capitalist society because the bourgeoisie do not come to know an active nature through a mutually determining relation to it, as in the case of the proletariat through their labor, but construe humanity's relation with nature as one of "the owner of the machine," the owners themselves separate from and therefore undetermined by

[329] Caudwell, *The Crisis in Physics*, 46.

that which they own.[330] From this historical materialist perspective, we find that these socially-determined structuring premises of bourgeois physics, throughout the course of the disciplines historical development, have entailed the reduction of all qualitative, subjective aspects of the object of study, nature, to pure quantity, until the domain of physics has gradually come to be represented as Absolute, objective reality consisting only of isolated particles quantified in terms of mass and velocity - this is bare 'matter,' distilled to pure quantity, separate and distinct from humanity (i.e. mind). To grasp this process, its history, meaning, and consequences, it is helpful to quote Caudwell at length:

> Matter to Galileo and Bacon is still matter full of quality and sensuousness. But to realize 'matter as owned by the bourgeoisie,' it is necessary to eliminate the observer. Since Nature is to be apprehended as it were by a kind of divine apprehension on the part of the observer, in which he stands in no mutually determining relation to Nature, it is necessary to strip matter of all the qualities in which the observer is concerned. Colour, for example. Here the colour involves a subjective element: it is not the thing in itself, but the thing as seen. At first matter is only stripped of colour, sound, 'pushiness,' heat, which all prove to be modes of motion. Motion, length, mass and shape are however believed to be absolutely objective qualities, independent of the observer. However they prove one after the other to be relative to the observer. Thus matter is left finally with no real i.e. non-subjective qualities, except those of number…The categories of Time and Space, regarded as *absolute* categories, express this attempt to remove the bourgeois from active relation with the object…[Humanity's] relation to it is not, in that case, an umbilical cord of mutual dependence; the known Nature is not an active mutually-dependent relation between [Humanity] and the rest of reality, but known Nature is Nature absolute and yet in contemplation…Since every quality of Nature is found to contain a subjective element which makes [humanity] dependent on something 'out there,' just as it makes the quality dependent on something 'in man,' this contradiction strips all Nature of quality. The most general objective qualities of Nature seem those of Time and Space.[331]

Caudwell's brilliant account highlights the centrality of the process of reduction for the development of modern mechanistic physics; the process by which it dissolves all qualitative

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[330] Caudwell, *The Crisis in Physics*, 40. Of course, the externality of the contemplative subject in bourgeois physics is an ideological supposition, as Caudwell explains, the bourgeois' "relation to nature is god-like. She serves his end like a slave. Nature, the machine, takes the place of the slave…But even so, this godlike detachment of man from machine is an illusion. For this godlike survey of the machine overlooks the [person] who works the machine" (Caudwell, *The Crisis in Physics*, 38-9).

[331] Caudwell, *The Crisis in Physics*, 45-7. (Quote edited to remove unnecessarily gendered language.)

aspects of matter, reducing the sensuous reality of nature to a purely quantitative abstraction. By eliminating the qualities of matter which can only be explained through an account of the relation of subject and object, of humanity and nature, the relation itself is dissolved at the theoretical level and thus nature is treated as a machine which simply adheres to deterministic laws of Absolute time and space, ontologically distinct from the 'mind' of humanity. Hence nature, despite all its systemic, processual, interconnected, dynamic, qualitative complexity in reality (of which humanity is a part), is represented in bourgeois physics as something like an ahistorical, immutable, quantitative grid, without contradiction or the possibility for development, set *in* external, absolute, uniform, time. On this view, humanity, theoretically severed from its metabolic relation to nature, is not dependent on nature in any meaningful sense, and therefore the appropriation of this nature which is distinct from its own existence can proceed as the appropriation of a 'free gift.' This representation of nature can be understood as a theoretical reproduction of the worldview implied by the temporal logic of capital because it corresponds to "capital's reductionist approach to space and time" and moreover because, as Altvater argues, "The logic of shortening the time of economic activity and the removal of qualitative and quantitative impediments in space is precisely the imperative of capital valorization."[332] This argument, which highlights the scientific understanding of the world and the economic ends of capital, brings us to the relation between physics and political economy. By providing the worldview upon which bourgeois economics is constructed (which I will discuss in more detail below), the reductionism of bourgeois physics can be understood as the removal of qualitative impediments to capital at the theoretical level within the discipline which provides the groundwork and worldview for another 'science' which serves to secure and guide capital's practical reproduction and ideological justification, that is political economy. Indeed, then, the worldview presented by

[332] Altvater, "Ecological and Economic Modalities of Time and Space," 77-8.

the reductive, quantitative tradition of bourgeois physics, and especially by the Newtonian paradigm, is an approximation of the world *as it appears to capital*: completely devoid of qualitative nature and humanity, a mere quantitative obstacle consisting only of the abstract categories of Absolute time and space which, through calculation and domination, must be subject to acceleration and compression in the pursuit of the valorization of value.[333]

In relation to time and temporality, we have traced the historical unfolding of the related processes of abstraction and reduction, beginning from the economic crisis and subsequent reorganization of European society in the wake of the collapse of feudalism and culminating with Newton's formal theoretical exposition of the bourgeois worldview at the dawn of the industrial era. Capitalism's industrial period in Europe saw science flourish "along with the bourgeoisie…[because] the rising bourgeoisie brought natural science into its service, into the service of the developing productive forces."[334] This brings us to an important point. The relation between science and production in this period was (and remains to this day) a dialectical one, and we should be careful to avoid attributing linear causality to science in relation to the industrial revolution. Indeed, as Engels remarked in a telling marginal note in *Dialectics of Nature*, "Hitherto, what has been boasted of is what production owes to science, but science owes infinitely more to production."[335] The bourgeois scientific revolution of this period, an incredible explosion of rapid development of the means of production, was predicated on the Newtonian paradigm which, with its mechanistic Absolute

[333] This is precisely why mechanics, particularly the Newtonian version, was such a useful theoretical apparatus for the expansion of capitalism, and why, as Hessen points out, Newton was addressing the "purely mechanical problems" of the mercantile and bourgeois classes in the 17th and 18th centuries who operated as the personifications of economic categories. This fact may also play some part, I suggest, in explaining the popularity of technocratic views of governance in advanced capitalist states because governance becomes the task of simply overcoming technical (quantitative) problems (of the valorization of value).

[334] Hessen, "Roots of Newton's Principia," 56. See also: "If, after the dark night of the Middle Ages was over, the sciences suddenly arose anew with undreamt-of force, developing at a miraculous rate, once again we owe this miracle to production" (Engels, *The Dialectics of Nature*, 214-5).

[335] Karl Marx and Frederick Engels, *Marx & Engels Collected Works, Volume 25, Engels* (London: Lawrence & Wishart, 2010), 466.

time concept, provided the theoretical exposition of 'nature according to and for capital.' As I have shown, the reductive abstractions of the Newtonian paradigm constructed an image of nature as one that could be precisely understood in purely quantitative terms and therefore more easily manipulated for the quantitative expansion of capital, a theoretical depiction of "Nature [as] law-abiding, docile, and predictable instead of being chaotic, unruly, and stochastic."[336] This is not nature as it really is, but rather nature as it can be most effectively dominated for purposes of capital accumulation. Further, for the mechanistic science of industrial capitalism, "Nature was not regarded at all as something that developed historically, that had a history in time; only extension in space was taken into account" such that nature "remained to-day as it was at the beginning of the world, and in which right to the end of the world everything would remain as it had been in the beginning."[337] This conception of an atemporal nature, which banishes any sense of historical development from the world and which denies the varied, intersecting, qualitative, and complex temporalities of ecosystems, constituted the theoretical basis upon which capital, according to the dictates of its temporal and spatial logic, could (and would) establish and expand its totalizing, destructive socio-metabolic order. The theoretical exposition of capitalism's socio-metabolism, that is the representation of the form and content of capitalism's relation to nature which ideologically justifies and provides theoretical grounds for the practical reproduction of this form of metabolism, would be problematically constructed by the mechanistic discipline of bourgeois political economy on the basis of this atemporal, mechanistic conception of nature.

That the construction of bourgeois political economy converged with the mechanistic Newtonian worldview and paradigm meant that there was extensive overlap between the categories deployed in the economic and the physical sciences, including the abstract,

[336] Prigogine and Stengers, *Order Out of Chaos*, 63.
[337] Engels, *Dialectics of Nature*, 185-6.

reductive time concept described above. Newton's Absolute time concept, "the time concept which lies at the heart of Newtonian mechanics, which shaped modern science paradigmatically…did so not only in physics and the other so-called natural sciences, but also in the so-called social sciences and particularly, as Georgescu-Roegen already showed, economics."[338] However, due to the challenges posed by developments in physics such as thermodynamics, relativity theory, and quantum theory, and evolutionary theory in ecology, natural science has in fact been gradually moving away from a mechanistic paradigm towards alternatives such as complexity or systems theory paradigms (which have, in the first place, been made possible by advances in the technological capacities of computing and data sciences), or to a dialectical worldview.[339] Despite this, "Our present social order is entrapped in a mechanistic view of human freedom, and of the human relation to nature" because "Newtonian mechanics…has not yet however been replaced by any other equivalent worldview."[340] The resultant situation being that "it is not science (that is, the physical and natural sciences) but economics that is the mainspring of the mechanistic outlook that still characterizes our culture."[341] In a world made by and for capital, the power of political economy looms large over all aspects of social organization, human life, and socio-metabolic relations with nature, particularly since in the last 50 years neoliberal capitalism has ruthlessly commodified and marketized everything that hitherto stood outside of market relations, and thus society is very much tethered to the mechanistic outlook which theoretically enables and bolsters the practical reproduction of capitalism's socio-metabolic order. On this note, it is

[338] Stahel, "Time Contradictions of Capitalism," 102. In a footnote, Stahel presciently adds: "Although Roegen sees this attachment to the Newtonian paradigm as a historical puzzle, it should not surprise us once we consider the fundamental role modern economics played in legitimizing the emerging industrial order and how the mechanical time concept at the heart of the Newtonian physics was (and still is) coupled to modern social an economic time practice" (Stahel, "Time Contradictions of Capitalism," 103).

[339] This point is strictly about the internal development of natural science and does not bear on the social implications of these sciences, e.g., the Absolute time concept of Newtonian mechanics, expressed via clock-time, is still very much the socio-temporal hegemon today.

[340] Foster, *Ecology Against Capitalism*, 52-3.

[341] Foster, *Ecology Against Capitalism*, 53.

crucial to avoid underestimating the importance of the mechanistic worldview for the genesis of classical political economy. In summarizing his central critique of economics at the outset of his magnum opus, Georgescu-Roegen offers a damning assessment: "economics, in the way this discipline is now generally professed, is mechanistic in the same strong sense in which we generally believe only Classical mechanics to be," adding that the discipline's founders attempts to "create an economic science after the exact pattern of mechanics" succeeded to such an extent that "the conception of the economic process as a mechanical analogue has ever since dominated economic thought completely."[342] Importantly, Georgescu-Roegen emphasizes that the adoption of the mechanistic worldview in political economy is not limited to just the Classical or Neoclassical periods, but rather has afflicted economic theories and models throughout the entire history of the discipline, right up to the present.[343] Suffice to say, the convergence of economics and mechanics represents a serious theoretical problem that severely distorts the understanding of the objects of inquiry, both nature and society and their interrelation, and therefore also, on some level, serves to cast aspersions on the solutions and recommendations provided by economists, specifically in relation to a metabolic problem such as climate collapse or generalized ecological crisis.

In mainstream political economy, the reductive mechanistic paradigm leads to a view of the economic process as one which "neither induces any qualitative change nor is affected by the qualitative change of the environment into which it is anchored."[344] Natural resources, as we have seen, are treated as a 'free gift' which, according to the economist's view, our economic models need not seriously account for since they are, after all, the resources of a nature which is eternal and immutable. The reductive abstractions at the heart of Newtonian

[342] Georgescu-Roegen, *The Entropy Law and the Economic Process*, 1-2.
[343] Only with the current development of Ecological Economics, Marxist Ecological Economics, Thermoeconomics or indeed the Bioeconomics that Georgescu-Roegen himself championed, do we see the discipline moving away from the problematic presuppositions of mechanistic Political Economy.
[344] Georgescu-Roegen, *The Entropy Law and the Economic Process*, 1.

mechanics, which we should recall was an attempt to explain the eternal laws of nature in part by stripping nature of all quality, have here been illegitimately transposed onto social and economic processes in an attempt to explain, in purely quantitative terms, without consideration of or concern for the qualitative aspects of social relations and socio-metabolic interchange with nature, the 'eternal' laws of production and exchange. Thus, in the models of mechanistic political economy, the economic process is presented as "an isolated, self-contained and ahistorical process" which operates, as it always has and as it always will, within a 'naturally balanced' economic sphere without negatively or harmfully impinging upon other spheres of social activity or indeed upon the natural environment itself.[345] It is precisely this economistic ideology in service to capital that made it possible for one of the 20th century's leading economists and the most ardent defender of the opaque yet inevitably freedom-producing 'mechanisms' of the market, Friedrich Hayek, to proclaim, even as late as 1988, that "there is no danger whatever that, in any foreseeable future with which we can be concerned, the population of the world as a whole will outgrow its raw material resources, and every reason to assume that inherent [market] forces will stop such a process long before that could happen."[346] In Hayek's (Austrian/Chicago School) neoliberal version of this economistic ideology, it is *precisely the opaque mechanisms of the market*, and the fact that they spontaneously engender a nomocratic structure which enables individuals to freely pursue their own ends while contributing "'to ends which were no part of [their] purpose,'"

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[345] Georgescu-Roegen, *The Entropy Law and the Economic Process*, 2.

[346] Hayek, *The Fatal Conceit: The Errors of Socialism*, 125. Another striking example of this type of economistic ideological hubris comes in a passage from a colleague of Hayek, Wilfred Beckerman, whose professional relationship I have briefly discussed in footnote 12. The passage is used as an ironically humorous epigraph in Georgescu-Roegen's paper, "Energy and Economic Myths," and (rather patronizingly) reads: "So you can now all go home and sleep peacefully in your beds tonight secure in the knowledge that in the sober and considered opinion of the latest occupant of the second oldest Chair in Political Economy in this country, although life on this Earth is very far from perfect there is no reason to think that continued economic growth will make it any worse" (Beckerman quoted in Georgescu-Roegen, "Energy and Economic Myths," 347). It is of note that Beckerman, during his tenure in the Political Economy department at University College London, and quite astoundingly given the content of the passage above, served the UK government as a "key adviser on the first Royal Commission on Environmental Pollution" (Debbie Beckerman, "Wilfred Beckerman obituary," *The Guardian*, 26 April, 2020, https://www.theguardian.com/education/2020/apr/26/wilfred-beckerman-obituary).

which would prevent the world outgrowing its natural resources as, for Hayek, the mechanisms of the market represent a form of secular providence.[347] For the gains of the free and open society that the opaque mechanisms of the market promise, all that is required is total and subservient faith in these mechanisms. Unfortunately, for Hayek's economistic ideology, the "'ends which were no part of [the individual's] purpose'" turn out to be, ecologically speaking, climate collapse, generalized ecological crisis, and the potential extinction of the human species.

This economistic ideology, which arises from the flawed worldview and premises of mechanistic political economy, erroneously holds that "human cultures can *outpace* or transcend altogether the ecological consequences of their activities…[through] the perpetuity of technological mastery over nature, [which makes] humans exempt from the biophysical constraints" of nature.[348] Notice, this is a subtly temporal ideological proposition[349] which, by a claim that exudes the 19th century anthropocentric teleological faith in the inevitability of human progress, inverts the true ecologically destructive nature of the expansive, accelerating temporal logic of capital by representing it as its opposite, that is, as the very redemptive force which will save us from climate collapse and ecological ruin (phenomenon which then, of course, must be explained by other means than the logic of capital itself). For bourgeois political economists, the situation appears as follows: the cause of climate change could be anything but capitalism, and the solution to climate change cannot be anything but capitalism.

From an ecological perspective, perhaps the most serious issue with this form of mechanistic political economy, the very 'science' which is supposed to best understand effective use of limited resources, is that it leads to the "complete failure [of mechanistic

[347] Friedrich von Hayek, "Individualism: True and False," in *The Essence of Hayek*, ed. Chiaki Nishiyama and Kurt R Leube (Stanford: Hoover Institution Press, 1984), 140.
[348] York and Mancus, "Critical Human Ecology: Historical Materialism and Natural Laws," 126. Emphasis is my own.
[349] One which is key to the arguments of many Ecological Modernization Theorists and therefore will be discussed in more detail in Chapter 6.

economic models] to incorporate as basic a phenomenon as entropy into its understanding of the process of production and reproduction" and as a result "economics is incapable of making even the first few steps toward understanding nature's changing qualitative states."[350] In other words, political economy, a discipline which aspires to the status of science, has been generally developed until recently on the basis of a view of nature so distorted by reduction and abstraction as to preclude its practitioners from accounting in their models for the central law of energetics in nature. Rather than the entropy law which provides a scientific basis for an energetic understanding of (systemic) time, bourgeois political economy proceeds on the basis of the reductive, mechanistic time concept and capitalist temporality that cohere with the temporal logic of capital and therefore ultimately to the valorization of value. The treatment of "the economic process as a mechanical analogue consisting - as all mechanical analogues do - of a principle of conservation (transformation) and a maximization rule," by excluding the thermodynamic law of entropy, leads to the reduction of "economic science itself…to a *timeless* kinematics."[351] The economic process, then, constituted according to the reversibility rule of mechanics, is extricated from the historical and evolutionary processes of society and nature, and all the qualitative, irreversible developmental changes these processes entail. What is lost in these economic models, therefore, is the possibility of any consideration of the qualitative historical development of the conditions of production, i.e. nature, which leaves mainstream economics "heedless of the thermodynamic origins for the necessary production of 'waste' with its consequences for pollution, damage to health and habitat, and destructive ecological change."[352] Hence, capitalism comes to be regarded as a suprahistorical social

[350] Foster, *Ecology Against Capitalism,* 54.
[351] Georgescu-Roegen, "Energy and Economic Myths," 348.
[352] Altvater, "Ecological and Economic Modalities of Time and Space," 84.

formation, operating outside of the temporality of history, thus self-eternalizing,[353] and accountable only to its own self-referential temporal logic, even at the cost of the destruction of its own objective conditions of existence.

Although "an economy without space and time exists only in neoclassical models of 'pure economics,' and its theoretical relevance remains limited precisely because of this heroic feat of abstraction," the problem here is rather that it is "this model [which] drives social change" and, more exactly, that it does so from the perspective of and in service to capital's destructive socio-metabolism, without confronting serious analytic lacunae with regards to the irreversible qualitative effects on nature of the current form of human economic activity.[354] While true of social change in general, this is also particularly, and alarmingly, true of governmental responses to global warming. In a searing critique of the "appallingly bad neoclassical economics of climate change," one scholar remarks that neoclassical "economic arguments, claims, and calculations have been the dominant influence on the public political debate on climate policy in the United States and around the world."[355] Commenting on the extent of this neoclassical influence over not just governmental, but the broad international social responses to climate change, the author adds that the "impact of these economists goes beyond merely advising governments, to actually writing the economic components of the formal reports by the *IPCC* ('Intergovernmental Panel On Climate

[353] "There results a peculiar end of history characteristic of the bourgeois economists, who famously believed that 'there once was history, but there isn't any anymore'. Characteristically, in virtually all theories of modernity, acknowledgement is made of the existence once upon a time of the pre-modern, and of other radically different modes of production; but with capitalism the possibility of such difference vanishes (there is no alternative, said Mrs. Thatcher famously), and *having once been historical capitalism now becomes eternal*. This particular incapacity to integrate a future of time into our analysis of current society accounts for the tendency of bourgeois thought to alternate between images of regression or dystopian collapse, and conceptions of progress which amount to little more than the perfecting of what is there already" (Fredric Jameson, *Representing Capital: A Commentary on Volume One* (New York: Verso, 2011), 105, emphasis is my own). It is my hope that the analysis presented in the current work of the role of the abstract mechanistic time concept in both bourgeois physics and bourgeois political economy serves to dispel some of the 'peculiarity' surrounding the 'end of history characteristic' of bourgeois economists.

[354] Altvater, "Ecological and Economic Modalities of Time and Space," 77.

[355] Quoting DeCanio, 2003, pp. 2–4, Steve Keen, "The appallingly bad neoclassical economics of climate change," *Globalizations* (September, 2020): 2.

Change'), the main authority coordinating humanity's response, such as it is, to climate change."[356] In light of the findings in their research, they conclude that "Given the impact that economists have had on public policy towards climate change, and the immediacy of the threat we now face from climate change, this work could soon be exposed as the most significant and dangerous hoax in the history of science."[357]

Like the mechanistic paradigm in physics, which holds that the contemplative physicists (i.e. the subject) is undetermined by the physical reality which they observe (i.e. the object), in mechanistic political economy, economic models hold that capital (i.e. the dominant subject [übergreifendes Subjekt] of social processes) is undetermined by that which it appropriates, namely nature and the labor power of the workers of the world (i.e. the dominated objects in the process of the valorization of value). In material reality, however, as critics of mechanistic political economy have correctly pointed out, "the economic process is not an isolated, self-sustaining process. This process cannot go on without a continuous exchange which alters the environment in a cumulative way and without being, in its turn, influenced by these alterations."[358] The undialectical perspective of mainstream Political Economy which, in keeping with dictates of the temporal logic of capital, promises infinite economic growth without serious (or problematic) ecological consequence, proves in a rapidly warming world to be a seriously flawed worldview; one which, on the basis of the reductive mechanistic view of nature, asserts the alienated mechanical clock-time of capitalist temporality as the 'one true' temporality (if the economic model acknowledges temporality at all[359]), thus abstracting away from the complex and varied systemic temporalities of the actual

[356] Keen, "The appallingly bad neoclassical economics of climate change," 2.
[357] Keen, "The appallingly bad neoclassical economics of climate change," 3.
[358] Georgescu-Roegen, "Energy and Economic Myths," 348.
[359] For example: "In capitalist economics, the modality of time and the connectedness of [past, present, and future material and social processes] have been largely eliminated by the introduction of the concept of 'interest,' or the discounting of future economic values" (Altvater, "Ecological and Economic Modalities of Time and Space," 84). The Marxist economist Michel Aglietta argues the discount principle expresses capital's

ecosystems that make possible and support human life. Because the temporal logic of capitalism produces a social formation "driven by the imperatives of capital accumulation in competitive global markets" which increasingly promotes and rewards "short time horizons and the immediate exploitation of nature in ways profoundly antithetical to long-term conservation," capital's social formation proves to be profoundly alienated "from the periodicities of nature, [to the point whereby] our clocks and schedules allow us to impose science and technology on the tempos of the biological, physical and social worlds."[360] In light of this, we now come to the question of capitalist temporality and nature, and ask: in what ways does the temporal logic of capital determine capitalism's socio-metabolism, and how does this determine capitalism's relationship to nature?

(purposeful) temporal "confusion between present and eternity" because the "logical time of discounting is that of an automatic valorization of [present] capital. It is claimed that what exists today has existed before and will exist for all time"; of course, in relation to non-renewable natural resources and biodiversity, the discount principle serves to reduce varied and complex temporalities to the temporality of capital whereby "time is simply one exchangeable good among others" (Michel Aglietta, A Theory of Capitalist Regulation: The US Experience, trans. David Fernbach (New York: Verso, 2015), 21). More directly, bioeconomist Colin W. Clark argues that, in relation to natural resources, "Generally, high rates of discount have the effect of causing biological overexploitation whenever it is commercially feasible" (Colin W. Clark, "The Economics of Overexploitation," *Science* 181, no. 4100 (August 1973): 632). Considered in connection to the politics of environmental regulation, the discount principle is an illustrative example of the economic formalization of capital's temporal-ecological rift because, being "based on the principle that a dollar today is worth more than a dollar in the future," it serves to enshrine as a principle in applied economics capital's short-term temporal logic and capitalism's restricted systemic temporal horizon. The discount principle is, in essence, a method by which capitalism transfers current costs onto future generations in order to bolster present rates of growth; one potential outcome of this will likely be the ecological indebting of future generations, which is to say that the ecological problems generated in the present (and from the past, for that matter) by the economic process, despite the economic wealth generated by this process, will be too severe, broad, and destructive to be dealt with, even with the wealth currently being generated.

[360] Wood, "Time, Cycles and Tempos in Social-Ecological Research and Environmental Policy," 265.

CHAPTER V

CAPITALIST TEMPORALITY AND ECOLOGICAL TEMPORALITY: THE PRODUCTION OF TEMPORAL-ECOLOGICAL RIFTS

1. The Temporality of Capitalism's Metabolic Rift

When initially developing the theory of the Metabolic Rift, a contradictory and destructive state of affairs in which the mutual metabolic interpenetration of society and nature becomes antagonistically estranged due to the capitalist mode of production, Marx was inspired by the work of German organic chemist and biologist, Justus von Liebig, who had postulated a chemical theory of soil degradation based on his observations of the recently industrialized forms of capitalist agriculture during the second agricultural revolution.[361] Liebig had identified the "decline in natural fertility due to the disruption of the soil nutrient cycle accompanying capitalist agriculture" as the first stage of the crisis of capitalist agriculture and, should this issue remain unaddressed and these exploitative agricultural practices to continue as usual, highlighted the possibility of soil exhaustion as a potential second, even deeper, stage of the crisis of capitalist agriculture.[362] Liebig's arguments about soil fertility and nutrient cycles, which strongly influenced Marx, posited both a spatial aspect (qualitative) and a temporal aspect (quantitative) to the metabolic rift.

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[361] The "first agricultural revolution was a gradual process taking place over several centuries, connected with the enclosures and the growing centrality of the market [and, I would add, the increasing dominance of clock-time]; technical changes included improvements in manuring, crop rotation, drainage, and livestock management. In contrast the second agricultural revolution took place over a shorter period - 1830-1880 - and was characterized by the growth of a fertilizer industry and the development of soil chemistry, associated in particular with the work of Justus von Liebig. The third agricultural revolution took place still later, in the twentieth century, and involved the replacement of animal traction with machine traction on the farm, followed by the concentration of animals in massive feedlots, coupled with the genetic alteration of plants (producing narrower monocultures) and the more intensive use of chemical inputs - such as fertilizers and pesticides" (John Bellamy Foster, *Marx's Ecology: Materialism and Nature* (New York: Monthly Review Press, 2000), 148-149). "If the first agricultural revolution was bound up with the origins of capitalism (as Ellen Meiksins Wood has argued), the second agricultural revolution was bound up with the shift to industrial capitalism, and the third agricultural revolution with the rise of monopoly capitalism" (John Bellamy Foster, *Marx's Ecology: Materialism and Nature* (New York: Monthly Review Press, 2000), 284).

[362] Foster, *Marx's Ecology: Materialism and Nature* (New York: Monthly Review Press, 2000), 152.

Firstly, in terms of *space*, the separation of town and country - a result of capital's process of spatial expansion in the search for new commodities and resources, the generation of new markets, and the perpetual hunt for value, and of the concomitant concentration of labor in great manufacturing centers for the ease and efficiency of the exploitation of this labor-power[363] - meant that there could often be "hundreds, sometimes thousands, of miles…between the centers of grain cultivation and their markets. The constituent elements of the soil were therefore shipped to locations distant from their points of origin, making the reproduction of soil fertility that much more difficult."[364] Capital's processual materialization, its production and social division of space, then, was a central reason for the decreasing levels of soil fertility. Capitalist (industrial) agriculture, which has served to compound and intensify the consequences of capital's general metabolic rift in myriad ways, because it originated in the alienation of workers and peasants from the land through enclosures and violent evictions, is the product of one of capital's primary spatial-ecological rifts.

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[363] Engels describes this complex process with remarkable clarity and detail: "The centralizing tendency of manufacture does not, however, stop here. Population becomes centralized just as capital does; and, very naturally, since the human being, the worker, is regarded in manufacture simply as a piece of capital for the use of which the manufacturer pays interest under the name of wages. A manufacturing establishment requires many workers employed together in a single building, living near each other and forming a small village of themselves in the case of a good-sized factory. They have needs for satisfying which other people are necessary [sic]; handicraftsmen, shoemakers, tailors, bakers, carpenters, stonemasons, settle at hand. The inhabitants of the village, especially the younger generation, accustom themselves to factory work, grow skillful in it, and when the first mill can no longer employ them all, wages fall, and the immigration of fresh manufacturers is the consequence. So the village grows into a small town, and the small town into a large one. The greater the town, the greater its advantages. It offers roads, railroads, canals; the choice of skilled labour increases constantly, new establishments can be built more cheaply, because of the competition among builders and machinists who are at hand, than in the remote country districts, whither timber, machinery builders, and operatives must be brought; it offers a market to which buyers crowd, and direct communication with the markets supplying raw material or demanding finished goods. Hence the marvellously rapid growth of the great manufacturing towns. The country, on the other hand, has the advantage that wages are usually lower than in town, and so town and country are in constant competition; and, if the advantage is on the side of the town today, wages sink so low in the country tomorrow, that new investments are most profitably made there. But the centralizing tendency of manufacture continues in full force, and every new factory built in the country bears in it the germ of a manufacturing town. If it were possible for this mad rush of manufacture to go on at this rate for another century, every manufacturing district of England would be one great manufacturing town…for in commerce, too, this centralization of the population works in precisely the same way, and hence it is that one or two great harbours, such as Hull and Liverpool, Bristol and London, monopolize almost the whole maritime commerce of Great Britain" (Engels, *The Condition of the Working Class in England*, 55-6).

[364] Foster, *Marx's Ecology: Materialism and Nature* (New York: Monthly Review Press, 2000), 154.

Secondly, in terms of *time*, the pursuit of short-term economic gain by industrial capitalism was robbing the soil of its nutrients at such an intensive and accelerating *pace* that the soil could not naturally replenish and regenerate quickly enough to keep up with the *capitalist rate of extraction*. In other words, the tempo and rhythm of capitalist industrial agricultural practices so vastly outpaced the natural tempo and rhythm of the nutrient cycle of the soil that a contradiction - *a temporal-ecological rift* - arose between these two temporalities. This phenomenon, upon which Marx established his general theory of the metabolic rift, is fundamentally indicative of the relationship between capitalist temporality and nature, as time and again we see capital operating at such a ferocious and exponentially increasing pace that nature is 'used up' at such a rate as to make impossible the natural restoration of that which is used. However, capitalism, as we have seen, is regularly able to turn the prohibitive boundaries indicated by crisis situations into mere barriers, which it can then overcome, thus simultaneously suspending while deepening each crisis.

In response to the soil fertility crisis emerging from the conditions created by the first and second capitalist agricultural revolutions, capital was able to provide a single solution. The answer offered by capital to both the spatial and temporal aspects of this agricultural crisis was 'guano imperialism,' a specific form of "ecological imperialism"[365] which marked "the emergence of a *global* metabolic rift that involved environmental degradation and unequal ecological exchange" on an international scale.[366] Guano, the accumulated manure of sea birds and bats, a substance high in the very nutrients being depleted from the soil by intensive capitalist agricultural practices, would help to replenish some of the lost soil fertility, such that by the 19th century "the guano/nitrates trade united China, Peru, Chile,

[365] "Ecological imperialism is generally defined as a phenomenon of unequal ecological exchange associated with the robbery of external nature, as famously depicted in Marx's theory of metabolic rift" (Lola Loustaunau, Mauricio Betancourt, Brett Clark & John Bellamy Foster, "Chinese contract labor, the corporeal rift, and ecological imperialism in Peru's nineteenth-century guano boom," *The Journal of Peasant Studies* 49, no. 3 (May 2022): 511-12.

[366] Foster, Clark, and York, *The Ecological Rift*, 352. Emphasis is my own.

Britain, and the United States in a global metabolic rift."[367] The spatial aspect of the soil fertility crisis, that is the extraction and transportation of the soil's nutrients over great distances in the form of food and clothing, was remedied by capital's extended spatial expansion in the search for stores of those same nutrients, in the form of alternative fertilizers such as guano, to be brought back to the capitalist core nations to remedy their soil fertility crises; a process that certainly amounts to "Ecological imperialism [as] the expropriation or robbery of nature in one part of the world for the exclusive benefit of another."[368] This imperialist form of spatial expansion, while socially and ecologically damaging, was effective in buttressing capital's assent to global hegemony, which can be seen in its lasting effects:

> Under the authority of what became the Guano Islands Act, passed by Congress in 1856, U.S. capitalists seized ninety-four islands, rocks, and keys around the globe between 1856 and 1903, sixty-six of which were officially recognized by the Department of State as U.S. appurtenances…Nine of these guano islands remain in U.S. possession today [in the year 2000].[369]

The nutrients lost to the soil by their conversion into commodities were, therefore, replaced by nutrients from far-flung, external sources, through a form of ecological imperialism which aligned with capital's tendency toward spatial expansion. 'Guano imperialism' as a driver of capital's spatial expansion was regarded as a possible remedy to the agricultural crisis in the capitalist core precisely because it was preceded by the successes of parallel process, that of fossil fuel imperialism: "In the second quarter of the nineteenth century, the British Empire deployed steamboats to extend its control over territories and accelerate its appropriation of resources from around the world [because] They required coal."[370] Thus, we can see that

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[367] Foster, Clark, and York, *The Ecological Rift*, 352. Industrially produced nitrogen fertilizer, for example, was not developed until 1913 (Foster, *Marx's Ecology*, 151).

[368] Loustaunau, "Chinese contract labor, the corporeal rift, and ecological imperialism in Peru's nineteenth-century guano boom," 511.

[369] Foster, *Marx's Ecology*, 151.

[370] Malm, *The Progress of this Storm*, 19.

imperialist spatial expansion for purposes of resource extraction has been a successful strategy for capitalism in attending to various ecological rifts and crises throughout its history, yet we should also recognize how certain consequences of this (ecological) imperialist expansion have contributed to a deeper metabolic rift.[371] Perhaps most evidently in the context of the U.S., capitalist imperial-colonial expansion has propagated "colonial ecological violence…[which] disrupts Indigenous eco-social relations…[and] results in particular risks and harms experienced by Native peoples and communities."[372] For example, the "slow forms of violence, which occur more-or-less invisibly over long durations of time" through the poisoning of indigenous communities and communities of people of color[373] which comes from "the decision to place particularly polluting military installations or waste disposal facilities in close proximity to reservation lands" and communities of color.[374]

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[371] We might also add, on this point, that ecological imperialism also drives the production of a "corporeal rift" in the physical bodies of workers which is exemplified by the particular form that capitalist exploitation of Chinese labor took (i.e. the "coolie trade") during the phase of guano imperialism: ecological imperialism "represents capitalist socio-ecological relations in their most global and most inimical forms, characterized by a *double rift*: (1) the rift in the human metabolism between nature (the metabolic rift), and (2) the corresponding rift in human bodily existence itself (the corporeal rift). This *double rift* emerged in an unmistakable form at the global level in the guano trade in the mid-nineteenth century. Chinese guano diggers on the islands off the coast of Peru were inserted into a racialized system of contract labor (or the so-called coolie system), in which they experienced the most extreme forms of superexploitation." The corporeal rift is "evident in the rapid morbidity and mortality of the workers involved in extractive labor, as well as in surrounding populations affected by the negative effects of the robbery of ecosystems" (Loustaunau, "Chinese contract labor, the corporeal rift, and ecological imperialism in Peru's nineteenth-century guano boom," 511, 529).

[372] J.M. Bacon, "Settler Colonialism as Eco-Social Structure and the Production of Colonial Ecological Violence," *Environmental Sociology* 5, no. 1 (May 28, 2018): 59.

[373] The origin of the Environmental Justice movement in the U.S. is a seminal 1986 study which showed that "the racial and ethnic composition of a place was by far the strongest and most consistent predictor of the location of commercial hazardous waste facilities," and while much effort has been expended to address these racial iniquities, "20 years later, a follow-up study showed that the racial composition of a place continued to be the strongest predictor of hazardous waste facility locations" (Margaret T. Hicken, Lewis Miles, Solome Haile, and Michael Esposito, "Linking History to Contemporary State-Sanctioned Slow Violence through Cultural and Structural Racism," *The ANNALS of the American Academy of Political and Social Science* 694, no. 1 (March 2021): 48).

[374] Bacon, "Settler Colonialism as Eco-Social Structure and the Production of Colonial Ecological Violence," 64. Slow-violence has been defined by the originator of the concept in the following way: "By slow violence I mean a violence that occurs gradually and out of sight, a violence of delayed destruction that is dispersed across time and space, an attritional violence that is typically not viewed as violence at all. Violence is customarily conceived as an event or action that is immediate in time, explosive and spectacular in space, and as erupting into instant sensational visibility. We need, I believe, to engage a different kind of violence, a violence that is neither spectacular nor instantaneous, but rather incremental and accretive, its calamitous repercussions playing out across a range of temporal scales." (Rob Nixon, *Slow Violence and the Environmentalism of the Poor* (Massachusetts: Harvard University Press, 2011), 2). While there is not sufficient space for a sustained

Capitalist spatial expansion, therefore, while undertaken in order to enable further accumulation and often to remedy ecological crises in the capitalist-core, ultimately serves to deepen and compound both capitalism's general metabolic rift and the social crisis of racism.

The temporal aspect of the soil fertility crisis, that is capitalism's use of the crop-producing nutrients in the land at a rate that completely outstripped the rate of the soil's natural nutrient cycle, was remedied by the use of the potent, naturally occurring fertilizer sourced and extracted by the now-global, ecologically imperial guano trade. This natural fertilizer had the effect of replenishing some of the lost soil fertility and thus of temporarily staving off the broader soil fertility crisis that sparked such a panic in the capitalist West in the 18th and 19th centuries. It is important to note here that there is nothing inherently problematic about the use of guano or other natural fertilizers, and these practices have a long history in society, particularly among indigenous communities in South America where guano was plentiful for centuries. Rather, the problem resides in the use of guano as only a short-term 'fix,' a mere palliative, for the broader soil fertility crisis brought about by conditions of increasingly industrialized capitalist agriculture. This short-term 'fix' delayed the immediate consequences of capitalist agriculture by bringing soil fertility to levels that enable the continuation of this form of agriculture yet failed to address the long-term ramifications of soil degradation of capitalist agriculture. Marx, however, was keenly aware of the nature of this situation, remarking that "all progress in increasing the fertility of the soil for a given time is a progress towards ruining the more long-lasting sources of that fertility."[375] Interestingly, yet unsurprisingly, it is in relation to the use of natural fertilizers to prop up capitalist agricultural profits in the short-term that Engels offers the following

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discussion of this concept in the present discussion, efforts to bring together the concepts of temporal-ecological rift and slow-violence, given the unique temporal conception of violence inherent in the latter, may offer an interesting possibility and fruitful direction for future research.

[375] Marx, *Capital Volume 1*, 638.

comment, in which he clearly, if not quite explicitly, identifies the temporal-ecological contradictions at the heart of the capitalist mode of production, in *Dialectics of Nature*:

> What did the Spanish planters of Cuba, who burned down forests on the slopes of the mountains and obtained from the ashes sufficient fertilizer for *one* generation of very highly profitable coffee trees, care that the tropical rainfall afterwards washed away the now unprotected upper stratum of the soil, leaving behind only bare rock? In relation to nature, as to society, the present mode of production is predominantly concerned only about the first, tangible success; and then surprise is expressed that the more remote effects of actions directed to this end turn out to be of quite a different, mainly even of quite an opposite character.[376]

The short-termism of capital's restricted systemic temporal horizon, determined by the temporal logic of capital, is clearly expressed by capitalist agriculture and operative in its treatment of the soil, engendering a temporal-ecological rift between capital and the natural world, whereby the rate at which capitalism operates and expands outpaces the cycles and rhythms of the regeneration and replenishment of nature. It is precisely this fact which prompts Altvater, in speaking of "the 'contradiction of economy and ecology,'" to argue that "The space and time of a society, and the physical time and space of nature, are in no way identical - and this is especially true for capitalism. The logics of their respective functional spaces collides [sic]. Ecological crises can, in many regards, be understood in terms of this collision."[377] Building on this insight, as a sub-component of capital's general metabolic rift, the concept of the *temporal-ecological rift* specifically captures the destructive relationship between capitalist temporality and nature, since the operation of capitalism - structured by an alienating temporal logic, which is socially expressed as abstract, mechanical clock-time - cannot abide by the ecological limitations or extractive rates necessary for the metabolic temporality of society to be ecologically sound, balanced, or healthy. Therefore, I argue that it is through the concept of the temporal-ecological rift that we can identify, grasp, and describe

[376] Engels, *Dialectics of Nature*, 296.
[377] Altvater, "Ecological and Economic Modalities of Time and Space," 82.

more precisely the specifically temporal aspect of the antagonistic contradiction between capitalism and nature.

2. Temporal-Ecological Rifts: Real Subsumption of Science, Ecological Imperialism, and Specifically Capitalist Use-Values

The concept of the temporal-ecological rift enables us to better analyze and understand capitalism's transformations throughout the last century, specifically in terms of its metabolic relation to nature. Because nature is ultimately autonomous and so stifles capital's attempts to totally subsume its various temporal rhythms and cycles, the form of capitalism's temporal-ecological rift itself has changed and intensified as a response to this resistance. This is the case with the soil fertility crisis because, ultimately, for example, "guano imperialism was unsuccessful in providing the United States with the quantity and quality of fertilizer it needed."[378] The short-term 'fix' of guano therefore proved to be just that: a short-term 'fix,' as opposed to a thorough, root-and-branch resolution to the crisis. But a moment of all-consuming and intense crisis-transformation of capitalism at the beginning of the 20th century, particularly in the relation of capital to science and technology, meant that alternative 'fixes' for the crisis could now be procured by a more technical and intentional method.

The economic and political crises of imperialism which led to the eruption of World War I marked a moment of profound transformation of capitalism in which entire sectors of society and production, thus far having resisted real subsumption by capital, were brought into the service of capital's destructive mode of production in relation to the war efforts before being fully subsumed. "The novelty of the Great War resided in the integration it accomplished between the State, economic monopolies, society, work, science, and technology," and thus WWI constitutes a moment whereby "scientific and technological innovation is now subsumed under the direct control of the State [for purposes of war and its

[378] Foster, *Marx's Ecology*, 151.

economic benefits] while undergoing a violent acceleration."[379] The acceleration in science and technological development that war and the emerging military-industrial complex gave rise to in the beginning of the twentieth century (an accelerative phenomenon firmly in line with the dictates of the temporal logic of capital), produced a form of science which, unsurprisingly, does not develop methods of meeting the material needs of workers and the poor, but rather "radically expands [capitalism's] destructive power," both directly, in the case of the explicit development of the tools of war, and indirectly, in the case of innovations for war which could also function as short-term 'fixes' for capitalism's various crises, oftentimes with a great deal of convergence between these direct and indirect developments.[380] There is perhaps no better example of this overlap than the development of the first method for nitrogen fixation. During the pre-WWI arms race, a period in which science was being increasingly conscripted into the service of imminent capitalist war efforts, synthetic nitrogen fertilizer was discovered "when the German chemist Fritz Haber, who was to go on to pioneer in the development of explosives and nerve gases for war production, originated such a process."[381] Industrially produced nitrogen fertilizer, while bolstering the German war effort as a chemical weapon and ingredient for the manufacture of explosives, also played a major part in solving the crisis of guano imperialism, thus enabling capitalist agriculture to continue and grow, despite the temporal-ecological rift it at once imposed and expanded.

This example is particularly illustrative of the way in which the development of capitalist science, especially after the turn of the twentieth century, by providing short-term

[379] Maurizio Lazzarato, "War, Capitalism, Ecology: Why Can't Bruno Latour Understand Anything about Them?" *Ill Will*, April 3, 2022, https://illwill.com/war-capitalism-ecology.
[380] Lazzarato, "War, Capitalism, Ecology."
[381] Foster, *Marx's Ecology*, 151. Synthetic nitrogen, although important in agriculture for its properties as a crop fertilizer, was the main ingredient in the production of ammonia gas, a deadly chemical weapon, alongside several explosives during WWI. Haber's process of synthesizing ammonia was important to the German war effort mainly because of the British monopoly over sources of nitrates, like guano and saltpeter, in South America at the time.

'fixes' to various ecological crises stemming from capital's global metabolic rift, served to reproduce and reinvigorate capitalism by turning daunting ecological boundaries into mere barriers, and then proceeding to 'overcome' them. While necessary to some degree in order to avert a system-threatening level of crisis, the process of confronting and overcoming (albeit not resolving) its own temporal-ecological rifts through scientific and technological innovation is a part of capital's broader process of the capitalization of nature; a process which "represents at its heart a subordination of biospherical temporality to the temporal logic of capital whenever capital expands spatially to new natural domains."[382] In the process of the capitalization and commodification of nature, the "fundamental contradictions that arise…are the contradictions between these different temporalities."[383] On the one hand, as Stahel notes, this capitalization process forms a continuum with capitalism's tendency to subsume all concrete temporalities, social and ecological, by bringing their rhythms and cycles into line as much as possible with the temporal logic of capital. On the other hand, this process can be seen as one way in which capitalism has reacted to itself as a now-global system, wherein there is no longer any serious possibility of external spatial expansion - essentially, there are no more frontiers left to conquer in physical space.[384] In light of the diminished possibility of spatial expansion, whereby there is a lack of places, social relations, and labor processes for capital to subsume, one alternative for maintaining growth to which capitalism has resorted,

[382] Stahel, "Time Contradictions of Capitalism," 101.

[383] Stahel, "Time Contradictions of Capitalism," 101.

[384] Capital's shift in focus from external spatial to internal temporal frontiers is also reflected in the transition from colonialism to neocolonialism, wherein the digital revolution, which has overcome spatial distances by reducing time intervals for the transfer of wealth to almost zero, has made it possible to exert economic domination from a distance, thus rendering the need for 'boots on the ground' largely redundant in previously or currently colonized spaces. In other words, one can understand the transition from colonialism to neocolonialism as a shift from extensive capitalist spatial domination/accumulation by intensive capitalist temporal domination/accumulation. However, this idea would need to be more fully worked out, and we unfortunately do not have the scope for such a project here. Moreover, I will leave aside, mostly for reasons of irrelevance to the present discussion, the current issue of billionaire-funded colonialism and imperialism in outer space, although I do see these phenomena being a result of capital, in some sense, grasping towards the (probably fictitious) possibility of continued extensive spatial expansion and the uncovering of new stores of natural resources. Whether or not this endeavor is viable or could even be achieved before climate collapse on Earth, however, is another matter entirely.

with regards to certain forms of naturally occurring commodities such as plants and animals, is what I call *incisive temporal domination* of nature, and (when possible) *complete temporal subsumption*.[385]

Let us now examine how this form of subsumption of nature, that is the subsumption of the temporalities, cycles and rhythms of parts of nature, occurs. In order to understand this process, we must first identify the ways in which capitalist accumulation, and therefore also the capitalist domination and control with which accumulation is inherently bound up[386], materially proceeds. On the one hand,

> Extensive accumulation is the quantitative expansion of the system… [wherein,] As a class, capitalists, are busily 'opening up' markets through colonization, imperialism, expropriation and incorporation of new swathes of population into wage labour and commodity based consumption, growth in this first sense always occurs in an 'outside,'

while, on the other,

> Intensive accumulation…refers to an expansion process that qualitatively changes the system…Marx's concept of 'real subsumption' captures the essence of this relation, where the object of exploitation – be it living labour, *nature* or social relations – is no longer incorporated as it is in a process of valorization, but *the process of valorization actively and purposefully transforms the appropriated object's nature*.[387]

The subordination of biological and biophysical temporalities of particular parts of nature to the temporality of capital corresponds to the form of *intensive* accumulation, or real subsumption. Understanding temporal-intensive domination/accumulation, or the incisive temporal domination of nature, as a form of real subsumption of organisms such as animals

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[385] I use the word 'incisive' here in the sense of 'incision' from the Latin '*Incidere*,' meaning 'to cut into,' as this best represents the method of capital's real subsumption of nature, as it 'cuts into' the temporal cycles and rhythm in order to rearrange, adapt, and repurpose them according to the dictates of the temporal logic of capital, thus producing commodities which are 'specifically capitalist use-values' for the sake of accumulation through the valorization of value.

[386] Capitalist accumulation, says Marx, has as its fundament the violent process of primary or "primitive accumulation" which "is nothing else than the historical process of divorcing the producer from the means of production," and consists, in its "actual history," of "conquest, enslavement, robbery, murder, in short, force." That capitalist accumulation could begin in such a manner only to later transform itself into an "idyllic" process which advances freedom and equality is part of the "insipid childishness" of the foundational "nursery tale" of "the tender annals of political economy" (Marx, *Capital Volume 1,* 873-5).

[387] Pineault, "Growth and Overaccumulation in Advanced Capitalism," 4-5. Emphasis is my own.

and plants, whereby capital's "process of valorization actively and purposefully transforms the appropriated object's nature," in this case that is the organisms' own tempos, cycles and rhythms, so as to accord with the short-term demands of capitalist temporality/the temporal logic of capital, however, first requires a reference to the emergence and production of "specifically capitalist use values" within monopoly capitalism.[388] Producing 'specifically capitalist use-values' means that, in the use:exchange value ratio that any given commodity carries, exchange-value comes to subordinate use-value, marking a historical shift from the nature of the commodity form in the competitive capitalism of the 18th and 19th centuries, and thus making the "primary 'usefulness' [of the commodity]...the exchange value they generated for corporations."[389] In other words, these are "Use values whose very form answers to the imperative of over-accumulation: absorb the surplus."[390] Specifically capitalist use-values are thus a hallmark feature of monopoly capital and although this concept is typically applied to manufactured commodities, namely because it is clear that capitalism can and does temporally structure these objects during the production process, usually in order to cause them, once exchanged for money, to degenerate and become defunct at a quicker rate than they do would under a rational system of production, here I wish to extend this concept to include certain parts of nature that have been commodified through capital's process of the capitalization of nature. While it is quite clear how, under socio-economic conditions that correspond to capital's accumulation imperative, the production of a "light bulb that can shine on for decades" would be "economically disastrous to monopolistic corporations - and bad for growth," and that the technique of the production process is therefore adapted accordingly in

[388] John Bellamy Foster, "The Ecology of Marxian Political Economy," *Monthly Review* 63, no. 4 (September 2011), https://monthlyreview.org/2011/09/01/the-ecology-of-marxian-political-economy/#fn33.
[389] Foster, "The Ecology of Marxian Political Economy." In terms of manufactured commodities, as discussed above, the term 'planned obsolescence' is often used to describe the purposeful shortening of the life-cycle of the object for the sake of increasing consumption; examples include lightbulbs, nylon stockings, and smartphones. In another register, this is what Baudrillard means by the phenomenon whereby humans now live by 'object time' (see Chapter 4, footnote 7).
[390] Pineault, "Growth and Overaccumulation in Advanced Capitalism," 14.

order to produce a commodity that meets the economic needs of monopoly capital, it is less clear how certain highly commodified parts of nature are rendered 'specifically capitalist use-values' in industries such as agriculture and natural resource extraction.[391]

If we begin by recognizing that "A specifically capitalist use value has a planned useful life-cycle that locally and specifically accelerates the productive capacity of over-accumulated fixed capital," then we are able to see, on the one hand, the temporal logic of capital clearly at work in this process, and on the other hand, that, with regards to nature, it is only in light of the developments of modern science and technology, particularly the developments in sciences occurring during and in the wake of WWI (and by extension WWII), that have enabled capital to render naturally occurring organisms commodities that carry 'specifically capitalist use-values.' Partly in order to overcome the temporal-ecological rifts and contradictions of its mode of production, and partly to stave off economic crises of falling rates of profits/stagflation, capital, by means of the developments of the scientific and technological apparatuses brought into its service at the beginning of the twentieth century, has come to chemically, biologically, and even genetically dominate and control nature. A central aspect of this development has involved adapting the time cycles and rhythms of the parts of the natural world to meet, to whatever degree possible, the demands of the cycles and rhythms of capitalist temporality, that is, those cycles and rhythms which cohere with the dictates of the temporal logic of capital for purposes of accumulation. Therefore, we find that it is in the convergence of capitalism's increasing scientific and technological mastery over nature, its turn from extensive spatial domination/accumulation to intensive temporal domination/accumulation, and the emergence of 'specifically capitalist use-values' in monopoly capitalism that have produced conditions which make possible capital's incisive temporal control over certain parts of commodified nature. Moreover, despite nature's

[391] Pineault, "Growth and Overaccumulation in Advanced Capitalism," 14.

objective autonomy from capital, taking control of the temporality of specific parts of nature is the closest capital has yet come to truly contesting this autonomy. Nevertheless, because a "specifically capitalist use value accelerates biophysical throughput," producing specifically capitalist use-values out of both manufactured and natural commodities thus has the effect of worsening the ecological crises through which nature reasserts its autonomy from capital.[392]

3. Temporal-Ecological Rifts: Three Case Studies

Here it bears repeating Marx's dialectical insight (and warning) on this issue: while the capitalist mode of production "creates the material conditions for a new and higher synthesis" of industry and agriculture by a "conscious, technological application of science [which] replaces the previous highly irrational and slothfully traditional way of working" and therefore holds the promise of human emancipation from a great deal of toil and drudgery, it also has the effect of disturbing "the metabolic interaction between [humanity] and the earth" thus "simultaneously undermining the original sources of all wealth - the soil and the worker."[393] Beyond just the soil, however, capital has developed in such a way as to now, in its monopoly form, undermine nature *in toto*, which is reflected in the numerous severe ecological crises society is currently confronting; this is precisely what the concept of the Metabolic Rift captures. Let us now examine two examples of capital's incisive temporal control, and one example of complete temporal subsumption, from industries in which capital appropriates and capitalizes parts of nature in order to produce 'specifically capitalist use-values,' namely chickens in industrial livestock production (factory farming); genetically modified plants in industrial crop agriculture; and the case of old growth forests, tree farms, and the timber/lumber industry.

[392] Pineault, "Growth and Overaccumulation in Advanced Capitalism," 14.
[393] Marx, *Capital Volume 1*, 637-8.

3.1 Factory Farmed Chickens and 'For-Profit Selective Breeding'

Factory farming is a much discussed (and often morally condemned) phenomenon that emerged in the middle of the twentieth century in accordance with the continued application of the logic of capital to animal agriculture.[394] At least, so say the representatives of the (poultry) factory farming industry themselves: "The object of producing eggs is to make money. When we forget this objective, we have forgotten what it is all about."[395] Despite the attempts to keep the industry shrouded in secrecy,[396] it is now well known thanks to the exposés of workers, activists, and journalists that under conditions of capitalist industrial agriculture, livestock animals live short lives of squalor, misery, and pain, yet this is, when its logic is followed strictly, what capital's accumulation imperative demands. "Chickens, like most animals in factory farms, suffer conditions that are harsh and unnatural, *designed to maximize production*, not quality of life."[397] While certain environmental factors such as levels of light and type of feed are manipulated in order to increase production,[398] I am interested here in how the incisive temporal control of the life-cycle of a chicken-commodity

[394] Apropos of our discussion of monopoly capital and the emergence of 'specifically capitalist use-values,' these conditions are also reflected in the fact that "Three companies worldwide supply 90% of broiler chicks and selective breeding has resulted in 50% or more of genetic diversity loss in commercial lines compared with ancestral breeds" (CE Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," *Royal Society Open Science* 5, no.12 (December 2018), 8).

[395] Fred C. Haley, "How I Really Feel About the Egg Business," *Poultry Tribune*, January 1974, quoted in Darian M. Ibrahim, "Return To Descartes: Property, Profit, and the Corporate Ownership of Animals," *Law and Contemporary Problems*, 70, no. 1, Animal Law and Policy (Winter, 2007), 89.

[396] "But in most of the major agricultural states, laws have been introduced or passed that would make it illegal to gather evidence, by filming or photography, about the internal operations of factory farms where animals are being raised…Some states already exempt factory farms from animal cruelty restrictions." These laws are commonly referred to as agricultural gag, or 'ag-gag,' laws (The Editorial Board, "Eating with Our Eyes Closed," *The New York Times*, April 9, 2013, https://www.nytimes.com/2013/04/10/opinion/eating-with-our-eyes-closed.html).

[397] Drew Leder, "Old McDonald's Had a Farm: The Metaphysics of Factory Farming," *Journal of Animal Ethics* 2, no. 1 (Spring 2012), 76. Emphasis is my own.

[398] "Broiler [chicken] farming is undertaken within a complex mechanized system that operates with the integration of computer software, electricity, transportation vehicles, refrigeration, feed processing factories and more. This is epitomized in the life-cycle of intensively farmed broilers: eggs are laid in broiler breeder facilities and transported to hatcheries, where eggs are incubated artificially for 21 days. After hatching, the 1-day-old chicks are transported to high-capacity finishing units housing up to 50 000 individuals in climate-controlled sheds. For the first week of life, chicks are kept at temperatures of 32°C to 35°C and relative humidity of 60% to 70%." (Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," 7).

renders the animal a 'specifically capitalist use-value,' or rather how the real subsumption of a commodified part of nature results in the subordination of biological temporality to the temporal logic of capital. The main way in which this is achieved in factory farmed broiler chickens[399] is human-directed selective breeding which, according to the fossil records, can be dated to as early as the 16th century as an agricultural practice involving chickens, yet is only given a sound scientific basis following Darwin's theory of evolution through genetic inheritance.[400] The question we are faced with, then, if selective breeding in chickens dates to the 1500s, is why "Chickens from the late twentieth century are markedly different in terms of size, growth rate and body shape" to chickens from before the mid-twentieth century and, moreover, why and how "Broilers from a 1957 breed are between one-fourth and one-fifth of the body weight of broilers from a twenty-first century breed"?[401] The drastic extent of the change in broiler physiology in such a short period of time alone is enough to raise concern, and this is before any consideration of the moral implications of the extremely damaging effects of altering a living creature's body and life-cycle so intensely.[402]

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[399] In this analysis I will focus on broiler chickens for three reasons: (a) "until the 20th century the chicken was prized more as a showpiece than as an item for the table…[and] It was not until about 1910 that the raising of hens for egg-laying [and meat] became a more important enterprise in the U.S. than the breeding of fancy poultry for exhibition," thus the commodification of the chicken corresponds chronologically with the real subsumption of science by capital, which is important in understanding *how* the broiler chicken was to become not only a commodity, but a 'specifically capitalist use-value' (Wilbor O. Wilson, "Poultry Production," *Scientific American* 215, no. 1 (July 1966), 56); (b) because "This mono-specific vast bird biomass is unprecedented in Earth's recent history and perhaps also in Earth's geological history," and thus represents, simultaneously, the world-historical productive achievements of capitalist industrial agriculture *and* an example of the extent of the destruction and violence capitalism will commit against nature in accordance with its accumulation imperative and corresponding temporal logic; and (c), perhaps most importantly, because "Domesticated chickens…are a striking example of a human reconfigured biosphere" in a specifically temporal sense, as we shall see, due to the "genetic make-up of the modern broiler morphospecies [which]...differs from the ancestral red jungle fowl, in terms of deletions and mutations, some of which relate to the modification of the animal *for maximum growth*" (Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," 1, 2, 8. Emphasis is my own).

[400] Roger J. Wood and Orel Vítězslav, "Scientific Breeding in Central Europe during the Early Nineteenth Century: Background to Mendel's Later Work," *Journal of the History of Biology* 38, no. 2 (2005).

[401] Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," 7.

[402] "The change in body mass and body shape has been visually documented by photographs of broiler breeds throughout ontogeny from 1957, 1978 and 2005. Broilers from a 1957 breed are between one-fourth and one-fifth of the body weight of broilers from a twenty-first century breed. The modern broiler is a distinctive new morphotype with a relatively wide body shape, a low centre of gravity and multiple osteo-pathologies. *If left to*

Answering these questions requires that we account, on the one hand, for the qualitative difference between traditional human-driven selective breeding practices and "for-profit selective breeding" practices, and on the other, for the role of the temporal logic of capital in driving this difference.[403] With regards to the former, the inversion of use-value and exchange-value that occurs with the proliferation of the commodity form under capitalism means that whereas traditional human-driven selective breeding practices may have previously aimed at any number of various outcomes, for example specific practical traits in dogs which correspond to use-values such as hunting, herding, or guarding, for-profit selective breeding under factory farm conditions, although still largely human-driven (albeit now with the aid of data), is fundamentally guided by the interests and logic of capital, with capitalists acting "as capital personified and endowed with consciousness and a will," and therefore aims solely at the maximization of the exchange-value of the chicken-commodity.[404] While for much of human history, "selective breeding was largely consistent with local environments, complementing other natural selective agents, such as local pests and symbionts, soil conditions, and climate," in the case of for profit selective breeding, because it aims at maximizing exchange-value, these important local ecological factors are entirely disregarded, or removed through stringently controlled environments, much to the detriment

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live to maturity, broilers are unlikely to survive. In one study, increasing their slaughter age from five weeks to nine weeks resulted in a sevenfold increase in mortality rate: the rapid growth of leg and breast muscle tissue leads to a relative decrease in the size of other organs such as the heart and lungs, which restricts their function and thus longevity. Changes in the centre of gravity of the body, reduced pelvic limb muscle mass and increased pectoral muscle mass cause poor locomotion and frequent lameness. Unlike most other neobiota, this new broiler morphotype is shaped by, and unable to live without, intensive human intervention" (Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," 7-8. Emphasis is my own). While moral arguments against this kind of treatment are important parts of the broader discussion of the human-nature relation, there is not sufficient scope to engage this part of the discussion here, and I am instead interested in exploring the nature of capitalism's real subsumption of nature by subordinating biophysical temporalities to the temporal logic of capital.

[403] Michael Friedman, "GMOs: Capitalism's Distortion of Biological Processes," *Monthly Review* 66, no. 10 (March 1, 2015), https://monthlyreview.org/2015/03/01/gmos-capitalisms-distortion-of-biological-processes/.

[404] Marx, *Capital Volume 1*, 254.

of the safety and nutritional value of the food-product,[405] the broader ecological consequences of such selective practices, and, not least, in the case of selective breeding of livestock, the quality of life of the animal. Due to this qualitative difference in the impetus for selective-breeding, chickens are now bred "for a single trait, as with large-breasted 'white meat' chickens" which leads to the production of "deformed, neurologically or cardiologically damaged, and generally unhealthy" animals, yet animals which are, at the same time, more profitable commodities because of the high meat yield attained.[406] Regarding the former, that is, the role of the temporal logic of capital in the process of the capitalization of this specific part of nature, in search of surplus value capital requires an increase in the rate of production of the commodity-chicken. Thus, capital's incisive temporal domination and control of the life-cycle of the chicken, the subordination of the biophysical temporality of the chicken to the temporal logic of capital, becomes the method by which 'production' (i.e., the fertilization, growth, and harvest of a chicken) is accelerated substantially in order to increase

[405] A prominent example of this, which has been a recurring feature of public discourse around biotechnologically altered crops, is genetically modified "high fructose, nutritionally empty sweet corn" (Friedman). It is particularly important to consider the socio-ecological consequences, especially in the context of the U.S., of the mass-production of cheap agricultural commodities bereft of nutritional value in a society structured by a form of racial capitalism which therefore systematically produces environmental racism, or, as Laura Pulido succinctly puts it, "environmental racism is part of racial capitalism" (Laura Pulido, "Geographies of Race and Ethnicity II: Environmental Racism, Racial Capitalism and State-Sanctioned Violence," *Progress in Human Geography* 41, no. 4 (August 2017): 526.). The effects of environmental racism stemming from agriculture and food production can be found in Maryland, where factory farmed chicken production has been recently expanding. In Prince George's County, a "predominantly African-American (62%) and Hispanic (18.5%)" area, researchers have found evidence of "limited nutritional resources within the region" which "can be classified as environmental injustice" (Lucy Kavi, et al., "Environmental Justice and the Food Environment in Prince George's County, Maryland: Assessment of Three Communities," *Frontiers in Built Environment* 5, no. 121 (October 18, 2019): 7). Moreover, in terms of distribution of ecological impacts, recent empirical studies have shown that "Low socioeconomic status communities and communities of color are disproportionately [ecologically] burdened by chicken CAFOs [concentrated animal feeding operations, i.e. factory farms] and meat processing facilities across Maryland, making the state's chicken industry an environmental justice concern" (Jonathan Hall, et al., "Environmental Injustice and Industrial Chicken Farming in Maryland," *International Journal of Environmental Research and Public Health* 18, no. 21, From Environmental Health Inequalities to Environmental Health Justice (October 2021): 11039). While these findings are restricted to Maryland, the trends they expose track across the U.S., as one team of researchers notes that "greater availability and variety of more healthful foods combined with lower food costs at supermarkets versus smaller grocery stores and chain versus non-chain supermarkets underscores the implications of these results for the low-income and minority neighborhoods that are found to be under-served by chain supermarkets" (Lisa M. Powell et al., "*Food Store Availability and Neighborhood Characteristics in the United States*," Preventative Medicine 44, no. 3 (March 2007): 194).

[406] Leder, "Old McDonald's Had a Farm: The Metaphysics of Factory Farming," 76.

the generation of surplus value. The extent to which capital is able to achieve this, as we shall see, is quite astonishing.

First, as a point of reference, it is important to note that the lifespan of the broiler's genetic ancestor, the red jungle fowl, can be in the range of anywhere from "3 years to 11 years…in captivity."[407] In contrast, the lifespan of the contemporary broiler chicken (which, we should recall, refers to a broiler chicken from after the mid-twentieth century, therefore an incredibly recent phenomenon, because "the speed and scale of changes [in the chicken's rate of growth] escalated considerably in the second half of the twentieth century"), is *short at five to seven weeks*, with egg-laying hens living for 1 year - both types of chicken "are slaughtered at a young age *for economic reasons*."[408] The "domestic chicken's genetic make-up differs from the ancestral red jungle fowl, in terms of deletions and mutations, some of which relate to the modification of the animal for maximum growth," to such an extent that the "growth rate of modern broilers is now three times higher than that of the red jungle fowl."[409] Although at the typical time of slaughter the broiler chicken is at a young age - between five to seven weeks - the pace of the chicken's rate of growth/life-cycle has been so intensely accelerated by for-profit selective breeding that, at least in terms of muscle maturity (i.e. in industry terms, when considered as a commodity, the chicken's meat yield), it has reached adulthood. We can see, therefore, that capitalism, and its temporal logic, has rendered the broiler chicken a 'specifically capitalist use-value' both by drastically increasing the size of the chicken's body mass and phenomenally increasing the rate of growth of the animal. This is reflected clearly in the fact that, not only has the chicken's life-cycle undergone an incredible acceleration, but that if it were not to be slaughtered for food production purposes,

[407] Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," 7.
[408] Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," 5, 7. Emphasis is my own.
[409] Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," 8.

its lifetime is consequently severely compressed because of the health complications which come from such a heightened growth rate:

> In one study, increasing their slaughter age from five weeks to nine weeks resulted in a sevenfold increase in mortality rate: the rapid growth of leg and breast muscle tissue leads to a relative decrease in the size of other organs such as the heart and lungs, which restricts their function and thus longevity.[410]

The reduction of this creature, a part of nature, to a 'specifically capitalist use-value' has entailed a reduction, by means of genetic manipulation through 'for-profit selective breeding,' of its lifetime into a short, dense period during which the chicken carries high value as a commodity. This illustrates how the temporal logic of capital, when applied to a production process which involves the capitalization and commodification of nature, promotes precisely this form of capitalist 'efficiency' which can greatly increase surplus accumulation. Yet this occurs not without broader ecological consequences which, in this case, are found in the fact that "for-profit selective breeding [has] brought us a long series of aberrations from a biological and ecological point of view…[including the] depletion of genetic variation so necessary for adaptation."[411] In the case of the modern broiler chicken, robust genes which ensure evolutionary fitness in the species across generations, quality of life in each animal, or the stability of the ecosystem(s) in which the organism lives and contributes, are all redundant considerations in selective breeding practices, only profit (and therefore surplus) maximization are to be taken into account, which logically justifies the adaptations purposefully introduced to these chicken-commodity's genes. In the new, capital-driven, for-profit selective breeding determined life-cycle of the broiler chicken, we find a specific manifestation of the subordination of a biological temporality to the dictates of the temporal logic of capital, and therefore a striking example of one of capital's many temporal-ecological rifts produced in the perpetual hunt for surplus value in order to support the system's

[410] Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," 7.
[411] Friedman, "GMOs: Capitalism's Distortion of Biological Processes."

expansion. Turning now from the application of the temporal logic of capital in livestock agriculture to its application in crop agriculture, we find a similar situation.

3.2 Genetically Modified Organisms and 'Terminator Technology'

While factory farming practices have attracted widespread moral condemnation, likely due to the visceral reactions induced by evidence of the repugnant conditions animals are subjected to in these facilities, although also controversial, the use of genetically modified organisms (GMOs) in capitalist crop agriculture has produced a much more divided discourse; this is likely because of the fact that, despite the apparent and serious biological and ecological dangers of GMOs such as potentially carcinogenic crops and the exposure of farmers to carcinogenic herbicides to which these GMOs are resistant,[412] there are also apparent benefits to using GMOs such as protection of crops against drought and pests and increased crop yield. However, my intention here, as above, is not to intervene in debates about the ethics of this issue, but rather to show, once again, how this particular phenomenon can best be understood by grasping it as an instance of the creation of a specifically capitalist use-value through the subordination of the temporal rhythms and cycles of biota to the temporal logic of capital. As with broiler chickens, the present example of genetically modified (GM) crops as a specifically capitalist use-value comes from a highly monopolized industry: "In the space of roughly one year [2015-2016], the so-called 'Big Six' ag-biotech companies announced three mega-mergers…Collectively, these mergers will reduce farmer choice and will likely lead to higher prices for farmers and consumers, while producing less

[412] The German chemical and pharmaceutical giant Bayer, who purchased Monsanto in 2018 for $63 billion, had to pick up some of Monsanto's legal tab by paying "more than $10 billion to end tens of thousands of lawsuits filed over its Roundup weedkiller…The settlement also resolves many other cases over the herbicide dicamba as well as water contaminated with toxic chemicals called [Polychlorinated biphenyls or] PCBs" (Bill Chappell, "Bayer To Pay More Than $10 Billion To Resolve Cancer Lawsuits Over Weedkiller Roundup," *NPR*, June 24, 2020, https://www.npr.org/2020/06/24/882949098/bayer-to-pay-more-than-10-billion-to-resolve-roundup-cancer-lawsuits). Moreover, "Pesticides meant to accompany GMOs transfer through the food web, but so can transgenic toxins and other transgene products" (Friedman, "GMOs: Capitalism's Distortion of Biological Processes").

investment in innovation."[413] Several innovations in the monopolized agricultural biotechnology (ag-biotech) industry present interesting examples of the overcoming of natural seasonal temporalities in order to cohere with the expansive temporality of capital, whether increasing the pace of plant breeding practices or developing a cold resistant crop, the growth cycle of which is no longer necessarily strictly bound to a particular season, thus partially overcoming the cyclicality of the seasonal temporalities of growth.[414] However, one example in particular best represents the temporal subordination of nature to capital in crop agriculture: that is the "emerging technology for inducing sterility in seeds, which has popularly come to be known as terminator technology or genetic use restriction technologies (GURTs)," and is also commonly referred to, much more somberly, as 'suicide seeds.'[415]

As with livestock agriculture, it is important to account for the qualitative changes that have occurred in plant breeding practices since the real subsumption of modern science by capitalism at the beginning of the twentieth century, as these have given rise to an unprecedented rate of development and innovation in the ag-biotech industry. Traditionally "the development of new varieties was the result of informal innovation by farmers over several generations, [but] in the last 125 years this process has been greatly accelerated by scientific plant breeding" such that "this process of evolving new varieties is fundamentally

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[413] Rebecca Bratspies, "Owning All the Seeds: Consolidation and Control in Agbiotech," *Environmental Law* 47, no.3 (Summer 2017): 584-599. "First, in December 2015, Dow and DuPont announced a "merger of equals" combining the two United States-based chemical firms into a new $130 billion company. In February 2016 - less than two months later - Basel, Switzerland-based Syngenta announced that it had agreed to be purchased by the Chinese National Chemical Corporation (ChemChina) for $43 billion. Syngenta made the ChemChina agreement after fending off repeated purchase offers from Monsanto. Then, in mid-September 2016, Monsanto announced its own deal - the company had accepted a $66 billion merger proposal from Bayer" (Bratspies, "Owning All the Seeds," 584).

[414] See, for example, Gulzar S. Sanghera et al., "Engineering Cold Stress Tolerance in Crop Plants," *Current Genomics* 12, no. 1 (March 2011): 30-43.

[415] C.S. Srinivasan and Colin Thirtle, "Potential Economic Impacts of Terminator Technologies: Policy Implications for Developing Countries," *Environment and Development Economics* 8, no. 1 (February 2003): 187. The authors continue: terminator technology or GURT "has the potential to bring far-reaching changes in the seed industry and the organization of agriculture. Terminator technology alters a fundamental characteristic of seed - its self-reproducing nature - and threatens to change agricultural practices that have been the norm for centuries. Seldom does an innovation have the potential to alter a production process in such a fundamental way" (Srinivasan and Thirtle, "Potential Economic Impacts of Terminator Technologies," 187).

different from the farmer's process that relies on careful selection from randomly occurring mutations in nature."[416] The point here is not that traditional methods are superior, or that they are something we should practice exclusively, but rather it is simply about recognizing that capitalism, in accordance with its expansive temporality, has produced a highly accelerated rate of change in plant breeding by subjecting it to the accumulation imperative, and that this recent emergence of the for-profit ag-biotech industry is something to note and try to understand. At the forefront of this industry is the controversial agrochemical company Monsanto who, after their merger with German giant Bayer, control around a quarter of the seed and pesticide global market share.[417] Although the origin of the 'terminator technology' "can be traced to a patent granted jointly to the United States Department of Agriculture and the Delta & Pineland [sic] Company," because they finally successfully purchased the Delta & Pine Land Company in 2007 (after one attempt failed in the late-1990s on account of a rejection by antitrust regulators in the U.S. Department of Justice), Monsanto are now one of the most prominent developers of this technology.[418] In 1999, however, despite failing to

[416] Srinivasan and Thirtle, "Potential Economic Impacts of Terminator Technologies," 189.

[417] Lucía Fernández, "Monsanto - statistics & facts" *Statista*, Jul 6, 2021. https://www.statista.com/topics/2046/monsanto/#topicHeader__wrapper.

[418] Srinivasan and Thirtle, "Potential Economic Impacts of Terminator Technologies," 188. Regarding the origin of 'terminator technology,' one author writes: "From Monsanto's perspective, TT was developed out of necessity. Apparently the impetus for the creation and development of this novel technology was to ensure that plant breeders' intellectual property rights would actually be protected. The practice of patenting agricultural plants is nothing new and has been available since 1930." (Keith Bustos, "Sowing the Seeds of Reason in the Field of the Terminator Debate," *Journal of Business Ethics* 77, no. 1, Ethical Issues in the Biotechnology Industry (January 2008): 68). In this, we can see that the origins of the technology itself are explicable only in light of specific capitalist private property relations which emerged concurrently with capital's real subsumption of science, according to which biotechnologically altered organisms can be patented as private property through the claim over intellectual property rights. On a somewhat tangential note, justifying the practice of asserting private property rights over biotechnologically altered organisms through patents by the claim that the patenting of agricultural crops is "nothing new" because it is a practice that has "been available since 1930" shows, by regarding socio-economic practices that originated less than 100 years ago to be "nothing new," or in other words are taken as 'time-tested,' when considered against the scale of the history of human society, a bizarrely narrow and fairly shallow view of the lengths of time involved in this history. This historical short-sightedness is 'nothing new' in the ideological defenders of capitalism who aim in their pronouncements to conform with capital in "the way [it] effaces the traces of its own prehistory (and the existence of modes of production that preceded it), just as surely it extinguishes the immediate traces of production from the object produced" (Jameson, *Representing Capital*, 105). The extremely narrow view of history expressed in this revealing albeit innocuous remark betrays the author's own narrow view of history as merely the history of capitalism, and thereby contributes to the effacement of history that is generally promulgated by capitalist ideology. To see

purchase the initial patentors, Monsanto developed the technology on their own and yet, after completing "a six-month review of the technology," then-CEO of the company, Robert Shapiro, "announced the decision not to market the sterile-crop seeds" yet admitted that "Monsanto will continue research internally."[419] While it may be the case that the technology has not yet ever been brought to market (in large part due to the critical and important work of activists and scholars like Vandana Shiva in raising public awareness and campaigning against its use[420]), developments in gene-editing technologies such as CRISPR-Cas9 which improve the accuracy and efficiency of the gene-editing process, have spurred something of a resurgence of this possibility.[421] Regardless, the very fact that the technology exists *tout court* affords another example of capital temporally subsuming nature.

Commentators have pointed out that, in the pursuit of surplus value, "Monsanto is relying on a strategy similar to the one it tapped to dominate the world of commodity crops: *Use technology to speed up the breeding process*."[422] In the world of 'big-ag' business, the pressures exerted by the dictates of the temporal logic of capital mean that the process of carefully selecting and preserving certain traits in crops over generations, as with traditional

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precisely this narrow ideological view of history raised to its highest degree and purest form, we need only recall the (now infamous) pronouncements of Francis Fukuyama: "The triumph of the West, of the Western idea, is evident first of all in the total exhaustion of viable systematic alternatives to Western liberalism…we may be witnessing…the end point of mankind's ideological evolution and the universalization of Western liberal democracy as the final form of human government." (Francis Fukuyama, "The End of History?" *The National Interest* 16 (Summer 1989): 1). Of course, the multipolar world which seems to be emerging in the present moment contests this view.

[419] Eric Niiler, "Terminator Technology Temporarily Terminated," *Nature Biotechnology* 17, (November 1999): 1054.

[420] "Activists and development campaigners raised the alarm over the possibility that 'terminator' sterile seed technology could be used to prevent Third World farmers from saving seeds and make them more dependent on biotechnology and seed companies" (Dominic Glover, "Monsanto and Smallholder Farmers: A Case Study in CSR," *Third World Quarterly* 28, no. 4, Beyond Corporate Social Responsibility? Business, Poverty and Social Justice (2007): 855-6). Specifically regarding Vandana Shiva's work on this issue, see Michael Specter, "Seeds of Doubt: An Activist's Controversial Crusade Against Genetically Modified Crops," *The New Yorker*, August 18, 2014, https://www.newyorker.com/magazine/2014/08/25/seeds-of-doubt.

[421] As a journalist has recently noted, "A major player in the development of Crispr crops is the agricultural giant Monsanto" (Bertille Duthoit, "The Five: Genetically Modified Fruit," The Guardian, January 13, 2019, https://www.theguardian.com/science/2019/jan/13/the-five-genetically-modified-fruit-edited-bananas-tomatoes).

[422] P.J. Huffstutter, "Sprouting a New Line of Produce Seeds," *The Los Angeles Times*, October 20, 2011. https://www.latimes.com/archives/la-xpm-2011-oct-20-la-fi-monsanto-vegetables-20111020-story.html. Emphasis is my own.

methods of plant breeding, must be vastly accelerated. In the early 2010s, then-vice president of Monsanto's global vegetable group, Consuelo Madere, stated as much, remarking that "Such [biotech] techniques speed up the conventional breeding process."[423] Thus, the temporality of the evolutionary process of commodity-crops, even when directed and altered by human-driven practices like selective breeding of plants over generations, is subdued and accelerated by the incisive temporal control capital exerts through biotechnological processes such as transgenic plant breeding. Monsanto's business model, it can be said, relies at least in part on *intentionally producing temporal-ecological rifts*; that is, in being able to biotechnologically subordinate the natural temporalities of specific organisms to those dictated by the temporal logic of capital. In the case of the 'terminator technology,' however, we find the principle of biotechnologically intervening incisively in the temporality of the natural life-cycle of plants raised to an extreme. The 'terminator technology' "involves engineering seed in such a way that the seed is programmed to produce a plant that produces sterile seed," thus definitively interrupting by calling to a halt the temporal cycle of the natural, seasonal reproduction of the crop by restricting the plant's life-cycle to only one iteration of plant, rather than several different generational iterations.[424] Although Monsanto maintain the development of 'terminator technologies' is in line with their mission of 'feeding the world,' experts have pointed out that "Unlike genetically modified varieties that offer agronomic benefits to farmers, terminator technology offers only economic benefits to seed companies," and so it is clear that the development of this technology is another case of the production of a specifically capitalist use-value achieved via the subordination of the bio-temporality of crop reproduction cycles to the temporality of capital.[425] From the following,

[423] Huffstutter, "Sprouting a New Line of Produce Seeds."
[424] Bustos, "Sowing the Seeds of Reason in the Field of the Terminator Debate," 66.
[425] Srinivasan and Thirtle, "Potential Economic Impacts of Terminator Technologies," 189.

we can see that the GM crop with transgenic 'terminator technology' is produced as a specifically capitalist use-value in two ways:

> *From the economic point of view, the most important implication of this technology is that farmers cannot save seeds from their crops: they have to buy fresh seeds from the seed companies every year.* The technology is relevant only for self- or open-pollinated varieties, since for hybrids, farmers generally buy seed every year because of the loss in yield (owing to the loss of hybrid vigour) when second generation seeds (F2) are used. Thus, there is no incentive for seed companies to put terminator technology into hybrid varieties, as *there is already a mechanism to ensure repeat purchases of seed by farmers*. However, a review of the terminator literature shows that the development of the technology is not oriented only toward seed sterility. *The same technology can be used to switch on or off specific traits in the seeds of a variety. Particular traits can be rendered dormant and may be expressed only when the seeds are used in conjunction with proprietary chemicals. Thus, the technology opens up new possibilities for companies to bundle together seeds and other inputs.*[426]

Firstly, and straightforwardly, by subordinating the temporality of the life-cycle of the commodity-crop to the temporality of capital, the specifically capitalist use-value is produced by creating a situation that demands repetitive seasonal/annual purchases. In this way, vis-a-vis the incisive temporal control of the commodity-crop, the capitalist corporation controls and therefore ensures the temporality of market relations (i.e., the frequency of recurrence of exchange) between seed company and farmer which, in the context of monopoly capital, ensures at least the maintenance of the company's market share. Secondly, as noted in the quote above, the other possible uses of this technology, should it eventually be brought to market, mean that it is highly likely that it will be 'bundled' with other commodities (specifically, those patented by the seed company, as with, for instance, Monsanto's patent of plant genes which are resistant to the herbicide 'Roundup' and its patent of the herbicide 'Roundup') required to 'activate' the technology. In temporally subsuming the form of a commodity so as to create a specifically capitalist use-value, that is a commodity the "primary 'usefulness' [of which is]...the exchange value [it generates] for corporations," it logically

[426] Srinivasan and Thirtle, "Potential Economic Impacts of Terminator Technologies," 188-9.

follows from capital's accumulation imperative that restricting the use of said commodity so that it is only utilizable in conjunction with (perhaps several) other commodities (i.e. agricultural inputs) patented and sold by the same company would represent nothing more than a prudent logical (i.e. economic) decision.[427] The incisive temporal control which capital increasingly exerts over specific parts of nature as a function of its process of capitalization of nature enables the extension of monopoly over the agriculture industry by making possible strategies of potential value extraction such as the 'bundling' of agricultural inputs as commodities. From an ecological perspective, however, for-profit "genetic modification has led to undesired and potentially disruptive consequences for biological and ecological processes" which will only be augmented and compounded as capital advances its value-expanding method of incisive temporal domination over nature.

3.3 Old Growth and Tree Farms

The final example of capital's temporal domination of nature that I wish to address moves our discussion from an analysis of capitalist crop agriculture and biotechnologically produced temporal rifts, to the case of logging old growth forests, and the industrial tree farming strategy employed by the timber/lumber industry. In this example, as we shall see, capital is not deploying incisive temporal control over the life-cycle of specific organisms as a strategy for real subsumption, as in the above examples, but is instead imposing a form of complete temporal subsumption over ecosystems with compositional, functional, and structural features of old growth. To be able to grasp the temporal-ecological implications of this issue we must come to an understanding of, firstly, what old growth is (e.g., how old exactly is 'old'?) and the ecological implications of this type of forest/ecosystem and, secondly, the origins and effects of contemporary industrial tree farming practices.

[427] Foster, "The Ecology of Marxian Political Economy."

In silvicultural discourse, the definition 'old growth' forests, and even whether we can consider a forest in its entirety, rather than only a stand[428], to constitute 'old growth' are the subjects of continuing debate. The main reason for this debate is that, due to the rich variety of forest types around the world and their different compositional, functional, and structural features, the "development of a general definition of old-growth forest based on ecology is difficult."[429] The fact is that "Old growth varies in form from place to place as well as over time."[430] In light of the difficulty of a *general* definition, the "USDA Forest Service," for example, "has gone to great lengths to define old-growth characteristics for all forest types in the western, eastern and southern regions of the United States."[431] To take one definition as an example, in the 1986 United States Department of Agriculture (USDA) report on "Interim Definitions for Old-Growth Douglas-Fir and Mixed-Conifer Forests in the Pacific Northwest and California," the 'Old-Growth Definition Task Group' states that while for the "Douglas-fir forests of the Northwest, maturation typically occurs at 80 to 110 years," transition "from the mature to old-growth stage is gradual and not usually ap-parent in Douglas-fir stands until they are 175 to 200 years old."[432] The report adds that stands of Douglas-fir on Western Hemlock sites at 200 to "250 years of age" can be considered "'young' old-growth stands" whereas "Stands in which trees exceed 700 years are sometimes distinguished as 'super old

[428] A 'stand' is a "recognizable area of a forest that is relatively similar in species composition or physical characteristics and can be managed as a single unit. Stands are the basic management units of a forest" (David Mercker, *A Glossary of Common Forestry Terms*, Tennessee: Institute of Agriculture, University of Tennessee, 13).
[429] K.B.H Er and J.L Innes, "The Presence of Old-Growth Characteristics as a Criterion For Identifying Temperate Forests of High Conservation Value," *The International Forestry Review* 5, no. 1 (March 2003): 2.
[430] Glenn Patrick Juday, "Old Growth Forests: A Necessary Element of Multiple Use and Sustained Yield National Forest Management," *Environmental Law* 8, no. 2, A Symposium On Federal Lands Forest Policy (Winter 1978): 499.
[431] Er and Innes, "The Presence of Old-Growth Characteristics as a Criterion For Identifying Temperate Forests of High Conservation Value," 2.
[432] United States Department of Agriculture, Forest Service Old-Growth Definition Task Group, *Interim Definitions for Old-Growth Douglas-Fir and Mixed-Conifer Forests in the Pacific Northwest and California*, July 1986, 1, https://www.fs.fed.us/pnw/pubs/pnw_rn447.pdf.

growth.'"[433] Some recent estimations more conservatively report that "For Douglas-fir forests, the definition of old growth ranges from 150 to 200 years."[434] In general, then, when dealing with old growth stands, we are typically considering trees that are hundreds of years old, and sometimes in more extreme cases even several hundreds of years old.[435]

When we consider old growth stands as part of the broader ecosystem of a forest, we find that they are "more than collections of old growth species at a given place," that afford many ecosystemic benefits. Because "All species are tied together in a web of interrelationships," processes such as "energy production and storage, mortality, reproduction, nutrient cycling, and decomposition can only be fully understood from the perspective of the organisms involved and their places in the whole ecosystem."[436] "Decades of research [on old growth] in the Pacific Northwest" from an ecosystems perspective has "documented the many values of old-growth forests, including their importance as wildlife habitat, regulation of hydrologic processes, sequestration of carbon, and maintenance of soil and nutrient processes."[437] Some even argue that, due to the natural debris dams they produce, which contributes to bank stability in streams and rivers, "old growth watersheds produce the highest quality water for human consumption."[438] But one major (yet contested) advantage of old growth stands, particularly in a warming world, is their ability to sequester carbon from the atmosphere and store it in their "live woody tissues and slowly decomposing organic matter in litter and soil."[439] Recent research into the ecological impacts of old growth has contested the

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[433] United States Department of Agriculture, *Interim Definitions for Old-Growth*, 4.

[434] James R. Strittholt, Dominick A. Dellasala and Hong Jiang, "Status of Mature and Old-Growth Forests in the Pacific Northwest," *Conservation Biology* 20, no. 2 (April 2006): 364.

[435] An early classification (1978) by forest ecologist Glenn Patrick Juday attests to this and specifies the following general stages of old growth: early old growth, 200-400 years; middle old growth, 400-600 years, and extreme old growth, 600+ years (Juday, "Old Growth Forests," 500).

[436] Juday, "Old Growth Forests," 505.

[437] Strittholt, "Status of Mature and Old-Growth Forests in the Pacific Northwest," 364.

[438] Juday, "Old Growth Forests," 504.

[439] Sebastiaan Luyssaert, et al., "Old-Growth Forests As Global Carbon Sinks," *Nature* 455 (September 11, 2008): 213.

general belief that old growth stands are carbon sources rather than carbon sinks.[440] One group of international researchers has shown that "Old-growth forests accumulate carbon for centuries and contain large quantities of it,"[441] while noting that they "expect, however, that much of this carbon, even soil carbon, will move back to the atmosphere if these forests are disturbed."[442] On this basis, they argue that "carbon-accounting rules for forests should give credit for leaving old-growth forest intact."[443] This proposition forms a stark contrast to the recent recommendations of national forest management strategies in the U.S. which "Until recently…generally tried to harvest old growth as early as possible and replace it with younger, rapidly growing stands, thereby maximizing wood yields."[444]

In the centuries since the colonization of the U.S. by capitalist European nations, old growth stands have been gradually and continually decreasing. As many forest ecologists point out, "Since the time of European settlement [i.e. brutal imperial conquest and colonization], approximately 72% of the original old-growth conifer forest has been lost, largely through logging and other developments,"[445] and as such "It is likely that the early settlers [i.e. colonizers] found the larger trees relatively more abundant and a slightly higher mean size for all old growth tracts than ours today, since nearly all the best sites have been cleared, cut or burned for some years."[446] The drastic changes in the ecological conditions of

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[440] It "is generally thought that ageing forests cease to accumulate carbon" (Luyssaert, et al., "Old-Growth Forests As Global Carbon Sinks," 213). Some environmental activist groups, such as the 'Ancient Forest Alliance' in Canada's British Columbia region (a region geographically contiguous with the Pacific Northwest in the U.S.), assert that this belief emanates from "the timber industry's PR-spin" (Ancient Forest Alliance, "Myths & Facts," Accessed August 26, 2018, https://ancientforestalliance.org/learn-more/myths-facts/).

[441] "On the basis of our analysis, we expect that these forests [i.e., half of the unmanaged primary forest in Northern Hemisphere, or 15% of the global forest area] alone sequester at least 1.3 ± 0.5 gigatonnes of carbon per year." They add: "Hence, 15% of the global forest surface, which is currently not being considered for offsetting increasing atmosphericCO2concentrations, is responsible for at least 10% of the global NEP" (Luyssaert, et al., "Old-Growth Forests As Global Carbon Sinks," 213, 215).

[442] Luyssaert, et al., "Old-Growth Forests As Global Carbon Sinks," 213.

[443] Luyssaert, et al., "Old-Growth Forests As Global Carbon Sinks," 215.

[444] Juday, "Old Growth Forests," 498.

[445] Strittholt, "Status of Mature and Old-Growth Forests in the Pacific Northwest," 363.

[446] Juday, "Old Growth Forests," 500.

these stands, forests, and the larger ecosystems they participate in by the vast reduction of old growth "because of agricultural development, urbanization, and industrial-scale logging" can be understood as another form of "colonial ecological violence," which has been an integral driver of capitalist expansion both spatially, in terms of the geographical expansion of colonizers Westward across the continent, and economically, in terms of the value of the resources extracted via the logging of old growth.[447] Before the introduction of the Northwest Forest Plan in the U.S. in 1994, a federally produced guide on forest management, "logging on both private and federal lands had reduced old-growth forests substantially and would have eliminated most old growth within about four decades outside national parks, wilderness, and remote areas," however the plan is reported to have "dramatically reduced (~80%) the amount of logging on federal lands through a combination of reserves and management."[448] Despite the positive ecological outcome of protecting remaining old growth beginning in 1994 in the Northwest of the U.S., the reduction of old growth which had already taken place throughout previous centuries cleared the way for the expansion of industrial 'tree farms' to satisfy economic interests.

In the second quarter of the twentieth century, the private timber/lumber industry was facing two intersecting crises: (1) the "gradual ending of the era of logging virgin forests making it essential and profitable to grow trees" and (2) "the trend toward public ownership" of land and resources.[449] The response of the industry, which had to simultaneously assure the public that the timber/lumber industry was responsible and could be trusted to ensure forest productivity while materially ensuring the profitability of the industry for its private owners and investors, was the tree farm. As one defender of the move would write:

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[447] Strittholt, "Status of Mature and Old-Growth Forests in the Pacific Northwest," 364; Bacon, "Settler Colonialism as Eco-Social Structure and the Production of Colonial Ecological Violence," 64.
[448] Strittholt, "Status of Mature and Old-Growth Forests in the Pacific Northwest," 365.
[449] J. Granville Jensen, "Tree Farming in The Douglas Fir Region: An Evaluation," *Yearbook of the Association of Pacific Coast Geographers* 17 (1955): 21, 25.

> The immediate forerunner of the tree farm movement was article ten of the NRA lumber code of 1933, written by the industry and pledging its members to leave seed sources on cut-over land. At that time large areas were reverting to public ownership through tax delinquency, and there was a rising tide of sentiment and active forces moving toward public ownership as the only way to assure forest production for the future. *The tree farm movement is the answer of private industry to the threat of increased regulation and public ownership of forest land. It is a remarkably successful effort of private forest owners not only to establish intensified forest management practices in their own self interest,* but also to inform the public of their acceptance of responsibility for resource stewardship.[450]

At the time, those in the industry were indeed very well aware of the situation, as we see above, and recognized their plight as a purely economic one in which their interests had to be defended both through successful public relations work and the intensification of the timber/lumber industry business model. "Just as in every other facet of the American private enterprise system," an industry representative wrote, "forestry is a business in which intensified management practices are applied when it pays."[451] The industrial tree farm was therefore to be the specific form that 'intensified management practices' would take under the 'stewardship' of private interests in the timber/lumber industry. Pursuing and developing this form of management practice was certainly not an effort undertaken in the interests of either the long-term productive capacities of human society or the well-being of nature and health of ecosystems, but rather in order to maintain control over a highly profitable industry by countering the advancing forces of nationalization and conservation (the latter by the likes of Gifford Pinchot who was the '1st Chief of the United States Forest Service' between 1905-1910), while expanding the productivity of this industry in order to drive up the production of surplus value: "an industry organization wishing to assure an ample and continuous source of timber must own and manage forest land sufficient to supply a reasonable share of their

[450] Jensen, "Tree Farming in The Douglas Fir Region: An Evaluation," 25. Emphasis is my own.
[451] Jensen, "Tree Farming in The Douglas Fir Region: An Evaluation," 25.

requirement."[452] A tree farm is simply "land that has been dedicated to continuous commercial production of forest commodities" and are typically monocultures, and because of this are commonly referred to as 'plantation forests.' The 'tree farm movement' in the U.S. only "began in 1941," but by 1942 in Washington and Oregon alone there were "16 tree farms, including nearly two million acres," and then, by 1955, after a widespread uptake and dramatic expansion of these 'intensified management practices' in the timber/lumber industry, there were "185 tree farms" which covered "nearly 4 ½ million acres."[453] More recently, scholars have reported "a global trend of increasing forest plantations to relieve the pressure of deforestation and degradation of natural forests, in addition to meet demands of timber products and forest services."[454]

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[452] Jensen, "Tree Farming in The Douglas Fir Region: An Evaluation," 25. Further, Jensen provides a quote which appeared in a forestry magazine at the end of the 19th century which mirrors his perspective: "In April, 1898, the following appeared in the magazine "Forester." 'Forests will be managed properly and reproduced when it pays to do so, and love of trees and zeal for the beautiful will have as little to do in this business of wood cropping, as love for the waving field and the beauty of the tasseled corn is the incentive to the farmer to plow and sow.' The success of the tree farm movement is evidence that that day has come!" (Jensen, "Tree Farming in The Douglas Fir Region: An Evaluation," 25-6). Compare this with the (in)famous passage from Adam Smith regarding the foundations of capitalism as an economic systematization of self-interestedness: "It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their own self-interest. We address ourselves not to their humanity but to their self-love, and never talk to them of our own necessities, but of their advantages" (Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations* (Oxford: Oxford university Press, 1993), 22).

[453] Jensen, "Tree Farming in The Douglas Fir Region: An Evaluation," 23. "The term 'Tree Farm' was first used [in 1941] to include 120,000 acres, just south of Elma in Western Washington, about half of it belonging to the Weyerhaeuser Timber Company." (Jensen, "Tree Farming in The Douglas Fir Region: An Evaluation," 23). The Weyerhaeuser company website confirms that "In 1941 Weyerhaeuser continued to demonstrate its industry leadership by establishing the nation's first certified Tree Farm on 200,000 acres of harvested and fire-burned land in Washington State. This launched the American Tree Farm movement, which by the end of the century would cover 95 million acres and include more than 70,000 members in 50 states" (Weyerhaeuser Company, "History. Since 1900," Accessed May 1, 2022, https://www.weyerhaeuser.com/company/history/#23). As of 2015, *Forbes* estimated the net worth of the Weyerhaeuser family to be $1.7 billion and wrote that "Gilded age era timber baron Frederick Weyerhaeuser was one of the richest Americans to have ever lived. The German immigrant bought a bankrupt mill with his brother-in-law. He then went on a purchasing spree buying up timber around the country; he once acquired 900,000 acres of forest for $6 an acre from a railroad pioneer. Now the company, Weyerhaeuser, owns 7 million acres across America, though the family is no longer directly involved" (Forbes, "Profile: Weyerhaeuser Family," 2015 America's Richest Families, accessed May 1, 2022, https://www.forbes.com/profile/weyerhaeuser/?sh=51bce61535ec). The tree farm model, evidently, has been very economically successful.

[454] Corsa Lok Ching Liu, Oleksandra Kuchma, Konstantin V. Krutovsky, "Mixed-species versus monocultures in plantation forestry: Development, benefits, ecosystem services and perspectives for the future," *Global Ecology and Conservation* 15 (July 2018): 8.

Ecologically considered, monocultural tree farms have very different implications than natural forests, particularly those with old growth. Yet, before comparing the ecological effects of old growth stands with commodity tree farms, the ecological disadvantages of the latter can be observed by comparing them with young forests of a natural origin: "young forests originating from natural disturbance typically have much higher levels of structural complexity (e.g., snags and downed logs) and species richness than young forests managed for timber production."[455] In general, the ecological effects of monocultural tree farms include "the loss of soil productivity and fertility, disruption of hydrological cycles, risks associated with plantation forestry practices (e.g., introduction of exotic species), risks of promoting pests and diseases, higher risks of adverse effects of storms and fire, and negative impacts on biodiversity."[456] The lack of biodiversity in monocultural tree farms has led some scholars to describe them as "biological deserts," even yielding "poor habitat for native birds."[457] Further, upon fulfilling their function as a supply of timber/lumber, the fact that these trees are often harvested by machine "can promote soil compaction, which will adversely affect the growth of understory."[458] Perhaps most concerning in our warming world, however, is the fact that "young forests rather than old-growth forests are very often conspicuous sources of CO2," thus challenging the idea that simply planting trees in abundance will lead to the sequestration of carbon from the atmosphere (which is very often the PR spin given by the timber/lumber industry in support of tree farms, which often covers over related harms caused by monocultures, such as damaging biodiversity).[459] Ultimately, though, these negative

[455] Strittholt, "Status of Mature and Old-Growth Forests in the Pacific Northwest," 364.
[456] Liu, Kuchma, Krutovsky, "Mixed-species versus monocultures in plantation forestry," 4-5.
[457] Liu, Kuchma, Krutovsky, "Mixed-species versus monocultures in plantation forestry," 5.
[458] Liu, Kuchma, Krutovsky, "Mixed-species versus monocultures in plantation forestry," 5.
[459] This issue, increasingly gaining recognition, is now being reported on in popular media: "Amid that worsening crisis, companies and countries are increasingly investing in tree planting that carpets large areas with commercial, nonnative species in the name of fighting climate change…But when done poorly, the projects can worsen the very problems they were meant to solve. Planting the wrong trees in the wrong place can actually reduce biodiversity, speeding extinctions and making ecosystems far less resilient." (Einhorn, Catrin,

ecological impacts are to be expected, since "uniform rows of monoculture plantations are completely opposite to diversity."[460]

Historically considered, as we have seen, monocultural tree farms were fundamentally an economic strategy deployed by the timber/lumber industry to increase productivity, yet it is important to clarify exactly how this strategy was expected to work. By developing monocultural tree farms, "the goal was to simplify the structure [of the forest] and *speed up the cycles of natural ecosystems, together with producing large amount of wood* [sic] *within the shortest time*."[461] Clearly, then, to understand this form of production we must consider the dictates of the temporal logic of capital, to which monocultural tree farms precisely correspond by accelerating the pace of production to 'fix' the shortages of timber/lumber caused by capitalist expansion in the first place, and therefore by expanding the extraction of surplus value. However, more than this, the replacement of old growth by monoculture tree farms represents the creation of a 'specifically capitalist use-value' achieved by completely subordinating the ecosystemic temporality of old growth trees and stands to the temporal logic of capital embodied in the commodity-trees produced by a tree farm. In contrast to the *incisive temporal control* capital exerts over the life-cycles of specific organisms, in this example we find a case of *complete temporal subsumption* whereby capital simply replaces the organisms that do not correspond to its temporal logic (i.e., old growth stands and trees) with organisms which do (i.e., monocultural tree farms). Although this example involves a slightly different strategy for the reconfiguration of nature in the interests of capital, the phenomenon of tree farming can also be considered a temporal-ecological rift because the outcome of propagating this form of commodity production, which also entails the

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"Tree Planting Is Booming. Here's How That Could Help, or Harm, the Planet," *The New York Times*, March 14, 2022, https://www.nytimes.com/2022/03/14/climate/tree-planting-reforestation-climate.html).

[460] Liu, Kuchma, Krutovsky, "Mixed-species versus monocultures in plantation forestry," 5.

[461] Liu, Kuchma, Krutovsky, "Mixed-species versus monocultures in plantation forestry," 4.

subordination of natural temporalities to capitalist temporality, is no less ecologically damaging than the examples of incisive temporal control. In fact, the negative ecological implications and effects of this form of commodity cultivation, as discussed above, greatly harm and jeopardize the very conditions of life upon which humanity depends. In other words, "Research by various authors have criticised single-species monocultural plantations as supposedly having several negative social and environmental impacts in spite of the recognised economic benefits."[462] Once again, therefore, we find that capitalism turns to a temporal-ecological 'fix' which enables the expanded reproduction of the system in the short-term, but which in the long-run deepens the general metabolic rift which the system has produced. Given the short-termism of capital's restricted systemic temporal horizon, however, this is only to be expected. In a darkly ironic twist, the rift to which tree farms may most damagingly contribute to is that of soil fertility, as research has shown that "Under intensive management of stands *for repeated short rotations*, all nitrogen contributors are eliminated."[463] In light of this newly expanded form of capital's original soil fertility crisis, while it is unlikely that capital will resume guano imperialism, it may be the case that the palliative of industrially produced fertilizer may be utilized once again as a 'fix' for this rift, thus reproducing on an expanded scale all the negative ecological consequences of this 'fix.'

The replacement of old growth by tree farms, that is, the complete temporal subsumption of old growth stands which are several hundreds of years old by the temporality of specifically capitalist use-value of very young commodity trees on tree farms, is, in a warming world, an ecological catastrophe. An activist group dedicated to the protection of old growth explain clearly why this is the case:

> Old-growth forests on BC's [British Columbia's] coast store about twice the carbon per hectare as the ensuing second-growth tree plantations that they are

[462] Liu, Kuchma, Krutovsky, "Mixed-species versus monocultures in plantation forestry," 4.
[463] Juday, "Old Growth Forests," 505-6. Emphasis is my own.

> being replaced with – logging them releases vast amounts of carbon that would take 200 years to re-sequester, but only if forests were allowed to grow that long (which they don't under the 50 to 80 year rotation age on BC's coast).
>
> Replanting does not adequately replicate an old-growth forest ecosystem. Second-growth or replanted forests lack many of the important features of old-growth forests. The trees are all the same age, so there are few gaps in the canopy to let light through and allow a rich understory to grow – in old-growth forests, the multi-layered canopy of differently aged trees allows sunlight through, creating a rich, luxuriant understory that provides food and habitat for many species. It would take a long time, at least 200 years, for replanted stands to regain important old-growth characteristics, but because the rotations are about 55 years on Crown lands on BC's coast and as low as 30 years on private lands these second-growth stands will never regain these characteristics.[464]

The point made here that old growth serve as carbon sinks while replacement forests and monocultural tree farms function as carbon sources has also been made by international academic research groups who show that "old-growth forest stands with tree losses do not necessarily become carbon sources, as has been observed in even-aged plantations (that is, where trees are all of the same age)," i.e. in monoculture tree farms.[465] These activists show, through their detailed knowledge of the workings of the timber/lumber industry in British Columbia, that not only does the temporal logic of capital produces a hastening of the rotation cycle of growth-harvest-replanting of the specific trees in questions, but that it produces an immense acceleration of this process, sometimes allowing trees as little of a quarter (50 years) of the growing time it takes to develop the ecological characteristics of old growth (at least 200 years), and sometimes (on private land) less than a sixth of this time (30 years). For the temporal logic of capital and the demands of the accumulation imperative, then, nature is simply too slow, too ponderous, and when specific organisms cannot be sped up sufficiently to match the dictates of its temporal logic, capital will, when possible, find ways to replace these organisms with others that do conform to this logic. Undoubtedly, this strategy is eminently economically logical according to the dictates of the temporal logic of capital, and

[464] Ancient Forest Alliance, "Myths & Facts."
[465] Luyssaert, et al., "Old-Growth Forests As Global Carbon Sinks," 214.

serves to ensure capital's expansion, yet at the same time, as I have shown, serves to deepen and compound the broader metabolic rift produced by the system.

4. Ecological Acceleration: Capitalism's Alienated Socio-Metabolic Temporality

The problem we face, as I have stated above and which I hope to have explicated to some degree through the discussions of the three preceding examples, is not that humans must appropriate and use nature for survival through social production. In fact, we know that to live "we are completely dependent on the forces of nature and on natural resources," and that the true nature of the problem is "only the way capitalism makes use of them."[466] In the era of monopoly capitalism, with its capability for the production of specifically capitalist use-values in the wake of capitalism's "third agricultural revolution," which, we should recall, involved "the concentration of animals in massive feedlots, coupled with the genetic alteration of plants (producing narrower monocultures) and the more intensive use of chemical inputs - such as fertilizers and pesticides," capital, it appears, is undertaking a violent project of temporally distorting nature by subsuming the tempos, rhythms, and cycles of certain organisms in order to meet the needs of its own temporal logic and accumulation imperative.[467]

Scholars interested in questions and issues of time and temporality have recently been focusing on phenomenon, and their implications and consequences, such as the process of "social acceleration,"[468] the "'bad' speed of neoliberalism,"[469] and the "loss of a proper [subjective] sense of time"[470] in modern society, and while these phenomena certainly merit our critical attention, in a rapidly warming world, with its multifaceted general problem of

[466] Pannekoek, "The Destruction of Nature."
[467] Foster, *Marx's Ecology*, 148-149.
[468] Rosa, "Social Acceleration."
[469] Robert Hassan, *Empires of Speed: Time and Acceleration of Politics and Society* (Leiden: Brill Academic Publishers, 2011),188.
[470] Gault, "In and Out of Time," 150.

time, it is also of the utmost importance that we critically attend to capitalism's socio-metabolic temporality, and the developing process of *ecological acceleration*. This process is the product of a complex matrix of dominating and exploitative social relations, the temporal logic and conjoined alienated temporality of capital, and the crisis of an ever-deepening Metabolic Rift, but is also due to the fact that capitalist "agriculture no longer finds the natural conditions of its own production within itself, naturally arisen, spontaneous, and ready to hand."[471] In order to continue to reproduce itself on an expanded scale, capitalist agriculture must mold nature in its image through, I contend, the analogous strategies of incisive temporal domination and complete temporal subsumption. This project is possible, on one level, due to the mechanistic worldview of capitalist ideology wherein nature is regarded as thoroughly "law-abiding, docile, and predictable"; as a machine which capital can temporally re-engineer for its own accumulative purposes.[472] Just as capital must accelerate the production process in accordance with its expansive temporality to meet the demands of its accumulation imperative, which it does by temporally disciplining workers[473] and developing accelerative technology, in order to maintain its expansion, it now must also accelerate natural processes, which it does through incisive temporal control and complete temporal subsumption of specific organisms and ecosystems. The very conditions of

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[471] Marx, *Grundrisse*, 527.

[472] Prigogine and Stengers, *Order Out of Chaos*, 63. For a brief but insightful note on the extent of predictability imputed to Newton's universe by some of his followers, see Chapter 2, footnote 79 on Laplace's calculator.

[473] The temporal disciplining of workers, i.e., the acceleration of the production process by hastening the pace at which labor is performed, is first brought to its highest level, that of scientific management, in Frederick Taylor's *Scientific Management*. Taylor, who argued in 1911 that "Underworking, that is, deliberately working slowly so as to avoid doing a full day's work…constitutes the greatest evil with which the working-people of both England and America are now afflicted," sought to make every worker labor at their "best speed" by application of his principles of 'scientific management' (Frederick Winslow Taylor, *The Principles of Scientific Management* (New York: Harper & Brother Publishes, 1919), 13-4.) His guide to the application of the new, scientific form of management stipulates that "The *management* must supply continually one or more teachers to show each new man the new and simpler motions, and the slower men must be constantly watched and helped until they have risen to their proper speed. All of those who, after proper teaching, either will not or cannot work in accordance with the new methods and at the higher speed must be discharged by the *management*" (Taylor, *The Principles of Scientific Management*, 83). What is 'proper' about the 'proper speed,' of course, is that it coheres with the temporal logic of capital.

capitalist agricultural production, then, as Marx had already recognized in the 19th century, must be actively produced through "an independent industry separate from" agriculture, which is to say that "agriculture itself rests on scientific activities…it requires machinery, chemical fertilizer acquired through exchange, seeds from distant countries etc."[474]

The real subsumption of science by industrial capital in the early twentieth century, partly due to the inefficiency and insufficiency of guano imperialism, partly due to the crisis of imperialism culminating in WWI and WWII, and partly due to capital's necessity to exponentially increase the magnitude of the infinite circulation of capital, has enabled capital to overcome some of its more originary temporal-ecological rifts (e.g., the soil fertility crisis). Progress in science has made new strategies and methods for short-term 'fixes' available to capital, evidenced by the proliferation of instances of ecological acceleration as a technique by which capital can bring nature into line with its temporal logic and accumulation imperative. Yet, as we have seen, with each instance of temporal acceleration which enables capitalism's expansion - whether in broiler chickens, GMO crops, or industrial tree farms - a temporal-ecological rift emerges, with all the harmful environmental consequences that this entails - whether the genetic weakening of the broiler chicken species, the breeding of seeds which produce foodstuffs only once and the intensification of the use of dangerous herbicides, or the decimation of biodiversity and production of carbon by monocultural tree farms. In sum, then, in order to turn the temporal boundaries imposed upon accumulation by nature in the form of particular life-cycles, rhythms, and tempos, into mere barriers, capital has produced certain temporal-ecological rifts, which, although coherent with its temporal logic, have contributed to the expanded reproduction of the general Metabolic Rift on a much deeper level.

[474] Marx, *Grundrisse*, 527.

The socio-temporal hegemony of capitalism's expansive temporality contributes to the domination and destruction of nature through its alienated regulation of socio-metabolic interchange with nature by subsuming concrete ecological and social temporalities to this form of time (i.e., abstract, mechanical clock-time; the time of economic growth). This situation, especially when considered in the context of a warming world, indicates the necessity of politically redressing the conditions and social relations that give rise to deepening temporal-ecological crises by radically changing the temporal logic and temporality of our socio-economic system and, synchronously, the metabolic temporality produced by this socio-economic system. Despite the ominous conditions under which this practical task must take place, we should be encouraged by the fact that "Comparisons between different spatio-temporal frameworks can illuminate problems of political choice," and as such consideration of capital's temporal-ecological rifts can guide us in efforts to identify and develop political alternatives.[475] Critical consideration and analysis of the temporal-ecological rifts and contradictions of our present capitalist society brings us to questions of "a 'politics of time'," that is to say, a conception "of all politics as centrally involving struggles over the experience of time," and, as is therefore implied, struggles over the social organization and coordination of time in all areas of society.[476] In the warming world, with its complex, nonlinear "diachronic...discordant...inchoate" temporalities of socio-ecological crises driven by socio-economic crises, the most important struggle is that over our socio-metabolic temporality because it is this which determines the ways in which our society interpenetrates and interacts with nature. Thus, it is this struggle, as part of a broader struggle for environmental justice, that will determine whether our society continues to be ecologically reckless and destructive, producing crises wherever it appropriates and (now,

[475] David Harvey, *Spaces of Global Capitalism: Towards a Theory of Uneven Geographical Development* (New York: Verso, 2006), 123.
[476] Peter Osborne, *The Politics of Time: Modernity and Avant-Garde* (New York: Verso, 1995), 200.

incisively temporally) operates on nature, or whether it is to be transformed into one ecologically rational, promoting socio-metabolic well-being, balance, and health through a radically different form of socio-metabolic temporality.[477] In this struggle, on the side of theory, which cannot be separated from our practical actions lest we are to tragically condemn both to failure in the face of the gravest challenge our species has yet known, we must begin by examining our theories of ecological transition. This brings us to an analysis of our foremost theories of Political Ecology, which, firstly, must critically account for the socio-metabolic temporality of our present capitalist society; secondly, must present their own temporal position and perspective; and, thirdly, given that we have shown it in the preceding analysis to be fundamentally anti-ecological with no possibility of redress, must not adhere to or cohere with the temporal logic of capital.

[477] Malm, *The Progress of this Storm*, 11.

CHAPTER VI

POLITICAL ECOLOGY, TEMPORALITY, AND TRANSITION: A CRITIQUE OF ECOLOGICAL MODERNIZATION THEORY

1. Politics and Time: The Temporal Logic of Transition

Facing global anthropogenic climate collapse means that Marx's 19th century prognostication - that capitalism destroys the two original sources of all wealth: labor and nature - is on the brink of being fulfilled. Although this may have taken longer than Marx might have expected given capitalism's dynamism and fluidity in responding to its various crises, as the preceding discussion has shown, it presently seems increasingly likely that capitalism's self-maintenance has set human society cascading irreversibly into a 'Hothouse Earth' scenario.[478] As such, the theorization of transition, until recently a mainly economic project taken seriously only by those who recognized the necessity of transitioning out of capitalism for many non-ecological reasons, has now become a major part of mainstream academia and has been 'ecologized' primarily on the basis of our novel scientific understanding of the limits and ecological boundaries of the Earth System and its various sub-systems and ecosystems. How we are to escape the present existential predicament is a multi-faceted question many scholars, scientists, and experts are currently concerned with - and rightfully so given the socio-existential importance of the question. Renewed focus on the question of transition has given fresh impetus to the discipline of Political Ecology, a field of study concerned with questions regarding the interconnections of social and ecological systems as mediated by political forces and formations and social relations.

Where once the central focus of Political Ecology was the development of strategies for "incremental environmental governance," the insufficiency of this approach for coping with problems as urgent and grave as climate collapse and biodiversity loss has meant that,

[478] Steffen et al., "Trajectories of the Earth System in the Anthropocene."

within the discipline, a "quest for a 'societal transformations [sic] towards sustainability' or even for a 'Great Transformation' [has] emerged as a guiding theme."[479] Thus, Political Ecology has undergone a form of temporal reckoning, as the time-line of gradual, incremental change comes to be increasingly regarded as ill-suited for contending with problems of such immediacy and urgency. The question of ecological transition is, of course, highly complex, because it concerns all aspects of society and nature, and their dialectical relations, and urgent because the window of time available for effective remedial action is rapidly drawing to a close. In the following, I will undertake a critical analysis of the temporal logic and transitional temporality of Ecological Modernization Theory (hereafter EMT), currently the most politically and socially influential strain of Political Ecology, in order to show why this perspective is both theoretically and practically insufficient for genuine ecological transition.

The importance and relevance of an assessment of the temporal logic and temporality of transition - or what I will call the temporal-theoretical and temporal-practical - stem primarily from the fact that the time-perspective from which "the present is viewed is of considerable importance in determining the questions we ask and the actions we take."[480] In other words, when theoretically and strategically considering an ecological transition, the questions we ask and actions we take to address climate collapse are, and will continue to be, fundamentally construed upon and structured by our understanding of the temporality of society, of nature, and of our socio-metabolism. This puts enormous emphasis on the importance of recognizing the role of the systemic temporality (and therefore also, necessarily, the temporal logic) of our current capitalist socio-economic system in temporally

[479] Christoph Görg, Ulrich Brand, Helmut Haberl, Diana Hummel, Thomas Jahn and Stefan Liehr, "Challenges for Social-Ecological Transformations: Contributions from Social and Political Ecology," *Sustainability* 9, no. 7 (June 2017): 1. This

[480] George W. Wallis, "Chronopolitics: The Impact of Time Perspectives on the Dynamics of Change," *Social Forces* 49, no. 1 (1970): 105.

structuring our socio-metabolism. On the theoretical level, this has been well recognized by scholars such as Kolinjivadi et al., who argue that "any political strategy to respond to socio-ecological crises through fetishized representations of time will continue to deny the emergent and continual transformations of socionatures, further reinforce human–nature dualisms and perpetuate dynamics of deadening and extinction."[481] The necessity of a temporal analysis of theories and strategies for transition, therefore, arises from the fact that Political Ecological theories which are developed on the basis of, in deference to, or without seeking to break from abstract, alienated capitalist temporality, will perpetuate a mechanistic and reified understanding of capitalist socio-metabolic temporality, and will thus fail to grasp the dialectical complexity and emergentism that must inform any social or political response to climate collapse, ecological crises, and the metabolic rift. Incorporating a *critical* analysis of the socio-metabolic temporality of capitalism is, I contend, integral to the development of a transition strategy that is to hold any promise of successfully responding to and countering the metabolic rift. In the following, then, I will present a critical analysis of EMT by way of an exegesis of the theoretical content and review of the temporality of the practical strategies for ecological transition developed by this perspective, and by critiquing the temporal logic upon which this theory of transition is constructed.

2. Ecological Modernization Theory: A Brief Overview

Ecological Modernization Theory, commonly referred to as ecomodernism or ecomodernization, although encompassing a range of positions, has in recent decades coalesced into an "identifiable school of thought" which, in general, approaches and analyzes the environment and the climate crises from a predominantly techno-institutional reformist perspective.[482] EMT first emerged within the field of Environmental Sociology[483] during the

[481] Kolinjivadi, Almeida, and Martineau, "Can the planet be saved in Time?" 906.
[482] F.H. Buttel, "Ecological Modernization as Social Theory," *Geoforum* 31, no. 1 (February 2000): 58.

early 1980s, partly in response to the incipient academic and public awareness of pollution and the possibility of resource exhaustion in light of the Club of Rome's *Limits to Growth* report, and, as we shall see in more detail below, partly in response to certain trends that had developed in Environmental Sociology in the 1970s.[484] Originally gaining traction in the industrial core of Western Europe, EMT is prominent at the political level in many European countries "notably Germany, the Netherlands and the United Kingdom," and is closely associated with the work of "Social scientists such as Martin Janicke, Volker von Prittwitz, Udo Simonis and Klaus Zimmermann (Germany), Gert Spaargaren, Maarten Hajer and Arthur P.J. Mol (the Netherlands) and Albert Weale, Maurie Cohen and Joseph Murphy (UK)," and now, in the US, with Ted Nordhaus, Michael Shellenberger, Erle Ellis, Ruth Defries, and others, many of whom are associated with the Breakthrough Institute.[485] Extending out of the academy, EMT has garnered substantial political influence in advanced capitalist nations by engaging in "professional lobbyism" and by developing "relationships

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[483] Environmental Sociology itself emerged as a recognized and accepted field of study only after the work of William R. Catton Jr. and Riley E. Dunlap in the 1970s through which they sought to recast the paradigmatic theoretical grounds of sociology as a discipline (which they trace to the Durkheimian theory of sociology which holds that only social facts can explain social facts). Catton and Dunlap argued that the discipline of sociology should adapt by departing from what they called the Human Exceptionalism Paradigm (HEP) because this paradigm neglected "the ecosystem-dependence of human society...in sociological literature and economic development…[and had] simply not recognized biogeochemical limits to material progress." Instead, they argued for a move towards the New Environmental Paradigm (NEP) which highlighted that "the reality of ecological constraints posed serious problems for human societies *and* for the discipline of sociology," and thus broadened the scope of sociological inquiry to include "the study of interaction between the environment and society" (R.E. Dunlap and W.R. Catton, "Environmental Sociology," *Annual Review of Sociology* 5, no. 1 (1979): 244).

[484] Arthur P.J. Mol, and Gert Spaargaren, "Ecological Modernisation Theory in Debate: A Review," *Environmental Politics* 9, no. 1 (2000). See also: Arthur P.J. Mol, Gert Spaargaren, and David A. Sonnenfeld, "Ecological Modernization Theory: Taking Stock, Moving Forward," in *Handbook of Environmental Sociology*, eds. Lockie, S., D.A. Sonnenfeld, and D. Fisher (London: Routledge): 15-30.

[485] Arthur P.J. Mol and David A. Sonnenfeld, "Ecological modernisation around the world: An introduction," *Environmental Politics* 9, no.1 (2000): 4. While I will draw on literature from a range of ecomodernist scholars in this analysis, I will pay particular attention to the US based authors given my geographical proximity and the fact that their work, often being more recent than European based ecomodernists, has not yet received sufficient critical attention.

with policymakers," rather than attempting, as other strains of Political Ecology have done, to build "grassroots radicalism."[486]

Although it has undergone a number of challenges and developments in the period between its theoretical inception in the 20th century and its maturation as a prominent policy-shaping political force in the 21st, EMT first appeared, according to two of its leading theorists, Arthur Mol and Gert Spaargaren, as a reaction against the dominant theoretical perspectives at the early stages of the development of Environmental Sociology. On this point, Mol and Spaargaren note that EMT "can only be understood by taking into account the debate from which it originates," and explain that the trends in this debate to which EMT sought to provide an alternative can be collectively described as theories of "demodernisation, deindustrialisation or counter-productivity," principally represented by "neo-Marxists" in Environmental Sociology.[487] Accordingly, EMT was developed in order to theoretically and practically diverge from the "overall critical and pessimistic outlook" of the range of 'counter-productivity' theories, and thus defined itself in contradistinction to the rest of the field.[488] For Mol and Spaargaren, the crux of the distinction between EMT and environmental sociology - and the broader "environmental debate" of the 1970s and 1980s, dominated as it then was by 'counter-productivists' theorists and activists - centered around one principal difference. While the range of 'counter-productivists' accepted the

> traditional idea that a fundamental reorganisation of the core institutions of modern society (the industrial production system, the capitalist organisation of the economy and the centralised state) was essential in entering a path of long-term sustainable development

[486] Mol, Spaargaren, and Sonnenfeld, "Ecological Modernization Theory: Taking Stock, Moving Forward," 16-17.
[487] Mol and Spaargaren, "Ecological Modernisation Theory in Debate," 19. These terms stand-in for a very broad range of theories and perspectives in environmental sociology including steady-state, deep ecological, ecosocialist and ecomarxist (metabolic rift) theory, and degrowth theories.
[488] Mol, Spaargaren, and Sonnenfeld, "Ecological Modernization Theory: Taking Stock, Moving Forward," 16.

EMT rejected this position,[489] instead taking what can be fairly described as a much less radical approach by focusing on the *reform* of currently existing social forms, relations, and institutions and technologies as the correct strategy for contending with our current ecological crises. For EMT, "Institutional restructuring, technological innovation, market forces, the efforts of new social movements (NSM), and government regulation," more than anything else can bring about an ecologically sustainable society.[490]

On both the theoretical and practical level, EMT pursues the improvement of the ecological standards, that is to say the 'greening,' of the present society, including its methods of production, distribution, and consumption, technologies, and institutions. In response to the environmental problems brought about by industrial capitalist modernization, EMT "argues that further modernization can solve those problems."[491] Indeed, a defining feature of EMT over the course of its development has been its "unflappable sense of technological optimism."[492] The range of possible technological solutions (which will be a central focus of this analysis) invoked by ecomodernists is broad, including everything from "urbanization, agricultural intensification, nuclear power, aquaculture, and desalination,"[493]

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[489] Mol and Spaargaren, "Ecological Modernisation Theory in Debate," 19.

[490] Richard York, Eugene A. Rosa, and Thomas Dietz, "Footprints on the Earth: The Environmental Consequences of Modernity," *American Sociological Review* 68, no. 2 (April 2003): 285.

[491] York, Rosa, and Dietz, "Footprints on the Earth: The Environmental Consequences of Modernity," 285. We should recall, from Chapter 5, that the capitalist solution to the temporal-ecological rifts produced by capital's production and social division of space was extended spatial expansion. The solution was, therefore, an expanded form of the activity which was the initial cause of the problem. In the case of EMT, the answer to the ecological problems caused by capitalist modernization (i.e., industrialization) is extended capitalist modernization, albeit in a slightly modified, 'greened' form. Thus, we might identify here a trend of sorts in which, from the perspective of capitalist ideology which is, of course, incapable of offering systemic alternatives, the solution to problems wrought by the operations of capitalism is to expand, increase, or continue the operations of capitalism. Formally, there is nothing necessarily illogical about this, but in terms of content, it might strike us as a peculiar way of addressing problems.

[492] John Hannigan, "Contemporary theoretical approaches to environmental sociology," in *Environmental Sociology*, second edition (London: Routledge, 2006), 26.

[493] John Asafu-Adjaye, Linus Blomqvist, Stewart Brand, Barry Brook, Ruth DeFries, Erle Ellis, Christopher Foreman, David Keith, Martin Lewis, Mark Lynas, Ted Nordhaus, Roger Pielke, Jr., Rachel Pritzker, Joyashree Roy, Mark Sagoff, Michael Shellenberger, Robert Stone, and Peter Teague, *An Ecomodernist Manifesto* (Breakthrough Institute, 2015), www.ecomodernism.org/, 18.
It should be noted that *An Ecomodernist Manifesto* is not a peer-reviewed, academic publication. That being said, the eighteen authors/signatories of the *Manifesto* include eleven academics currently working at prestigious

to planetary geoengineering and carbon capture and storage technologies, and from novel green-technologies driven by "ecopreneurialism,"[494] to "the introduction of different motors and of entirely new propulsion systems in vehicles."[495] With regard to institutional reforms, EMT is interested in "the kind of institutional reform that is required to correct the design fault of modernity in its interaction with the sustenance base."[496] For EMT, then, the process of modernization, which capitalism initiates and carries out, must now, by correcting its 'design faults,' advance into its next stage: that is, the 'greening' stage, whereby "nation-states and industrial firms come to recognize the importance of environmental sustainability to their long-term survival" and adapt their activities and institutions accordingly.[497] The concept of ecological modernization, therefore, is "a variant of the idea of progress" which has perennially animated capitalist ideology, and is posited and supported on the grounds of a stadial view of historical development which 'progresses' through a three-stage process: "(a) industrial takeoff, (b) the construction of industrial societies, and (c) an ecological transition to a new phase of superindustrialization."[498] EMT is, ultimately then, a theory of environmental reform of the present society in the following sense:

> While there are some differences across theorists, the key assumption of the modernization perspective is that global environmental problems can be solved

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universities across the world, including the likes of Harvard, Stanford, Cornell, Columbia, Maryland, Queensland, Jadavpur, and Tasmania University. Suffice it to say, while the document should *not* be taken or treated as an academically rigorous, peer-reviewed publication might, neither should it be taken as a frippery contrivance, or even dismissed as unimportant, because the views expressed therein are the publicly presented views of some of the world's leading ecomodernist academics. For this reason, the *Manifesto* will be presented in conjunction with the peer-reviewed work of various ecomodernists, as though the rigor of each kind of publication may differ, there is continuity of perspective and authorship between them.

[494] See, for example: David Gibbs, "Sustainability Entrepreneurs, Ecopreneurs and the Development of a Sustainable Economy," *Greener Management International*, no. 55 (Autumn 2006).

[495] Joseph Huber, "Ecological Modernization: Beyond Scarcity and Bureaucracy," in *The Ecological Modernisation Reader: Environmental Reform in Theory and Practice*, ed. Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren (London: Routledge, 2009), 44.

[496] Gert Spaargaren and A.P.J. Mol, "Sociology, Environment, and Modernity: Ecological Modernization as a Theory of Social Change," in *The Ecological Modernisation Reader: Environmental Reform in Theory and Practice*, ed. Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren (London: Routledge, 2009), 63-4.

[497] York, Rosa, and Dietz, "Footprints on the Earth: The Environmental Consequences of Modernity," 285.

[498] Paul McLaughlin, "Ecological Modernization in Evolutionary Perspective," *Organization & Environment* 25, no. 2 (June 2012): 179-180.

> through existing and/or slightly modified social, political, and economic institutions, without renouncing economic growth, capitalism, and globalization.[499]

For these reasons, EMT, on the politico-economic level, "does not aim for a fundamentally different organization of the (capitalist) economy," and therefore, at the strategic level, "ecological modernisationists do not put revolutionary system change as an alternative on the agenda."[500] Contrary to the radical social, political, and economic transformations often prescribed by 'counter-productivist' theories, the "agenda for state and market change within ecological modernisation theory does not move beyond a modern market economy and a modern welfare state. In that sense, ecological modernisation theory remains with the paradigm of modernity."[501]

The prescriptions and strategies of EMT are situated squarely within the bounds of capitalist society, albeit while counseling reform of its institutions and technologies. In developing these reform-based prescriptions, "ecological modernization praises and builds on a neo-liberal ideology and market-based solutions to the environmental problems" and, further, "embraces a utilitarian and orthodox economic theory of consumption and rational, individual decision-makers."[502] This should be unsurprising since the politico-economic fidelity to capitalism explicitly expressed by the foremost ecological modernization theorists, in order to maintain theoretical consistency, implies fidelity to the theoretical premises of capitalist political economy. In adhering to the tenets of orthodox capitalist political economic theory, then, EMT is grounded in "a specific temporal orientation, which treats

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[499] York, Rosa, and Dietz, "Footprints on the Earth: The Environmental Consequences of Modernity," 285.
[500] Mol, Arthur P.J., and Martin Jänicke, "The Origins and Theoretical Foundations of Ecological Modernisation Theory," in *The Ecological Modernisation Reader: Environmental Reform in Theory and Practice*, ed. Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren (London: Routledge, 2009), 19.
[501] Mol and Jänicke, "The Origins and Theoretical Foundations of Ecological Modernisation Theory," 21.
[502] Mikko Jalas, "The Temporal Orientations of Ecological Modernization and Sustainable Consumption," Proceedings, *Sustainable Consumption: The Contribution of Research* no. 1, ed. Hertwich, Edgar, Tania Briceno, Patrick Hofstetter, and Atsushi Inaba, (Trondheim: Norwegian University of Science and Technology, Program for Industriell Økologi, 2005): 310.

time as an abstract commodity."[503] Given these commitments, both in general political outlook and specific grounding in political economic theory, I argue that EMT broadly *affirms a theoretical and practical coherence with the temporal logic of capital and capitalist temporality,* and therefore to the theorization and conceptualization of socio-ecological change grounded in capital's alienated temporal logic and the mechanistic, abstract, reified clock-time of the capital system.[504]

The ecologized restatement of the 'idea of progress' found in EMT is still, after all, progress brought about by and through the economic growth and development of capitalism, progress which, according to EMT's view of historical development, can only begin in the process of industrialization before developing into 'superindustrialization.' Indeed, EMT's variant of the idea of progress itself posits "progress under modernization [as] linear and fairly continuous,"[505] and is therefore an ideological derivative of the "continuous and progressive temporality, the time of the expanding capital."[506] Since the temporality of capital is continuous (as we saw in Chapter 3), the *progress* that is taken to accompany the perpetual cycle of the movement of capital is also said to be continuous and linear, and in this way the 'idea of progress' functions, in a circular manner, as an ideological buttress for the continuous temporality of capital, that is, the 'idea of progress' presents an ideological defense of the socio-temporality from which it is initially springs. Theoretically and practically, EMT aligns itself with capitalist temporality by maintaining that the continued function of capitalism on the basis of its temporal logic, and the 'progress' this inevitably delivers, will prevent human society from experiencing serious ecological obstacles or even

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[503] Jalas, "The Temporal Orientations of Ecological Modernization and Sustainable Consumption," 310.
[504] To deny this, especially given the ways in which EMT's leading proponents have positioned the theory both in its infancy and maturation, would be to deny any logical consistency between the theoretical perspective and the social, political, and economic prescriptions and applications of EMT.
[505] Patrick Trent Greiner, "Time, Power and Environmental Impact," *Human Ecology Review* 25, no.1 (2019): 47.
[506] Stahel, "Time Contradictions of Capitalism," 101.

catastrophe. In this sense then, while some EM theorists will diverge from the first component of the economistic ideology of the bourgeois/neoclassical political economists which they draw on[507] (i.e., 'the cause of climate change could be anything but capitalism') by their acceptance of the fact that capitalism has contributed to or caused global warming,[508] they certainly concur with the second component of this ideology: 'the solution to climate change cannot be anything but capitalism.' For these reasons, EMT has been described as "a prominent neoliberal theory" which seeks to maintain capitalism by improving the ecological standards of its existing institutions and technologies.[509] In other words, EMT is a theory of green capitalism.[510]

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[507] In one instance, there is a noteworthy *familial* connection between neoclassical political economy and EMT. As "one of the first of the very few Neoclassical economists to work on climate change," the political economist William Nordhaus, a doctoral student of Robert Solow, was from the early 1990s "in the position to both frame the debate, and to play the role of gate-keeper" (Keen, "The appallingly bad neoclassical economics of climate change," 2, 21). His 'appallingly bad' economic work on climate change "can be characterized as 'making up numbers to support a pre-existing belief': specifically, that climate change could have only a trivial impact upon the economy," and he has therefore been accused, should climate change turn out to be as catastrophic as many scientists now claim, of complicity in "causing the greatest crisis, not merely in the history of capitalism, but potentially in the history of life on Earth" (Keen, "The appallingly bad neoclassical economics of climate change," 22). William Nordhaus's brother, Robert, was appointed by Bill Clinton as the first General Counsel of the Federal Energy Regulatory Commission, and Robert Nordhaus' son, William's nephew, is leading ecological modernist, co-author of the *Ecomodernist Manifesto*, and founder of the EMT championing Breakthrough Institute, Ted Nordhaus. However, the extent to which Ted has been influenced by his father and uncle on issues economic and ecological is, of course, a matter of mere speculation.

[508] In some cases, however, a defense of capitalism against charges of complicity in ecological destruction is mounted by an analytical sleight-of-hand which historically dissociates capitalism and industrialism, casting them as separate phenomena, as in the following passages: "We deal here with the debate about whether capitalism or industrialism is the major factor behind the environmental crisis" and "The rather straightforward Marxist analysis used by Schnaiberg has come under attack within sociology from two different perspectives, which have in common their belief that the *industrial* rather than the *capitalist* character of modern society is the more important factor in explaining the environmental crisis." Instead, the authors "prefer to treat industrialism and capitalism as two of the four institutional dimensions or organizational clusters of modernity that can be separated analytically" (Spaargaren and Mol, "Sociology, Environment, and Modernity: Ecological Modernization as a Theory of Social Change," 60-70).

[509] Richard York and Eugene A. Rosa, "Key Challenges to Ecological Modernization Theory," *Organization & Environment* 16, no. 3 (September 2003): 273. See also Brian Coffey and Greg Marston, "How Neoliberalism and Ecological Modernization Shaped Environmental Policy in Australia," *Journal of Environmental Policy & Planning* 15, no. 2 (January 2013).

[510] Although it is uncommon for EM theorists to *explicitly* refer to themselves as 'pro-capitalism' (they are, rather, 'pro-modernity'), this politico-economic allegiance is subtly revealed in the implications of certain statements of leading EM theorists. For example, on the one hand, Mol and Spaargaren note in the abstract that while "mainstream ecological modernisation theorists interpret capitalism neither as an essential precondition for, nor as the key obstruction to, stringent or radical environmental reform," they concurrently claim, on the other hand, in a more practical register, that capitalism *is* necessary for environmental reform because, for them, "all major, fundamental alternatives to the present economic order [of neoliberal capitalism] have proved

3. Ecological Modernization Theory and the Temporal-Theoretical: The Temporal Logic of Ecological Modernization Theory

The techno-institutional reforms proposed by EMT as the central strategy for addressing climate collapse and ecological crises are formulated according to, or in coherence with, a certain form of socio-temporality. Given that the prescriptions and strategies of EMT are situated within the systemic parameters of capitalism and do not look to move beyond this system, the temporal logic and socio-temporality they cohere with and conform to are, necessarily, the temporal logic of capital and capitalist temporality. There are two levels on which the temporal logic of EMT must be assessed: the first, the temporal-theoretical, which, as we have seen, refers to EMT's endeavor to provide a theoretical account of the ecological reform of capitalist society - an account which must necessarily cohere with the temporal logic of capital (lest the reforms endanger the functioning and perpetuation of the capital system[511]); and the second, the temporal-practical, which refers, more empirically, to the temporal practicality or feasibility of the prescriptions and strategies, which, in order for EMT to maintain consistency of theory and praxis, necessarily proceed according to the dictates of the temporal logic of capital. In analyzing the temporal-theoretical, I will predominantly focus on EMT's theoretical advocacy of 'green'/'greened' technologies because this aspect of the theory, which also best exemplifies EMT's Prometheanism, most clearly reveals its operative temporal logic. In this regard, EMT aims at overcoming

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unfeasible according to various (economic, environmental, and social) criteria" (Mol and Spaargaren, "Ecological Modernisation Theory in Debate: A Review," 22-23). Thus, we see that EMT is committed to the project of 'greening' capitalism because, at least in its mainstream form, it does not accept the possibility of achieving an ecologically sustainable society through an alternative economic system or social arrangement. EMT is necessarily, therefore, a theory of green capitalism.

[511] EMT, committed as it is to modernization through economic growth, is incapable, for example, of prescribing ecological strategies oriented around de-growth because this contradicts the temporal logic and accumulation imperative of capitalism. Indeed, this is why EM theorists disparagingly label anyone who questions or opposes the necessity of economic growth and the 'progress' it delivers a 'counter-productivist.' Given the socio-cultural meaning, connotations, and importance of the terms 'productive' and 'productivity' in advanced capitalist countries, the use of the term 'counter-productivist' is heavily ideologically loaded and as such is quite clearly intended to dismiss a range of perspectives on the ecological crises and transition through a particular synthesis of straw-man and ad hominem.

ecological crises by ecologically reforming the technologies utilized in production processes (i.e., the means of production) by the process of *decoupling*, or, we might say, by *extricating* production from the limits of nature through ecological technological reforms. In critiquing the temporal-practical I will focus on some of EMT's specific strategic plans and prescriptions, such as continued modernization and the possibility of implementing carbon capture and storage technologies to counter climate collapse, which are problematic precisely because of the temporal logic these techno-promethean solutions are grounded in, and which practically give rise to unworkable timeframes of implementation in relation to the urgency of the crises we are collectively facing.

The fundamental premise of EMT's conceptualization of the relation between human society and nature, and therefore of the relation between socio-temporality and the temporalities of nature, is stated in the beginning in the *Ecomodernist Manifesto*: "we [ecomodernists] reject another [long-standing environmental ideal], that human societies must harmonize with nature to avoid economic and ecological collapse."[512] Considered in terms of temporality, this proposition expresses two points: first, a recognition of the autonomous existence of the temporal rhythms and cycles of nature, and second, a denial that these natural temporalities function as boundaries that limit human productive activity and the processes of economic growth. Negating the need to 'harmonize' human social production with the limits and boundaries of nature here implies that, for EMT, social production is not necessarily *limited* by these boundaries, and instead expresses the idea that

[512] Asafu-Adjaye et al., *An Ecomodernist Manifesto*, 6. There are two possible valences to this sentence, the difference arising through the degree of Promethean aspiration that we are willing to ascribe to EMT, however only the interpretation given above fits with the theory's overall socio-ecological aims. A less plausible, but possible, interpretation of this statement is that we can use technology and modernization processes to stave off *complete* economic and ecological collapse, or even human extinction. This secondary interpretation, however, does not imply that human beings will experience the high and (hyper-) modernized quality of life that EMT is committed to - that is, the "good Anthropocene" the *Manifesto* calls for (Asafu-Adjaye et al., *An Ecomodernist Manifesto*, 1). This secondary interpretation, then, although semantically possible, does not fit with the overall outlook of EMT, which is clearly aiming at an eco-techno utopia, not an eco-techno dystopia.

a dissonant relation between social production and nature need not be damaging or harmful for society and can in fact be ecologically rational. In other words, society, according to the perspective of EMT, can overcome and transcend (primarily through technological innovation and, as we shall see in more detail below, the process of 'decoupling') the limitations and planetary boundaries of the Earth System that scientists have been warning, for the last couple of decades, have already been already grossly overstepped.[513] Temporally, this statement implies that the antagonistic contradiction between the alienated, abstract socio-temporality of capitalism (the socio-economic system EMT situates itself within) and the multiplicitous, interconnected temporalities of nature's rhythms and cycles need not necessarily drive or contribute to environmental degradation and ecological crises.

The temporal logic of EMT, like that of capital, by ridding capitalist social production (and therefore also capitalist accumulation) of any objective external limitation or boundary, such as those found in nature, is self-referential. For EMT, human productive activity, being determined by the temporal logic and socio-temporality of capital, with the right technological and institutional reforms, is able to transcend the limitations imposed upon it by the finitude of natural resources and planetary boundaries. In this way, then, the temporal logic of EMT, especially in the context of the relation of social and natural temporalities, *mirrors* quite exactly the temporal logic of capital in that neither recognizes, much less abides by, any external relations or constraints in nature. However, this mirroring is not merely coincidental, but rather discloses the *coherence of the temporal logic of EMT with the temporal logic of capital* - a feature of EM confirmed by its status as a theory of green capitalism that "does not aim for a fundamentally different organization of the (capitalist)

[513] "The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded" (Rockström, et al., "A safe operating space for humanity," 472).

economy."[514] In fact, this mirroring indicates in a certain way the *convergence* of the temporal logic of EMT and that of capital, since to posit an alternative temporal logic and socio-temporality would be, in essence, to posit a fundamental reorganization of the capitalist economy. If not an outright convergence of temporal logics, we find at the very least that the temporal logic of EMT operates *in deference to* the temporal logic of capital since this is necessary for the maintenance of the system and, moreover, the overt political aim of EMT is the ecologically rationalization of capitalism, rather than its fundamental transformation into another system.

3.1 The Ontological Separation of Nature and Society

If we accept that human society has a material basis,[515] which all earth and climate scientists do whenever they warn of the ecological implications of human (namely, productive) activity by referring to *anthropogenic* climate change (and which, publicly, in a rapidly warming world, and sociologically, after Catton and Dunlap's New Environmental Paradigm (NEP), is becoming increasingly difficult to deny), then we must ask why EMT holds that society need *not* harmonize with nature to avoid economic or ecological disruption; particularly because the fact of the material basis of human society necessarily refers to a relation of *dependence* of the social upon the natural. Yet, from the ecomodernist perspective:

> Despite frequent assertions starting in the 1970s of fundamental "limits to growth," there is still remarkably little evidence that human population and economic expansion will outstrip the capacity to grow food or procure critical material resources in the foreseeable future.

[514] Mol and Jänicke, "The Origins and Theoretical Foundations of Ecological Modernisation Theory," 19.

[515] That is, that production is the foundation of human society, and that production necessarily requires both human labor and material found in nature. In other words, "The materialist conception of history starts from the proposition that the production of the means to support human life and, next to production, the exchange of things produced, is the basis of all social structure; that in every society that has appeared in history, the manner in which wealth is distributed and society divided into classes or orders is dependent upon what is produced, how it is produced, and how the products are exchanged. From this point of view, the final causes of all social changes and political revolutions are to be sought, not in men's brains, not in men's better insights into eternal truth and justice, but in changes in the modes of production and exchange" (Friedrich Engels, "Socialism: Utopian and Scientific" in *The Marx-Engels Reader, Second Edition*, ed. Robert C. Tucker (New York: W.W. Norton & Company, 1978), 701).

> To the degree to which there are fixed physical boundaries to human consumption, they are so theoretical as to be functionally irrelevant.[516]

In fact, to claim that society and social production do not need to be made consistent with the planetary boundaries and limitations of nature is, albeit in a slightly different register, to hold that the social is *not* grounded in the natural, or that production is not necessarily dependent on nature.[517] Concretely, as we have seen above, "ecological modernization theory proposes that as industrial processes mature, ecological impacts may decrease dramatically as production systems are restructured along ecologically rational lines."[518] Theoretically, this position is expresses the "dematerialisation thesis," which has been described as "quintessential capitalism" because it is predicated on "the classic scientific substitution of mechanism for organism."[519] In this sense EMT's dematerialization perspective affirms, in a new guise, the mechanism of the Newtonian paradigm whereby humanity/society is separate and distinct from a mechanical nature - and therefore also affirms the abstract, mechanical temporality of this paradigm, i.e. the alienated temporality of capitalism. In the mechanistic paradigm in general, "[Humanity's] relation to [Nature] is not…an umbilical cord of mutual dependence; the known Nature is not an active mutually-dependent relation between [Humanity] and the rest of reality, but known Nature is Nature absolute and yet in contemplation."[520] While for the Newtonian paradigm, the contemplative physicist was conceived of as separate and distinct from the universe which they objectively observed, in

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[516] The claim that there is "little evidence" that humanity will "outstrip the capacity to grow food or procure critical material resources in the foreseeable future" raises the temporal question of what constitutes, for these ecomodernist authors, the "foreseeable future." Given that on the next page of the *Manifesto* we find the claim that "Human civilization can flourish for centuries and millennia on energy delivered from a closed uranium or thorium fuel cycle," it would appear that what constitutes the "foreseeable future" varies quite extensively for ecomodernists (Asafu-Adjaye et al., *An Ecomodernist Manifesto*, 9-10).

[517] This latter iteration - that production is not necessarily dependent on nature - is precisely the ontological perspective which undergirds EMT's calls for 'decoupling,' that is, the separation of economic growth from environmental impacts, because it posits the possibility of human social productive activity that does not entail harmful material consequences.

[518] York, Rosa, and Dietz, "Footprints on the Earth: The Environmental Consequences of Modernity," 285.

[519] Ariel Salleh, "Climate Strategy: Making the Choice Between Ecological Modernisation or Living Well," *Journal of Australian Political Economy* 66 (December 2010): 129.

[520] Caudwell, *The Crisis in Physics*, 45-7. (Quote edited to remove unnecessarily gendered language.)

EMT's contemporary form of mechanism, modernized humanity/the social is conceived of as *actively transcending* a nature from which it is becoming increasingly and consistently distinct, and nature is conceived of as "dead, merely a 'raw materials warehouse'," from which modernized humanity can continue to extract resources until total 'dematerialization' has been achieved - at which point humanity, ostensibly, will be completely independent of and from nature.[521] The subtle difference in the mechanism of Newtonianism and that of EMT, then, is that while in the former the distinction of the physicist and the universe is established in this framework from the beginning, in the latter the distinction between society and nature is being actively created - for EMT this happens through modern technology and 'innovation.' Note how exactly this perspective parallels the perspective of capital:

> Capital secretes fantasies about transcending the laws of matter and accumulating *in vacuo*. It projects an image of itself 'as a power springing forth from its own womb'; but some way or other – and the ecological crisis represents a myriad of routes – it is brought down to earth.[522]

Thus, we see that EMT's conception of the relation of society and nature (right at the historical moment when a rapidly warming world demands our most sophisticated understanding of this complex interrelation) actually expresses a *disrelation* or disjunction between the social and the natural - a disjunction being actively expanded by further modernization - and which gives ultimate precedence to the social *over* the natural or, we might say, to capital over nature (and labor).[523]

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[521] Salleh, "Climate Strategy: Making the Choice Between Ecological Modernisation or Living Well," 129.

[522] Andreas Malm and Wim Carton, "Seize the Means of Carbon Removal: The Political Economy of Direct Air Capture," *Historical Materialism* 29, no. 1 (March 2021): 25. Recall here, for example, Marx's comment that "Capital as such creates a specific surplus value because it cannot create an infinite one all at once," by which is meant that if capital *could* overcome its own entropic time-boundedness (i.e. the most basic form of being, or matter) in order to accumulate *in vacuo*, it undoubtedly would.

[523] Recall, from Chapter 2, that it is through capital's assumption of the role of the dominant subject [übergreifendes Subjekt] of social processes, brought about by the inversion of use- and exchange-value in the commodity form, that it is able to treat objective boundaries as mere barriers to be overcome. In a similar fashion, by adhering to the temporal logic of capital, which of course asserts capital as the dominant subject of social processes, EMT is able to deny the dependence of the social upon the natural and to posit between them a categorical distinction which frees human productive activity from the objective limitations and boundaries of nature.

The independence that EMT ascribes to the social through the dematerialization thesis - the privileging of the properties of the social as capable of transcending all limitations of the natural - is only logically possible, I argue, on the basis of a conception of the social and the natural as substantively distinct; only through this framework can the dependence of the social upon the natural be denied. In other words, for EMT, the relation between society and nature is an ontological dualism, whereby the categories are of different substances and therefore society, being essentially different in kind, is not necessarily dependent upon nature.[524] Such an ontological

> dualism is there whenever humans put it in their heads that they live in a region levitating somewhere above the biosphere, independent of it, free and able to bracket it off as an inferior order unrelated to theirs, except as a storehouse of resources they can use up in perpetuity.[525]

For EMT, then, the relation between nature and society is one of dualism and mechanism, rather than one of dialectical interchange and metabolism.[526] Here, society is actively diverging away from its dependence on nature, while at the same time extending its control over nature, much as an engineer controls a machine. Thus, nature is conceived of as a machine and, in order to counter ecological crises, EMT need only correct "the design fault of modernity in its interaction with the sustenance base" - we can see in this claim how society and nature are set against each other as two separate spheres which interact only when

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[524] Andreas Malm, among others, connects this "substance dualism…in conventional perceptions of society and nature" to the originary substance dualism of Western modern philosophy, that of mind and body in the "philosophy of Rene Descartes," (Malm, *The Progress of this Storm*, 50) a philosophical system, we should note, that was closely connected to mechanistic conception of the world, so much so that the "the Cartesian-Newtonian paradigm" is often "dubbed as 'Science I'" (Poe Yu-ze Wan, *Reframing the Social: Emergentist Systemism and Social Theory* (London: Routledge, 2011), 1). "Not so much a philosophical programme declared by avid preachers," Malm writes, "more a syndrome than a credo, this dualism is present in everything from neoclassical economics to climate change denial and sheer indifference to issues of ecology" (Malm, *The Progress of this Storm*, 53).

[525] Malm, *The Progress of this Storm*, 53.

[526] While we are without the requisite scope for a comprehensive discussion of the claim here, I contend that the mechanism reproduced in EMT may be partly related to its theoretical affinity with the mechanism of neoclassical Political Economy.

society (represented by modernity itself) accesses the 'storehouse' for sustenance.[527] The central problem for this mechanistic, substance-dualist ontological formulation, as is well-known in the history of Western philosophy from the many tribulations of Cartesianism, is "that of causal interaction."[528] By reproducing a mechanistic framework that substantively separates nature from modernized society, EMT (as we shall see in more detail below), renders itself incapable of accurately grasping the causes of climate collapse and other ecological crises - and thus, implicitly, is incapable of attending to these causal factors, and only able to treat symptoms. Moreover, and importantly for our purposes, in terms of temporality, the ontological precedence that EMT grants to the social over the natural diminishes any possibility of accurately conceptualizing the intersecting and interdependent relations of social and natural temporalities. Reflexively, however, this is not an issue for EMT because in a mechanistic framework which actively separates and elevates the social to the role of engineering the natural, only the socio-hegemonic temporality - i.e., the mechanistic, abstract, alienated time of capital - is important. Since the relationship between nature and society is not treated as one of dependence and instead the social is *absolutized,* grasping natural temporalities and their intersections with society carries little theoretical weight for EMT. While capitalist temporality abstracts away from concrete social and ecological temporalities by asserting itself as the temporality of the dominant subject

[527] Spaargaren and Mol, "Sociology, Environment, and Modernity: Ecological Modernization as a Theory of Social Change," 63-4.

[528] Malm, *The Progress of this Storm*, 52. Unsurprisingly then, EMT's promotion of further and accelerated 'modernization' to counter ecological crises is given without any attempt "to interrogate the concept of modernisation, to determine what it means and what it doesn't, to examine its problems as well as the benefits it delivers"; which is to say, further modernization is prescribed without consideration of whether what is recommend as the cure may in fact be the cause (George Monbiot, "Meet the ecomodernists: ignorant of history and paradoxically old-fashioned," *The Guardian*, September 24, 2015). As such, "For all its talk of 'the liberal principles of democracy, tolerance, and pluralism,' the ecomodernist agenda resonates with a long history of such proposals [for rural depopulation which have resulted not in a smooth transition to the formal urban economy, but in a highly precarious existence on the economic margins], from the enclosures in England and the Highland clearances in Scotland, the colonial seizures of land in Kenya and Rhodesia, the Soviet dispossessions and the villagisation in Ethiopia to the current theft of farmland in poor nations by sovereign wealth funds and the rich world's financiers" (Monbiot, "Meet the ecomodernists: ignorant of history and paradoxically old-fashioned").

(*übergreifendes Subjekt*) of social processes, by reproducing a form of the mechanistic framework upon which capitalist temporality is founded, EMT is only able to affirm and theoretically account for a form of abstract, mechanistic temporality, that is, alienated capitalist temporality. It is in this sense that we can say, now more conclusively, that EMT *affirms a theoretical and practical coherence with the temporal logic of capital and capitalist temporality*. In other words, by absolutizing the social over against the natural, EMT absolutizes the temporal logic of capital over against the complex, intersecting temporalities of nature and the metabolic temporality of socio-ecological material interchange. On the basis of this socio-temporal absolutization, EMT theoretically upholds the temporally "linear developments" of consistent and gradual (social and technological) 'progress,' rather than engaging in "a consideration of the interplay of change and persistence, critical developments, ruptures and discontinuities" in socio-politico-economic formations and their concomitant socio-ecological metabolic relations.[529]

By positing the (technologically-produced) possibility of the substantive ontological dualism of society and nature, EMT leaves itself in a state of causal confusion when it comes to understanding the origin(s) of climate collapse and ecological crises. Just as Descartes and his followers struggled to explain the relation and interaction of mind and body in his dualist ontological framework, EMT struggles to explain the relation and interaction of nature and society; for example, the *Manifesto* asks: "how is it possible that people are doing so much damage to natural systems without doing more harm to themselves?"[530] Incapable of truly identifying the source of (or even of recognizing a responsibility differential for) ecological crises, EMT reduces the complex problems involving factors such as the historical emergence

[529] Görg et al., "Challenges for Social-Ecological Transformations: Contributions from Social and Political Ecology," 14-5. Incidentally, it is for precisely this reason that EMT is conceptually hamstrung as to why intensive expansion of capitalism and the connected (bio-)engineering solutions it prescribes are, especially in the long-term, more ecologically destructive than beneficial.
[530] Asafu-Adjaye et al., *An Ecomodernist Manifesto*, 9.

and development of a now-global politico-economic system, processes such as imperialism and colonialism, and the serial production of intensifying economic and ecological crises (such as the soil fertility crisis of the late 19th century), to the simple fact of materiality, that is, the fact of the "continued dependence of humans on natural environments" *tout court.*[531] EMT thus attributes responsibility for environmental problems to those it judges to be dependent on nature, that is, those who "over-rely" on ecosystems: examples of which, in EMT's estimates, are "people who depend on firewood and charcoal for fuel [and who] cut down and degrade forests…[or] people who eat bush meat for food."[532] Here, quite clearly, 'dependence on ecosystems' is generally characterized by one's proximity to nature in terms of one's material-biological reproduction, rather than the material-energetic costs of one's consumption, such that the wealthy consumers of industrialized Europe who do not need to directly interact with nature to reproduce themselves because of the ways capital mediates this process are seemingly absolved of all blame, while the poor of the Global South are held directly culpable for climate collapse because they might happen to collect fallen branches from a forest in order to cook meals. In other words, on the basis of the ontological dualism of its conceptual framework, EMT mirrors certain tendencies found within neo-colonial political ecologies: "In the ideology of ecological modernisation, the poor are characterised as unsophisticated 'victims' and patronised as unwitting contributors to the environmental crisis."[533] Whether it be "a local indigenous community or a foreign corporation that benefits," for EMT "it is the continued dependence of humans on natural environments that is the problem," and therefore it is this dependency that must be transcended in order to

[531] Asafu-Adjaye et al., *An Ecomodernist Manifesto*, 17. As has been pointed out, "A word you won't find in the Ecomodernist Manifesto is inequality...There is no sense that processes of modernisation cause any poverty...There's nothing on uneven development, historical cores and peripheries, proletarianisation, colonial land appropriation and the implications of all this for social equality. The ecomodernist solution to poverty is simply more modernisation" (Smaje quoted in Monbiot, "Meet the ecomodernists: ignorant of history and paradoxically old-fashioned").

[532] Asafu-Adjaye et al., *An Ecomodernist Manifesto*, 17.

[533] Salleh, "Climate Strategy: Making the Choice Between Ecological Modernisation or Living Well," 136.

overcome generalized ecological crisis.[534] According to this view, British Petroleum (BP) is equally to blame for climate change as, say, a poor person in the Global South practicing subsistence farming because both activities (i.e. global extraction and exchange of carbon-laden fossil fuels for profit, and subsistence farming to materially reproduce oneself, family, and community) are similarly predicated on a dependency upon nature.[535]

For EMT, it is *technology* that has (substantively) 'freed' humans from our dependence upon nature and therefore from the need to align ('harmonize') our productive activities with the limits and boundaries of natural systems. In EMT, the development of modern forms of technology represents the process of extricating human society from dependence on nature for sustenance, and of extricating human productive activity from the ecosystems it once depended upon. This perspective can be seen in statements like the following:

> The role that technology plays in reducing humanity's dependence on nature explains this paradox. Human technologies, from those that first enabled agriculture to replace hunting and gathering, to those that drive today's globalized economy, have made humans less reliant upon the many ecosystems that once provided their only sustenance, even as those same ecosystems have often been left deeply damaged.[536]

The implication of this perspective, which aligns with the dematerialization thesis and the absolutization of the social in EMT's ontological framework, is that the continued development and 'innovation' of technology will prevent further ecological damage by rendering modernized society less and less dependent on nature for sustenance.[537] While it is

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[534] Asafu-Adjaye et al., *An Ecomodernist Manifesto,* 17.

[535] In reality, however, "Scientific evidence supports the argument that both subsistence farming and indigenous gathering economies in the global South are ecologically benign and climate friendly" (Salleh, "Climate Strategy: Making the Choice Between Ecological Modernisation or Living Well," 137).

[536] Asafu-Adjaye et al., *An Ecomodernist Manifesto,* 9.

[537] It is unclear what, if not nature, will provide sustenance for humanity, yet the ecomodernists remain optimistic in the possibility of the development of a range of "technological environmental innovations" which they contend will make this extrication from nature possible, examples of which include "new materials which are simultaneously ultra-light and ultra-strong, thus saving larger volumes of conventional materials and energy" (Joseph Huber, "Upstreaming Environmental Action," in *The Ecological Modernisation Reader:*

true that technology has enabled human society to expand productive capacity well beyond historically more basic forms of production, such as those found among bands of hunter-gatherers or even in feudal societies, technology does not in fact herald a *substantive transformation* of society that removes us from the biogeochemical processes, physical laws, or limits of nature. To these, we ultimately remain bound; indeed, our increased social powers of production, rather than enabling us to *transcend* these limitations, actually only make us more capable of *transgressing* them (hence the identification of the historically relatively brief period of industrial capitalism, rather than the *longue durée* of feudalism, is recognized as the period in which human productive activity resulted in an overstepping of the boundaries of the Earth System).[538] This brings us to an analysis of the place and role of 'decoupling,' the central technological reform associated with the 'dematerialization thesis,' through which EMT argues modernity (i.e. capitalist industrial production) can be ecologized.

Environmental Reform in Theory and Practice, ed. Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren (London: Routledge, 2009), 334-5). Of course, many of these 'new materials,' such as "new plastics and synthetic fibres," "new metal alloys," and "new composite materials," aside from their likely questionable ecological impacts (e.g. could new plastics be environmentally benign), do not exist at this time and, should they be created at some point in the 'foreseeable future,' it is accepted that they will have "to match economic criteria such as price and profitability sooner rather than later as they move along their learning curve" (Huber, "Upstreaming Environmental Action," 334). However, the fetishization of technological innovation and 'fixes' in EMT involves a forgetting that "technology and technological science must be analysed in the context of the social relations within which they are developed, which define their specific goals and determine their design and deployment," which specifically means analyzing the way technology is "Drafted into the capitalist valorisation process, [such that] this capitalist science of technology aims at mobilising, harnessing, arranging, using, and *using up various natural and human forces in order maximise output per unit of time*" (Joseph Fracchia, "The Capitalist Labour-Process and the Body in Pain: The Corporeal Depths of Marx's Concept of Immiseration," *Historical Materialism* 16, no. 4 (January 2008): 53-6, emphasis is my own). Thus, by theoretically adhering to the temporal logic of capital and its accumulation imperative, Huber, in the above statement, seems to simply accept the social relations of technology by implicitly admitting that ecologically beneficial technologies and innovations, should they not be affordable or profitable, will not be taken up in the capitalist production process. Aligning with the theoretical absolutization of the social (i.e., capitalism), EMT's 'co-benefits paradigm' which aims at the simultaneous creation of both economic and ecological benefits capitulates fairly quickly by giving absolute precedence to the economic.

[538] For an empirical account of this see Will Steffen, Wendy Broadgate, Lisa Deutsch, Owen Gaffney, and Cornelia Ludwig, "The trajectory of the Anthropocene: The Great Acceleration," *The Anthropocene Review* 2, no. 1 (January 2015): 81-98, which explains and updates (to 2010) the infamous 'hockey-stick' graphs of the 'Great Acceleration' which express the "holistic, comprehensive and interlinked nature of the post-1950 changes simultaneously sweeping across the socio-economic and biophysical spheres of the Earth System, encompassing far more than climate change" (Steffen et al., "The trajectory of the Anthropocene: The Great Acceleration," 82).

3.2 Decoupling, Intensive Growth, and the Jevons Paradox

The coupling of economic growth and ecological degradation throughout the industrial phase of modernity has led to the development of the concept of decoupling, an ideal strategy for EMT which "refers to a macro-level change in the industrial societies in which economic growth becomes increasingly decoupled from the use of natural resources."[539] As such, decoupling can be either absolute or relative: the latter occurring "when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of the economic variable"; the former "when the environmentally relevant variable is stable or decreasing while the economic driving force is growing."[540] Decoupling, then, means one of three things: (1) economic growth occurs at a greater rate than the rate of environmental degradation it is coupled to (relative); (2) economic growth occurs while the environmental degradation it is coupled to remains stable (absolute); or (3) economic growth occurs while the environmental degradation it is coupled to decreases (absolute). In other words, the logic implied by the concept of decoupling expresses a belief in the potential of technological innovations and modernizing institutional reforms to enable human production and socio-economic activity to transcend the physical limits, boundaries, and temporal cycles and rhythms of nature - that is, to 'dematerialize' production. At work in this concept is the Promethean notion of a possible world in which productive activity (and economic growth) is not necessarily or strictly bound by the laws and limitations of nature and rather exists and operates out with these objective boundaries, or in which the practical impact and limitations of these boundaries have been negated through technological innovation.[541] Technology, in

[539] Jalas, "The Temporal Orientations of Ecological Modernization and Sustainable Consumption," 310.

[540] Kenneth Ruffing, "Indicators to Measure Decoupling of Environmental Pressure from Economic Growth," *The OECD Environment Programme*, 1.

[541] As critics have noted the "goal [of EMT] is self-consciously one of Promethean control of nature through science and technology" (John Bellamy Foster, "The Long Ecological Revolution," *Monthly Review* 69, no. 6 (November 2017), https://monthlyreview.org/2017/11/01/the-long-ecological-revolution/). It is precisely here -

this view, is taken to be capable of rearranging the very ontological fabric of material reality, of actively substantively extricating society from its originary natural foundation, such that it could make possible a *supra-natural* (or what some ecomodernists call a "synthetic") existence for humanity.[542] On the basis of this conceptualization of technology, production, and economic growth, which demands a strong sense of Promethean technological optimism, the EM "perspective suggests that further development and modernization may alleviate environmental problems rather than adding to them" through the process of decoupling.[543] There are, however, issues with both the relative and absolute forms of decoupling.

On the one hand, there is the issue of material-energetic throughput in relation to *relative* decoupling and intensive accumulation. Ecological rationalization, for EMT, means "Intensifying many human activities — particularly farming, energy extraction, forestry, and settlement — so that they use less land and interfere less with the natural world [and this] is the key to decoupling human development from environmental impacts."[544] The problem arises because decoupling and the

> economics of ecomodernism are based on a trade-off between extensive and intensive accumulation, moving rapidly away from the former (shrinking our spatial grasp, intensifying a circular self-contained economy) and moving metabolically to the latter (geo-engineering an optimal world climate for example)

thus, we find that decoupling in the context of a capitalist economy actually means that

> the throughput of intensive accumulation will accelerate as more energy/matter/living biomass units are needed per unit of labour, and more importantly these entities will be caught up in a process of 'artificialisation' as capital deepens its determination on these inputs.[545]

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i.e., in the argument that technology can effectively negate the natural limitations to economic growth - that we find the Promethean kernel of EMT.

[542] However, this possibility isn't treated as a necessity: "Even if a fully synthetic world were possible, many of us might still choose to continue to live more coupled with nature than human sustenance and technologies require" (Asafu-Adjaye et al., *An Ecomodernist Manifesto,* 25).

[543] York, Rosa, and Dietz, "Footprints on the Earth: The Environmental Consequences of Modernity," 285.

[544] Asafu-Adjaye et al., *An Ecomodernist Manifesto,* 7.

[545] Pineault, "Growth and Overaccumulation in Advanced Capitalism," 7. In this way, the examples of incisive temporal control, domination, and subsumption of nature by capitalism discussed in Chapter 5, two of which are

While at a glance EMT may be commended for attempting to decrease the material-energetic throughput of the economic process by a shift from extensive to intensive accumulation, closer inspection shows that, by failing to critically consider the determination of this form of growth by capitalism's temporal logic and accumulation imperative, EMT is unable to recognize that "intensive accumulation accelerates the [material-energetic] throughput" of the economic process.[546] For example, the intensification of chicken farming through the incisive temporal control of the lifecycle of broiler chickens has meant that even though "the land area required to produce feed for chickens is lower than for pigs and cattle…the land area and reactive nitrogen emitted (from fertilizers) from the production of chicken feed is significantly higher (more than double) that used to grow plant crop staples (rice, wheat and potatoes)."[547] According to climate scientists, the production of reactive nitrogen through modern industrial agriculture now "significantly perturb the global cycles" of nitrogen "at the planetary scale," while also "polluting waterways and the coastal zone, accumulating in land systems," and because "Nitrous oxide, for example, is one of the most important non-CO2 greenhouse gases…[it] thus directly increases radiative forcing."[548] The aim of relative decoupling through intensified accumulation, achieved via strategies such as incisive temporal control, may well look ecologically beneficial when gauged against specific metrics that show a reduction in resource consumption, such as land use, but this is only one piece of the broader ecological puzzle. Attention to other aspects of the process of intensive

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cases of bioengineering (the biological counterpart of geo-engineering), thus correspond exactly with EMT's promotion of intensive economic accumulation. Indeed, that the product of the dictates of the temporal logic of capital and capitalist temporality in relation to nature (i.e., incisive temporal control, subsumption, and temporal-ecological rifts), are precisely the strategies EMT seeks to employ is yet further evidence of the exact coherence (or convergence) of the temporal logic of EMT and the temporal logic of capital.

[546] Pineault, "Growth and Overaccumulation in Advanced Capitalism," 7.

[547] Bennet et al., "The Broiler Chicken as a Signal of a Human Reconfigured Biosphere," 8.

[548] Rockström, et al., "A safe operating space for humanity," 474. Radiative forcing means "the rate of energy change per unit area of the globe as measured at the top of the atmosphere," and thus functions, alongside atmospheric concentration of greenhouse gasses, as one of the two main threshold measures of climate change (Rockström, et al., "A safe operating space for humanity," 473).

accumulation, as with the above example of the nitrogen cycle, show that relative decoupling of some ecological factors can very well occur, even while ecological degradation increases.

On the other hand, there is the issue of material-energetic throughput in relation to *absolute* decoupling, capitalist efficiency, and the temporal logic and accumulation imperative of capital. EMT's aim of maintaining economic growth through the ecological modernization of capitalist society fails to contend with the dictates of the temporal logic of capital which, in giving rise to an expansive and accelerating socio-temporality, cannot permit 'green'/'greened' technologies developed through ecological rationalization and increased efficiency to reduce harmful environmental impacts because these 'savings' are instead turned into 'additions.' Essentially, under capitalism's temporal logic, it is at best extremely unlikely that increased efficiency will lead to a reduction in resource usage and much more likely that it will lead, somewhat paradoxically, to an increase. The process behind this paradox is known as the rebound effect, or the 'Jevons' Paradox' after economist William Stanley Jevons, the first thinker to conceptually describe the effect:

> In the heyday of the Industrial Revolution, as Britain worried about running out of coal, William Stanley Jevons pondered two simultaneous phenomena: (1) required coal input per unit of smelted iron or work done by steam engines had long been falling; and (2) total coal consumption had been rising. Likewise, demand for labour input had been rising alongside rising labour productivity. From these observations, he derived the general claim that technological change which increases the efficiency with which a resource is used increases rather than decreases the rate of consumption of that resource.
> This claim was later exemplified by electric lighting, where a hundred-fold decrease in the amount of electricity needed for a lumen spawned a thousand-fold increase in the amount of electricity used for lumens to light buildings and streets. Jevons called this a 'paradox', because for psychological reasons we expect a per unit decrease in an input/output ratio to cause a decrease in the overall consumption of the input.[549]

Conceptually, the rebound effect refers to "any circumstance where efficiency improves by X%, but resource consumption declines by something less than X% or increases," while the

[549] Blake Alcott, "Jevons' Paradox (Rebound Effect)," in *DEGROWTH: A Vocabulary for a New Era*, ed. D'Alisa, Giacomo, Federico Demaria, and Giorgos Kallis (London: Routledge, 2015): 121.

Jevons paradox is a "subset of phenomena captured under assessments of the 'rebound effect'" which "occurs when the rebound effect exceeds 100%, meaning that there was an actual increase in resource consumption, not just the loss of some of the potential benefit."[550] In general, then, the Jevons paradox identifies phenomena whereby "Technological 'improvements' have actually increased the amount of resources used since expansion in production typically outstrips gains in efficiency," a paradox of which, besides Jevons study of the case of coal, there are now several examples.[551] For instance, although EMT promotes the use of alternatively fueled vehicles[552] (AFVs, i.e. engines which do not operate by the combustion of petroleum) as a modernizing technological reform in the fight against carbon emissions, scholars have shown that

> AFVs are associated with increases in total fuel consumption per vehicle, as well as rises in travel rates per vehicle. These findings suggest that AFVs are expanding vehicle use in the United States rather than shifting fuel consumption away from traditional sources (e.g., gasoline and diesel). Consequently, this means that AFVs may be increasing environmental impacts produced from the vehicle industry.[553]

The rebound effect/Jevons paradox, in this way, turns the *savings* made by technological improvements in efficiency into *additions* to the gross environmental impacts. To explain this, however, requires critical analysis of the capitalist mode of production and the temporal logic of capital - that is, "capitalism's inherent expansionary tendencies."[554] Under capitalism, due to the dictates of its temporal logic and accumulation imperative, "efficiency has been a strategy for reducing production costs, not conserving resources," and, subsequently, the

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[550] Richard York and Julius Alexander McGee, "Understanding the Jevons Paradox," *Environmental Sociology* (December 2015): 2.
[551] Richard York, "Carbon metabolism: Global capitalism, climate change, and the biospheric rift," *Theory and Society* 34, no. 4 (August 2005): 391.
[552] In order to decrease carbon emissions, ecomodernist Joseph Huber, for example, recommends "the introduction of different motors and of entirely new propulsion systems in vehicles" (Huber, "Ecological Modernization: Beyond Scarcity and Bureaucracy," 44).
[553] Julius McGee, "The Treadmill of Alternatively Fueled Vehicle Production," *Human Ecology Review* 23, no. 1 (2017): 94.
[554] York, "Carbon metabolism: Global capitalism, climate change, and the biospheric rift," 1.

economic savings in production costs generated by any improvements in efficiency of resource consumption are used "to expand production and increase profits, rather than to conserve resources and provide leisure time to workers."[555] Failing to critically analyze capital's temporal logic and accumulation imperative, EMT does not consider the

> the importance of distinguishing between trends in *efficiency* (i.e., impact per unit of production) and *total* resource consumption and waste production. Although evidence generally (but not entirely) supports the assertion that economies become more efficient as they modernize, the weight of evidence clearly indicates that modernization leads to increases in total environmental impacts. *Therefore, in an absolute sense, modernization leads to supermaterialization rather than dematerialization*.[556]

The possibility of reducing environmental degradation through absolute decoupling under capitalism then appears to be a rather problematic strategy as it is not only extremely unlikely that increased efficiency will result in savings (i.e., a decrease in material-energetic throughput), but rather the opposite due to capitalism's systemic tendency to profitize savings (i.e., increase material-energetic throughput to generate greater surplus value). In the context of EMT's variation on the idea of 'progress,' which of course implies consistent improvement over time, the intervention of the rebound effect means "assumptions that temporal progress in technological change, ecological awareness, and environmentally friendly policies and political regimes…lead to a gradual decline in the environmental impact of social processes are not necessarily valid."[557] This claim has been strongly empirically supported by a recent survey of decoupling processes which concluded that "with regard to the goal of ecological sustainability, the empirical evidence on decoupling is thin."[558]

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[555] York and McGee, "Understanding the Jevons Paradox," 6-8.

[556] York and Rosa, "Key Challenges to Ecological Modernization Theory," 282. Latter emphasis is my own.

[557] Greiner, "Time, Power and Environmental Impact," 62.

[558] T. Vadéna, V. Lähde, A. Majava, P. Järvensivu, T. Toivanen, E. Hakala, and J.T. Eronen, "Decoupling for ecological sustainability: A categorisation and review of research literature," *Environmental Science and Policy* 112 (July 2020): 243. The claim that evidence is 'thin' may be understating the matter: "We found that 170 articles presented cases of relative decoupling and 97 articles cased [sic] of absolute decoupling. Out of the 97 cases of absolute decoupling, 74 articles concern impact decoupling and 23 concern absolute resource decoupling. Out of these 23 we concentrated on eleven articles that present evidence of economy-wide and at

Researchers were forced to point out in this study that the process of decoupling is, at this point in time, no more than an abstract possibility: "an abstract possibility that no empirical evidence can disprove but that in the absence of robust empirical evidence or detailed and concrete plans rests, in part, on faith."[559]

EMT's theoretical (i.e. unsubstantiated) claims regarding decoupling and the necessity of "*superindustrialization*" to minimize environmental impacts of production are indicative of the temporal logic at work in EMT, since the explicit rejection of any need to harmonize socio-natural metabolic relations in general is simultaneously a disavowal of the temporal embeddedness of human society *in nature*.[560] As Marx famously stated, "One can look at history from two sides and divide it into the history of nature and the history of [humans]. The two sides are, however, inseparable; the history of nature and the history of [humans] are dependent on each other so long as [humans] exist."[561] For EMT, on the contrary, modern technology has rendered nature and society substantively distinct, and the social absolutized, and thus there exists in this framework, necessarily, a temporal division between nature and society, rather than a temporal embeddedness. Moreover, in treating the ecological crises as a problem with a strictly reformist, techno-institutional solution, EMT fails to recognize and account for the ways that society and technology are embedded not

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least national level absolute resource decoupling. *We found that none of those articles claimed robust evidence of international and continuous absolute resource decoupling, not to speak of sufficiently fast global absolute resource decoupling.*" Instead, the results of the study showed "evidence of increased material intensity and re-coupling" (Vadéna et al., "Decoupling for ecological sustainability: A categorisation and review of research literature," 243. Emphasis is my own).

[559] Vadéna et al., "Decoupling for ecological sustainability: A categorisation and review of research literature," 243.

[560] York, Rosa, and Dietz, "Footprints on the Earth: The Environmental Consequences of Modernity," 285. "Microelectronics, gene technology, and new materials are seen as promising technologies for disconnecting economic development from relevant resource inputs, resource use, and emissions" and "Chip technology is what makes the ecological switchover via super industrialization possible in the most recent phase" (Spaargaren and Mol, "Sociology, Environment, and Modernity: Ecological Modernization as a Theory of Social Change," 75-6).

[561] Karl Marx and Friedrich Engels, "The German Ideology: Critique of Modern German Philosophy According to Its Representatives Feuerbach, B. Bauer and Stirner, and of German Socialism According to Its Various Prophets," in *Marx & Engels Collected Works, Volume 5, Marx and Engels 1845-47* (London: Lawrence & Wishart, 2010), 28. The passage quoted above, while accurately capturing Marx and Engels' position, was crossed out in the original manuscript. (Quote edited to remove unnecessarily gendered language.)

only in larger natural systems which capitalist temporality cannot fully subsume (i.e., in the final analysis, nature is autonomous), but in dynamic historico-political contexts. On this basis, EMT need not account for "technological development as an evolutionary and political process" and thus as socially embedded technological development, but is able rather to take a "Mere efficiency engineering" approach which does not account for the socio-temporality of the socio-economic system, that is capitalism, in and through which these novel technologies arise.[562] It is for precisely this reason that EMT is unable to grasp the temporal issues of decoupling discussed above and why, even in the struggle against climate collapse and ecological crises, the socio-temporal "hegemony of mechanical time-based practice and concept in the industrial capitalist system" is not critiqued, but made absolute.[563]

4. Ecological Modernization Theory and the Temporal-Practical: Absolutization of Capitalist Socio-Temporality and the Fetishism of Technological Fixes

As we have seen, the conceptual errors and deficiencies of EMT generally lead to the theoretical absolutization of the temporal logic of capital, of which, on the temporal-practical side, the fetishization of technological 'fixes' for socio-ecological contradictions and problems is indicative. Essentially, in response to climate collapse and other ecological crises, EMT proposes that capitalist economic expansion can continue uninterrupted, while the ecological degradation that accompanies this growth can be mitigated by reforming existing technologies and developing other novel ones. The practical solutions proposed by EMT in the warming world, therefore, are typically presented in line with the short-termism of capital's restricted systemic temporal horizon, which means that while they serve to protect the immediate interests of capitalism, they fail to account for the long-term

[562] Jalas, "The Temporal Orientations of Ecological Modernization and Sustainable Consumption," 311-2.
[563] Stahel, "Time Contradictions of Capitalism," 108.

implications for the ecological conditions of life and for labor and humanity.[564] This theoretical approach is evident in statements and practical recommendations such as the following:

> Climate change and other global ecological challenges are not the most important immediate concerns for the majority of the world's people. Nor should they be. A new coal-fired power station in Bangladesh may bring air pollution and rising carbon dioxide emissions but will also save lives.[565]

On the one hand, the desire to improve the standard of living of the population of the Global South is admirable and is a part of a socio-ecological transition that must be taken seriously. However, on the other hand, coal-fired power stations are not the *only* option for achieving this improved standard of living for people of the Global South (let alone one they themselves might desire!) and it is almost certainly the case that the provision of power through an expansion of the fossil fuel industry, while perhaps improving living standards in the very immediate short-term, would leave the population of Bangladesh worse off in the

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[564] A very recent practical example is that of ecomodernist, co-author of *An Ecomodernist Manifesto,* and co-founder of the Breakthrough Institute, Michael Shellenberger's unsuccessful 2022 run for Governor of California on a platform which pledged "to increase California's reliance on nuclear power, which [Shellenberger] said provides far more reliability than renewables in the transition to a decarbonized energy system," despite the fact that "he concedes he has no formal training in nuclear engineering, he said he came to his fierce conviction that nuclear is the best source of power for a clean energy future by interviewing experts around the world" (Alexei Koseff, "What would Michael Shellenberger do as California governor?" Cal Matters, Elections 2022, June 6, 2022, https://calmatters.org/politics/2022/06/michael-shellenberger-california-governor/). Yet, at the same time, his platform "also favors increasing oil and gas production in the state" of California (Koseff, "What would Michael Shellenberger do as California governor?"). Shellenberger is aware that "He's even on the fringe among pro-nuclear activists, who generally favor transitioning to new plants with more advanced reactor designs, because he believes the existing cooling technologies are sufficient: 'I'm a heretic among heretics.'" (Koseff, "What would Michael Shellenberger do as California governor?"). As an unaffiliated libertarian, Shellenberger would no doubt insist that these nuclear plants are privately operated. The temporal issue here, only a part of the many problems of nuclear power, is that "The planning horizon of nuclear power companies, for example, is at most several decades. The half-life period of radioactive waste, however, is some 100,000 years" (Altvater, "Ecological and Economic Modalities of Time and Space," 86). Developing this point in a more specifically political register, Charles Wood highlights "the shortened lens of modern political leaders whose 'concept of decision-making responsibility barely extends beyond the four-year period that marks off each new general election.' Because the consequences of decisions made today will be experienced by present generations and by generations to come, futures are being constructed and foreclosed with political tools that are unresponsive to citizens who live beyond the temporal boundaries of the deciding government's term of office. A conspicuous example is the decision to construct a nuclear power station. The mere four- to five-year time horizon of a government's accountability is insufficient to cover the plant's building phase, let alone its period of decommissioning, and even less the time span of radioactive materials" (Wood, "Time, Cycles and Tempos in Social-Ecological Research and Environmental Policy," 264).

[565] Asafu-Adjaye et al., *An Ecomodernist Manifesto,* 21.

long-term from the air, water and land pollution and other environmental harms such a plant would inevitably produce.[566] From the EMT perspective in this case, the short-term gains of a new coal-fired power station - the expanded electrification of Bangladesh and stable provision of energy - over against the long-term harms - generalized environmental pollution and negative impacts on health of the inhabitants of Bangladesh - is a trade-off worth making.

The underlying reason for supporting this trade-off, I argue, is that because the practical solutions EMT conceives of and develops do not break with but are instead fundamentally determined by the temporal logic of capital and socio-temporality of capitalism, they give precedence to the immediate, short-term continuation of capitalist accumulation over the long-term ecological implications of these solutions. The above strategy, for example, illustrates precisely the short-sightedness of EMT's temporal logic which absolutizes the more immediate demands of the temporal logic of capital, i.e., economic growth, even at the expense of the long-term maintenance of the conditions which make this growth possible, and the wellbeing of the people who will be subjected to this 'solution.' Indeed, conceiving of climate change as both a separate and temporally more remote problem than that of 'modernizing' (i.e., industrializing) the Global South by way of expansion of the fossil fuel industry is illustrative of the subservience of EMT to the temporal logic of capitalism, since what is clearly taken to be the most immediate social problem from

[566] For example, counteracting the economistic discourse of ecological modernization, the paradigm of 'buen vivir,' or 'living well,' explores the possibility of climate change mitigation without recourse to the economic growth and the expansion/entrenchment of capitalism: "The eco-sufficiency of Living Well is a serious contender for the socio-ecological conversion of industrialised economies, but it means capacity building in a reverse direction…The deeply eurocentric and gendered focus on engineering infrastructure and the obsession with economic growth invert the thermodynamic order of nature, emptying out its metabolic value. In the language of ecological modernisation, 'biogrowth' means the exact opposite of organic flourishing; instead, it refers to the amount of biomass taken up by the machine. In this mainstream economic reasoning, productive efficiency is a formula by which dead matter (extracted from life giving biological relations) is transformed by dead labour (alienated or technologised) and distributed for consumption as dead product. By contrast, the reproductive economy catalyses vital matter/energy exchanges, a humanity-nature nexus in reciprocity. Against the ongoing dismemberment and commodification of nature, an alternative model of development could be premised on the common sovereignty of energy, land, water, and air…
It is time for climate activists to make a clear choice between the strategy of ecological modernisation and the strategy of Living Well - support for the latter will shift several historical processes forward" (Salleh, "Climate Strategy: Making the Choice Between Ecological Modernisation or Living Well," 142-145).

this perspective is the continuation of economic development and the accumulation of capital. Of course, any short-term gains of a new coal-fired power station for the people of Bangladesh will be severely displaced when, in the long-term, the poisonous gaseous pollution produced by such a power plant renders the air of the city unbreathable - and herein lies the temporal-ecological contradiction of the temporal logic of EMT.

One way in which EMT theoretically justifies this short-termist practical strategic approach to climate collapse is the fetishization of the possibility of technological 'fixes.' EMT can offer practical recommendations that maintain and expand economic growth while simultaneously expanding ecological degradation in part because the Prometheanism which stems from the substantive distinction between nature and society enables the belief[567] that technological innovations will be able to 'fix' the ecological degradation *eventually*, at some unspecified point in the future: "down the road, there will be a technology to bail us out."[568] The "ecological re-adaptation of industrial society," EMT argues - "which *in fact* can be achieved only through technological innovation" and involves the development of novel "integrated" (i.e. proactive) and "end-of-pipe" (i.e. reactive) technologies - is itself a process that can only be realized on the basis of continued economic growth.[569] The basic idea here is that "As income level rises, public spending on environmental research and development also increases."[570] This fetishization of *possible future* technologies entails an effect known as

[567] I do not use 'belief' here as a pejorative, but as an accurate description of the postulation given the conclusion of Vadéna et al.'s study which states that the advocacy of decoupling as a strategy for mitigating climate collapse "rests, in part, on faith" (Vadéna et al., "Decoupling for ecological sustainability: A categorisation and review of research literature," 243).

[568] Malm and Carton, "Seize the Means of Carbon Removal: The Political Economy of Direct Air Capture," 11.

[569] Joseph Huber, "Ecological Modernization: Beyond Scarcity and Bureaucracy," in *The Ecological Modernisation Reader: Environmental Reform in Theory and Practice*, ed. Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren (London: Routledge, 2009): 49.

[570] Soumyananda Dinda, "Environmental Kuznets Curve Hypothesis: A Survey," *Ecological Economics* 49 (July 2004): 442. Although we lack the scope to discuss the issue here, this claim is problematized by the aversion of neoliberal governance to any form of public spending, never mind what would in all likelihood be public spending without the serious possibility of return on investment. This particular aspect of neoliberal governance derives from the discounting of the future (in part through the economic discount rate, but also through a general ideological orientation) in favor of the present. Explaining the emergence of this extreme bias

'mitigation deterrence' whereby "the appearance of some other option that makes the mitigation of climate change look less critical, not because that option is proven and present in the material world, but because it has settled in the 'social imaginary'."[571] The logic of this perspective - of EMT's privileging of economic growth over environmental protection in the short-term in order to develop and implement technologies to resolve current environmental problems in the future - is often defended by ecomodernists through invocations of the Environmental Kuznets Curve (i.e. the EKC), which is said to empirically represent the process of decoupling (notwithstanding the criticisms of the empirical legitimacy of decoupling as a genuine possibility discussed above):

> The environmental Kuznets curve (EKC) is a hypothesized relationship between various indicators of environmental degradation and income per capita. In the early stages of economic growth degradation and pollution increase, but beyond some level of income per capita, which will vary for different indicators, the trend reverses, so that at high income levels economic growth leads to environmental improvement. This implies that the environmental impact indicator is an inverted U-shaped function of income per capita.[572]

The inverted U-shape of the EKC, it is claimed, expresses a process whereby "at high income levels economic growth leads to environmental improvement."[573] Evidence of the EKC is typically provided from highly developed Western European countries such as Germany and The Netherlands (coincidently, or perhaps not, countries where EMT is particularly prominent), yet is premised on "the relocation of polluting industries to less developed

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toward the present and short-term economic interests through neoliberalism, and the way that a general aversion to public spending fits into this model, Nancy Fraser writes that "Whereas the previous regime [of 20th century welfare-state capitalism] empowered states to subordinate the short-term interests of private firms to the long-term objective of sustained accumulation, in part by stabilizing reproduction through public provision, *this one authorizes finance capital to discipline states and publics in the immediate interests of private investors, not least by demanding public disinvestment from social reproduction*" (Nancy Fraser, "Contradictions of Capital and Care," *New Left Review* 100, no. 99 (August 1, 2016): 113).

[571] Malm and Carton, "Seize the Means of Carbon Removal: The Political Economy of Direct Air Capture," 11.

[572] David I. Stern, "The Rise and Fall of the Environmental Kuznets Curve," *World Development* 32, no. 8 (August 2004): 1419.

[573] Stern, "The Rise and Fall of the Environmental Kuznets Curve," 1419.

countries."[574] In cases of countries which seem to provide local, national-level evidence of the EKC, such evidence is based on a narrow abstraction of the local environment, which ignores broader global-ecological conditions, and thus "the so-called environmental Kuznets curve is a local illusion, ignoring the displacement of growing environmental loads to world-system sectors with less purchasing power."[575] Cases of putative EKC success, therefore, are theoretically predicated on a legitimation of a form of ecological imperialism, whereby extractive industries are 'off-shored,' typically to the Global South, thus producing "ecologically unequal exchange" which

> refers to the environmentally damaging withdrawal of energy and other natural resource assets from and the externalization of environmentally damaging production and disposal activities within less-developed/less-powerful countries.[576]

As such, and in keeping with the temporal logic of EMT, "EKC relationships are more likely to hold for certain types of environmental damage, *e.g., pollutants with more short-term and local impacts, rather than those with more global, indirect and long-term impacts*."[577] Ultimately, however, as even neoclassical critics have noted, "the statistical analysis on which the environmental Kuznets curve is based is not robust," and as such "There is little evidence for a common inverted U-shaped pathway that countries follow as their income

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[574] Jalas, "The Temporal Orientations of Ecological Modernization and Sustainable Consumption," 311.

[575] Alf Hornborg, "Ecological economics, Marxism, and technological progress: Some explorations of the conceptual foundations of theories of ecologically unequal exchange," *Ecological Economics* 105 (June 6, 2005): 12. Ariel Salleh has explained part of this process and the local-global contradiction it entails: "Thus the policies of the UN Framework Convention on Climate Change (UNFCCC) are circular and self-defeating in terms of sustaining environments. Schemes such as the Clean Development Mechanism (CDM) and Reduction of Emissions by Deforestation and Degradation (REDD) deal with carbon pollution from industrial nations by funding 'carbon sinks' or polluter offset opportunities in tropical forests. At the same time, the affluent North continues to generate more industrial pollution by manufacture of 'renewables' to sell to the global South for 'climate adaptation.' This kind of self-serving gesture is legitimised in the name of 'development'" (Salleh, "Climate Strategy: Making the Choice Between Ecological Modernisation or Living Well," 128).

[576] Andrew K. Jorgenson, "The sociology of ecologically unequal exchange, foreign investment dependence and environmental load displacement: summary of the literature and implications for sustainability," *Journal of Political Ecology* 23, *Special Edition: Ecologically Unequal Exchange and Ecological Debt*, ed. Hornborg, Alf, and Joan Martinez-Alier (2016): 335.

[577] Dinda, "Environmental Kuznets Curve Hypothesis: A Survey," 442. Emphasis is my own. According to this research, the relationships expressed by the EKC also worryingly fail to account for the 'slow violence' that characterizes a large proportion of environmental harms.

rises."[578] EMT, operating in deference to the temporal logic of capital and fetishizing technological 'fixes,' appears to be basing its strategic recommendations on theoretical claims of ecological benefits for which there is little to no evidence, yet which serve to maintain capitalist accumulation.

Practical problems arising from EMT's temporal logic are, however, not limited to proposals in which ecomodernists are advocating the expansion of the fossil fuel industry as a solution to climate collapse. Gradually, as renewable energy (RE) technologies have been developed and improved, and in addition to proposals to develop ecologically efficient fossil fuel technologies (i.e. decoupled fossil fuel extraction and combustion),[579] EMT has incorporated strategic proposals for the implementation of technologies to provide sources of renewable energy.[580] This shift of focus in EMT is understandable since the possibility of expanding sources of renewable energy "illustrates well the logic of ecological modernisation...[because EMT's] underpinning co-benefits paradigm claims that technological innovation and market-based prompts will help resolve environmental issues in ways that benefit both the economy and the environment."[581] For EMT, the investment, development, production, exchange, and operation of RE technologies and sustainable power represents an ideal way to ensure the co-benefits of increasing economic expansion and decreasing ecological degradation. However, upon closer inspection, we find that

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[578] Stern, "The Rise and Fall of the Environmental Kuznets Curve," 1435.

[579] "Fossil fuels with carbon capture and storage can likewise provide substantial environmental benefits over current fossil or biomass energies" (Asafu-Adjaye et al., *An Ecomodernist Manifesto*, 24).

[580] While some ecomodernists are supportive of RE - for EMT founder Joseph Huber, technological environmental innovations "include the following…fuelless energy such as photovoltaics and further regenerative energies which make use of sun radiation, geothermal heat, or wind and water currents" (Huber, "Upstreaming Environmental Action," 334) - others are much more skeptical and critical - "Most forms of renewable energy are, unfortunately, incapable of [transitioning to a world powered by zero-carbon energy sources]. The scale of land use and other environmental impacts necessary to power the world on biofuels or many other renewables are such that we doubt they provide a sound pathway to a zero-carbon low-footprint future." The reason given for this is that RE are not scalable "to power a growing human economy" (Asafu-Adjaye et al., *An Ecomodernist Manifesto*, 22-3).

[581] Giorel Curran, "Is Renewable Energy Still Green? Shaping Australia's Renewable Energy Enterprise in an Age of Ecological Modernisation," *Environmental Politics* 28, no. 5 (August 2018): 950.

> EM's shortcomings are equally present in the contemporary renewables landscape. The underpinning notion of 'decoupling' remains a problematic yet largely overlooked factor in the more commercial RE domains - and the community sector can treat it cursorily. While we focused [in this paper] on energy production through renewable technologies rather than the production of renewable technologies themselves, the environmental impacts of these technologies are important considerations. Ward et al. rightly point out that '[e]ven supposedly "green" technologies such as renewable energy require materials, land and solar exposure, and cannot grow indefinitely on this (or any) planet'. The social and environmental impacts of rare earth mineral mining that renewable technologies require are a case in point. Politically, the clean energy 'race' that is emerging in the wake of the renewables revolution has significant implications for power relations, particularly since energy transitions create new accumulation strategies that shape geopolitics in significant ways.[582]

Besides the ecological harms generated by the material-energetic throughput in the production of RE technologies, which we will leave aside here, EMT's turn to RE, due to its status as a prominent policy-shaping political force among neoliberal governments across the world (in the case of the above paper, in Australia), has broadly resulted in the corporatization of RE.[583] The influence of EMT over RE technologies has generated "a tension in the contemporary RE domain between those who seek to keep the vision 'green' and those primarily focused on its economic prospects."[584] The corporatization of RE technologies can be at least partly explained by recourse to the political character of EMT which, as a "prominent neoliberal theory," is generally politically invested in neoliberal processes of accumulation by dispossession, as has become the case with RE technologies.[585] Accumulation by dispossession, while often entailing "violence…mystified through political coercion," describes the way in which "capitalist policies under neoliberalism result in a centralization of wealth and power by dispossessing public and private entities of their wealth

[582] Curran, "Is Renewable Energy Still Green? Shaping Australia's Renewable Energy Enterprise in an Age of Ecological Modernisation," 965.
[583] Curran, "Is Renewable Energy Still Green? Shaping Australia's Renewable Energy Enterprise in an Age of Ecological Modernisation," 952.
[584] Curran, "Is Renewable Energy Still Green? Shaping Australia's Renewable Energy Enterprise in an Age of Ecological Modernisation," 951.
[585] York and Rosa, "Key Challenges to Ecological Modernization Theory," 273.

or land."[586] In the case of EMT and the corporatization (i.e. privatization) of RE technologies, we find that "Corporate and commercial actors have moved enthusiastically into a domain previously championed by greens or community groups," giving rise to a situation whereby "large energy corporations are poised to take advantage of investment opportunities…by investing in large scale, centralised and corporatised RE projects that mirror the commercial and structural character of their fossil fuel arms."[587] In turn, development of "future RE systems end up as prototypes of prevailing corporatised forms," as opposed to community based forms,[588] and therefore "the degree to which they can claim 'green' status is contestable."[589]

Corporatized forms of RE technologies, which EMT has championed and thereby helped to create, perpetuate the temporal logic of capital by engendering an accumulation (by dispossession) 'race' - with speed in bringing the product to market being an "absolute and unassailable imperative for business."[590] In this situation, then, the development and production of RE technologies, rather than following an ecological logic which seeks to diminish the environmental harms of energy production, follows an economic logic - the logic of capital - and therefore come to form a part of new corporate strategies for capital accumulation. Thus, despite EMT's shift of focus from fossil fuels to RE technologies and

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[586] Julius Alexander McGee and Patrick Trent Greiner, "Racial Justice is Climate Justice: Racial Capitalism and the Fossil Economy," *Hampton Institute* (May 2020): 14.

[587] Curran, "Is Renewable Energy Still Green? Shaping Australia's Renewable Energy Enterprise in an Age of Ecological Modernisation," 951, 964.

[588] "The community renewable energy (CRE) sector is a diverse and enthusiastic participant in the renewables enterprise. Compared to their individual and commercial counterparts, their motivations are also the most socially and environmentally directed" (Curran, "Is Renewable Energy Still Green? Shaping Australia's Renewable Energy Enterprise in an Age of Ecological Modernisation," 960).

[589] Curran, "Is Renewable Energy Still Green? Shaping Australia's Renewable Energy Enterprise in an Age of Ecological Modernisation," 966.

[590] Adam, "Comment on 'Social Acceleration' by Hartmut Rosa," 50. Moreover, in criticizing the corporatization of RE technologies, Curran is implicitly criticizing the fact that the dictates of the temporal logic of capital create conditions in which (i) "the production of something of equal quality in a shorter time allows for a reduction in the price of the product, which increases its competitiveness," (ii) that "the faster an invention comes to market the better it is for a competitive edge over business rivals," and (iii) that "To be first, to be faster than competitors, is crucial, and this applies whether the 'product' is a new invention, a garment, a news story, or a new drug" etc. (Adam, "Comment on 'Social Acceleration' by Hartmut Rosa," 50).

sources, "absent wider sociopolitical change" (i.e. a move away from an inherently expansionary capitalist socio-economic system), "the reform process becomes circuitous, leading back to 'business-as-usual'."[591] Naturally, as is the case for EMT, when capitalism is not conceptually understood as an obstacle to achieving a green society and, moreover, there is a theoretical and practical commitment to 'greening' capitalism, proposed solutions to ecological crises must first, necessarily, submit and adhere to the logic of capital: the laws of surplus maximization and accumulation. How could one seek to 'green' capitalism if the 'greening' process threatened the existence of capitalism? On the other side of this coin is the implication that potential solutions to ecological crises which do not adhere to the (temporal) logic of capital are therefore not really solutions at all. The short-term and short-sighted temporal logic of EMT, due to its affirmation of and coherence with the temporal logic of the capital, leads EMT to propagate temporal-ecological contradictions in and through its strategic prescriptions for actions to counter ecological crises.[592]

Another example of the temporal impracticality and infeasibility of the technological-reformist solutions proposed by EMT, which illustrates well the extent of the issue caused by adhering to the temporal logic of capital, is that of carbon capture and storage/sequestration technologies (CCS). This is perhaps the technology about which EMT is most optimistic at the moment and also that which is garnering the most support from capitalist elites as a

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[591] Curran, "Is Renewable Energy Still Green? Shaping Australia's Renewable Energy Enterprise in an Age of Ecological Modernisation," 966.

[592] It is worth mentioning here that not only is EMT aware of its limited temporal-perspective and shortsighted temporal-logic yet claims this as a theoretical *advantage* over (neo-) Marxism and other 'counter-productivist' green theories. The reason given for this is that while there is a "time-boundedness of both theoretical schemes," the "continuities over long time spans in neo-Marxist interpretations of the ecological crisis ever since capitalism started to take shape" exemplify a stagnant, out-of-date theory with nothing to offer the present, whereas "the shorter time spans and historical specificity [i.e. contemporaneity/ahistoricity] on which Ecological Modernization claims to have relevance" render it a more dynamic and up-to-date theory for dealing with the present ecological crises (Arthur P.J. Mol and Gert Spaargaren, "From Additions And Withdrawals To Environmental Flows: Reframing Debates in the Environmental Social Sciences," *Organization & Environment* 18, no. 1 (March 2005): 96). The claim Mol and Spaargaren essentially make here is that, because ecological crises are happening in the present, green theory should dispense with history and focus immanently on this present.

possible solution to the increasing concentration of atmospheric CO_2 which produces climate change in the form of global warming.[593] The possibility of developing and implementing CCS technology is particularly attractive to EMT precisely because it aligns with the logic of the 'co-benefits paradigm' by (potentially) offering a comprehensive solution to the problem of global warming without necessarily requiring any decrease in CO_2 emissions - or, in other words, without any interruption to the processes of capitalist production and accumulation. The idea is that, should CCS prove scalable, there would be no need to reduce emissions by, for example, transitioning away from fossil fuels, and instead fossil fuel extraction and combustion could continue 'as normal' indefinitely (or, at least until it is no longer profitable to continue 'as normal'). Thus, the possibility of CCS technology as a solution to climate change coheres with the dictates of the temporal logic of capital because, by ensuring the continuation of 'business-as-usual,' it does not interfere with the necessity of the continuous, perpetual cycle of capital, and even expands this cycle. Yet, however hopeful we might be about the possibility of an innovation in CCS that could render it scalable, when we consider the *timeframe(s) of implementation*, we can see clearly how EMT's (and capital's) short-termist temporal logic serves to mystify the irrationality of such a 'solution':

> Sequestering a mere 1/10 of today's global CO2 emissions (less than 3 Gt CO2) would thus call for putting in place an industry that would have to force underground every year the volume of compressed gas larger than or (with higher compression) equal to the volume of crude oil extracted globally by [a] petroleum industry whose infrastructures and capacities have been put in place *over a century of development. Needless to say, such a technical feat could not be accomplished within a single generation.*[594]

[593] For example: "Elon Musk has offered a $100m (£73m) [prize] for inventions that remove carbon dioxide from the atmosphere or oceans" (Rupert Neate, "Elon Musk Pledges $100m to Carbon Capture Contest," *The Guardian*, 8 February, 2021). In a moment of rich irony for someone committed to a solution that is, as we shall see, predicated on ecologically-problematic temporal logic, Musk said about the competition: "Time is of the essence" (Neate, "Elon Musk Pledges $100m to Carbon Capture Contest"). Whether Musk was referring to the temporal urgency of climate change or to the temporal demands of a new capital accumulation race remains unclear.

[594] Vaclav Smil, "Energy at the Crossroads," *OECD Global Science Forum: Conference on Scientific Challenges for Energy Research* (May 2006): 21. Emphasis is my own.

Although pro-CCS advocates have given various estimates about the time-line on which CCS technology might be able to begin reducing global CO_2 emissions, with some in the early 2010s touting the possibility of CCS becoming "a commercial reality and [beginning] to make deep cuts in emissions during the 2030s," skeptical climate scientists have noted that this does not correspond to the time-frame on which we must deal with carbon emissions, and have thus sardonically replied: "Ahh, if only the climate had two decades to wait," adding that "CCS simply hasn't yet proven to be practical, affordable, scalable, and ready to be *ramped up rapidly.*"[595] In effect, the hope generated by the possibility of CCS represents another case of 'mitigation deterrence' through which "The urgency of cutting back on fossil fuels is…blunted."[596] This blunted sense of urgency, in turn, serves to ideologically protect the continuation of capitalist accumulation, and all the emissions that come with it, in the short-term.

As more realistic appraisals of CCS have estimated, the scale at which CCS would have to be globally implemented is rather daunting, pointing out that "whatever type of CCS technology that is used, human beings would have to develop a huge carbon capture and sequestration industry that is about triple the size of the entire current fossil fuel industry."[597] Achieving this feat, in terms of time, would require construction "*at a rate of about one new CCS plant completed every working day for the next 70 years*, or from now [2016] until the year 2087."[598] To successfully implement CCS at a level that would somewhat meaningfully

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[595] Joe Romm, "Carbon Capture and Storage: One Step Forward, One Step Back," *Resilience* (October 2013). https://www.resilience.org/stories/2013-10-15/carbon-capture-and-storage-one-step-forward-one-step-back/. Emphasis is my own.

[596] Malm and Carton, "Seize the Means of Carbon Removal: The Political Economy of Direct Air Capture," 11.

[597] Andy Skuce, "'We'd have to finish one new facility every working day for the next 70 years' - Why carbon capture is no panacea," *Bulletin of the Atomic Scientists* (October 4, 2016), https://thebulletin.org/2016/10/wed-have-to-finish-one-new-facility-every-working-day-for-the-next-70-years-why-carbon-capture-is-no-panacea/.

[598] Skuce, "'We'd have to finish one new facility every working day for the next 70 years' - Why carbon capture is no panacea." Emphasis is my own.

mitigate global warming would essentially mean replicating a project that has taken generations to build:

> This means that in order to sequester just a fifth of current CO2 emissions we would have to create an entirely new worldwide absorption-gathering-compression-transportation- storage industry whose annual throughput would have to be about 70 percent larger than the annual volume now handled by the global crude oil industry whose immense infrastructure of wells, pipelines, compressor stations and storages took generations to build.[599]

Regardless of the questions that still exist around the efficacy of the technology itself, the time-frame on which a global CCS system would have to be implemented is utterly incompatible with the time-frame we actually have to mitigate the worst effects of climate change. Yet, when solutions to climate crises are conceived in deference to the temporal logic of capital and its conjoined accumulation imperative, as they are by EMT, these time-frames become superfluous - only the abstract, mechanical, alienated time of capital and its maintenance play an important role in these formulations. The short-termism of the temporal logic of capital serves to obfuscate the temporal efficacy of climate crisis solutions, and on this basis, despite all evidence to the contrary, EMT continues its advocacy of CCS. Should the temporal logic of capital be abandoned however, and our strategies for climate change mitigation conceived of according to an ecological rather than economic logic, we can see clearly that it is far more temporally "efficient and feasible to cut carbon emissions drastically than it would be to construct a globe-spanning CCS infrastructure, which would rival or

[599] Vaclav Smil, "Global Energy: The Latest Infatuations," *American Scientist* 99, no. 3 (May 2011): 219. A more recent, and more jarring, appraisal of the state of play regarding CCS (in this paper, termed 'Direct Air capture' or DAC) from 2021 states: "Lest there be any remaining illusions of dac serving as a quick-fix solution, consider a recent study that examined what 'wartime-like' mobilisation of the technology might do. Assuming governments plough up to 2 percent of world gdp into dac deployment every year after 2025, we could presumably pull down between 570 and 840 Gt of CO2 by 2100 – about 20 times current annual emissions. The result? A temperature reduction of a meagre 0.1 to 0.2°C by end of century compared to a dac-less world of continued emissions – not insubstantial from a climate-risk perspective, but hardly registering as a dent in the 2.5C warming that would still result. All diversions lead to the same conclusion: any dac strategy that does not begin with ending that assumed world of continued emissions, with dismantling fossil capital as fast as humanely possible, is a wasted effort. At most, then, dac can perform useful work in the background, its primary function to chip away at historical emissions, not cancel out present or anticipated ones – like the slow and tedious work of cleaning up after an oil-spill, futile before the leak has been stemmed" (Malm and Carton, "Seize the Means of Carbon Removal: The Political Economy of Direct Air Capture," 33-4).

exceed in size the current world energy infrastructure."[600] In continuing to center technological 'solutions' that are, even in the best case scenario, several decades away from being scalable, rather than promoting solutions that could be implemented immediately, like cutting current levels of carbon emissions, EMT illustrates the problems caused by a temporal logic that fails to recognize the fact that capitalist temporality is embedded within, and secondary to, the temporal rhythms and cycles of the natural world. The problem, ultimately, is that the ecological-temporal logic of EMT is determined by the temporal logic of capital.

[600] Foster, "The Long Ecological Revolution."

CHAPTER VII

TOWARD AN ECOSOCIALIST METABOLIC TEMPORALITY

> The alternative *socialist accountancy* cannot prevail unless it succeeds in radically reorienting the process of societal reproduction in its entirety by breaking the tyranny of capital's dehumanizing time imperative.
> István Mészáros, *The Challenge and Burden of Historical Time*[601]

1. The Challenge and Burden of Temporality, Transition, Necessity, and Freedom

By developing the means of production to the unprecedented level of productive capabilities witnessed throughout the last century, capitalism has made possible, for the first time in human history, a future in which the Earth System is pushed by human activity onto a pathway toward a Hothouse Earth - a future that will almost certainly endanger the survival of the human species. Yet, at the same time, by these advances in production, capitalism also makes possible, through the negation of such an ecologically destructive mode of production and its oppressive social relations, a transition to a new form of society in which human productive activity and social relations are consciously and intentionally organized for the preservation, sustainability and flourishing of humanity and the rest of the natural world. These are the conditions that determine the task at hand. In other words, if now, for the first time in human history, there exists a global political-economic system so potent that its processes of production and reproduction outstrip the (temporal) limits of the Earth System to such an extent that the existence of humanity, along with the majority of life on this planet, is threatened, then *precisely now more than any other time in human history*, social production and reproduction must be consciously and intentionally planned, and the temporality of nature, the cycles and rhythms of ecosystems, and the limits of the Earth System must become guiding principles of an ecologically rational socio-metabolism. Whereas, at the outset of the 20th century, the dichotomy through which the workers of the world faced the

[601] Mészáros, *The Challenge and Burden of Historical Time*, 47.

future was 'Socialism or Barbarism,' we now face, from the depths of barbarism in these fledgling decades of the 21st century, either 'Ecosocialism or Extinction.'[602]

Any socio-ecological transition that does not seek to institute a rationally planned socio-metabolic interchange with nature by negating and transcending the short-termism of capital's temporal logic and its restricted systemic temporal horizon, the imperative of accumulation to which everything must submit, and the inherently accelerative-expansionary, crisis-ridden nature of this system, simply cannot hope to produce an ecologically healthy, balanced, or sustainable society. Because the logic of capital is *necessarily* anti-ecological, as I have shown throughout this work, the only possibility of achieving an ecologically sound society arises from the abolition of capitalism. To achieve this, we must struggle against the present social order which "degrades the inescapable burden of meaningful historical time - the life-time of both the individuals and of humanity - into the tyranny of capital's reified time-imperative," by taking up the challenge and burden of historical time.[603] From an ecological perspective, the most important aspect of this task is to be 'faithful listeners to the laws,' which, in the construction of a sustainable society, is a "vital requirement…[that] does not refer simply to manmade laws," but rather to "the absolutely fundamental laws of humanity's relationship to nature itself: the objective *substratum of our very existence*."[604] On the basis of a faithful listening to the laws of nature, which "must be the ultimate foundation of the whole system of human laws," the social laws of our interaction with nature must be 'radically remade':

> Humanity never needed a more faithful listening to and observance of the laws than this crucial juncture of history. But the laws in question must be *radically remade*: by bringing into fully sustainable harmony the absolute and the

[602] Rosa Luxemburg, *The Crisis in the German Social-Democracy* (New York: The Socialist Publication Society, 1919), 18.
[603] Mészáros, *The Challenge and Burden of Historical Time*, 35.
[604] Mészáros, *The Challenge and Burden of Historical Time*, 27.

> relative determinations of our conditions of existence, in accord with the unavoidable challenge and burden of historical time.[605]

While the task at hand is undoubtedly daunting, and although the "inhuman, alienating, one-dimensional present time of capital's social reproductive order is still in control of the situation," we must remind ourselves and take hope from the fact that "the time of the oppressed and the exploited, with its vital dimension of the future, cannot be obliterated," and recognize that, in our struggle, it is "this time that helps to make the exploited and oppressed become aware of the outlines of a radically different future society."[606] Only through a radical transformation of the current society, wherein capital - and therefore its temporal logic and accumulation imperative - no longer reigns as the absolute, can we achieve a social formation in which the concrete social and ecological rhythms and time-cycles of workers and ecosystems, humanity and nature, are no longer dominated and subsumed by abstract time, but instead allowed to develop in appropriately sustainable forms through a rationally planned and organized mode of production seeking the satisfaction of material needs in a way that no longer transgresses the material boundaries of nature. Only in this way can the challenge of historical time be met and overcome. As Marx put it, genuine freedom, freedom from the realm of natural necessity, begins when "socialized [humanity], the associated producers, govern the human metabolism with nature in a rational way, bringing it under their collective control instead of being dominated by it as a blind power."[607] In the rapidly warming world we presently inhabit, planning and rationalizing human socio-metabolism on

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[605] Mészáros, *The Challenge and Burden of Historical Time*, 27-29.

[606] Mészáros, *The Challenge and Burden of Historical Time*, 22-3.

[607] Marx, *Capital Volume 3*, 959. Importantly for an ecosocialist project which makes a faithful listening to the laws of nature its fundamental premise, Marx's view of freedom does not lose sight of the natural necessity in dialectical interplay with social freedom: "The true realm of freedom, the development of human powers as an end in itself, begins beyond it, though it can only flourish *with this realm of necessity as its basis*" (Marx, *Capital Volume 3*, 959, emphasis is my own). Distinguishing this Marxist from the bourgeois conception of freedom, while showing the superiority of the former, Christopher Caudwell remarks: "In bourgeois theory thought is free of necessity and in bourgeois practice is therefore helpless in the face of necessity. In Marxist theory thought is conscious of necessity and therefore free" (Christopher Caudwell, *Studies in A Dying Culture* (London: John Lane The Bodley Head, 1938), 91).

the basis of the laws and boundaries of nature, rather than allowing the dictates of the temporal logic of capital and the accumulation imperative to blindly rule, represents, besides genuine freedom, the best possibility of survival.

The importance of considering issues of time and temporality in the struggle for a non-accumulative, classless, and ecologically sustainable society can be recognized throughout all levels of social organization, from that of the individual, the worker:

> Time is the room of human development. A [person] who has no free time to dispose of, whose whole lifetime, apart from the mere physical interruptions by sleep, meals, and so forth, is absorbed by [their] labour for the capitalist, is less than a beast of burden. [They are] a mere machine for producing Foreign Wealth, broken in body and brutalized in mind.[608]

To the level of socio-historical development and socio-ecological interaction; the historical Becoming of society in metabolic relation with nature:

> [Humanity's] world thus appears as made of emergences, of forms (in the plastic sense of the word) and of rhythms which are born in Nature and consolidated there relatively, even as they presuppose the Becoming in Nature. *There is a human space, and a human time, one side of which is in Nature and the other side independent of it.* It is obvious, for example, that the human rhythms (biological, psy-chological and social time-scales - the time-scale of our own organism and that of the clock) determine the way in which we perceive and conceive the world and even the laws we discover in it. But human time is abstract only from one point of view (the variable *t* of the physicists); from another it is a fact of Nature. The laws we discover may reflect our own duration but they also have an objective mean-ing. To use a Hegelian formula, the tranquillity of phenomena is measured by our own rhythm, *but our rhythm is immersed in the rhythms of Nature*, and this is why foresight and induction are possible.[609]

As these quotes express, the emancipation of labor and the emancipation of nature are intimately connected issues precisely because any possible solution to either (and both) must begin with the emancipation of society from the domination and control of the blind force of capital and its temporal logic. There is, on the one hand, no possible freedom for the workers

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[608] Karl Marx and Frederick Engels, *Marx & Engels Collected Works, Volume 20, Marx and Engels 1864-68* (London: Lawrence & Wishart, 2010), 142. (Quote edited to remove unnecessarily gendered language.)
[609] Henri Lefebvre, *Dialectical Materialism*, trans. John Sturrock (Minneapolis: University of Minnesota Press, 2009), 130. Emphasis is my own. (Quote edited to remove unnecessarily gendered language.)

without the emancipation of their *time*, by their self-unyoking from a system which cannot permit of 'free time' for human development, and which instead seeks to turn every moment of their lives into surplus-labor time for the production of surplus value. On the other hand, there is no possible healthy, sustainable interchange between society and nature without the former's emancipation from capital's accumulation imperative as determined by the dictates of its expansive-accelerating temporal logic. Even though "capital constantly strives to reduce the labor time necessary for the production of commodities, it does so with a view to harnessing the growing portion of potentially free time in order to consume it as surplus labor on the endless treadmill of ever-expanding private accumulation."[610] Because "True freedom, for Marx, can only be achieved beyond capitalism," the challenge of our time requires "not only putting the producers in charge of the production and circulation of goods, but also rethinking and reshaping the productive forces themselves and, thus, the relationships among human beings, nature, and time," and for this reason, "Mészáros, in restating the Marxist project for the 21st century, emphasizes a new political economy of *disposable time* as the true emancipation from the rule of capital."[611] Emancipation from capital's "anachronistic time accountancy," therefore, opens the dual possibility of *gaining time* for human social and individual development and the ascent of the human subject to its fullest potential, and for the *bestowing of time* for the cyclical regeneration of nature and the stabilization of society's metabolic relationship with its 'objective substratum' through a 'faithful listening to the laws,' and thus, reciprocally, for the preservation and maintenance of ecological conditions through which the continued development of the fullest expression of human subjectivity's potential can occur.[612] By both a faithful listening to the laws and through an attentiveness to the many levels at which various temporal concerns are relevant, particularly under the

[610] Paul Leduc Browne, "Disposable Time, Freedom, and Care," *Science and Society* 75, no. 3 (July 2011): 301
[611] Browne, "Disposable Time, Freedom, and Care," 297-8.
[612] Mészáros, *The Challenge and Burden of Historical Time*, 48.

conditions of a warming world, and therefore by sharpening our understanding of the ways in which "the spatio-temporal rhythms of capital accumulation [require] a quite different framework to that required to understand global climate change," we might continue to open up "Comparisons between different spatio-temporal frameworks [which] can illuminate problems of political choice."[613] In other words, recognizing the importance of the temporal is essential for Political Ecologies concerned with devising theories of socio-ecological transition that also account for the possibility of genuine freedom beyond the realm of natural necessity.

In the following, against the backdrop of the analyses presented in the previous chapters and in light of the task at hand, I aim to outline a brief account of some important theoretical and practical considerations for the advancement of the struggle against capital's alienated, anti-ecological temporality and for the creation of a non-accumulative, ecosocialist society with a sustainable socio-metabolism constructed upon a rational interchange with nature. To this end, I argue that Political Ecologies must become fully conscious of the questions and issues of temporality related to both theoretical and practical elements of the task of socio-ecological transition. This involves many theoretical considerations which have already been discussed in detail in this work including, for example, developing a critical approach to the socio-temporal hegemony of capital's temporal logic, attentiveness to the temporality of any form of transition to an ecologically sustainable society, accounting for the temporality of any novel form of socio-metabolic interchange with nature, and developing strategies that equally respond to the urgency of ecological crises while engendering long-term solutions rather than short-term palliative or mere quick 'fixes.' This task, of expressing theoretical-practical consciousness of the multifaceted, complex temporality of socio-ecological crisis and transition, I describe as the development of an 'ecological chronological

[613] Harvey, *Spaces of Global Capitalism*, 123.

politic,' or what I call an *eco-chronopolitic*. Any potentially successful socio-ecological transition, I argue, must be founded upon a strain of Political Ecology with an eco-chronopolitic that seeks to break with the mechanistic, abstract, temporality of capital, and which instead adheres to a dialectical conception of the temporal metabolic interrelatedness of social and ecological systems; in light of this, I will give a short account of Metabolic Rift Theory (hereafter MRT) to show that it is engaged in developing an eco-chronopolitic with the necessary perspective and content to make possible a just, long-term, successful socio-ecological transition.

2. Outline of an Eco-chronopolitic

Any strain of Political Ecology capable of contending with the inchoate, nonlinear, diachronic temporality of the ecological crises and metabolic rift of the 21st century must exhibit an '*Eco-chronopolitic*' which refers, generally, to the temporal logic, perspective, content, and strategies of Political Ecologies in relation to socio-ecological crises and transition. In using this terminology, I am borrowing from the sociological concept of 'Chronopolitics' which has been broadly defined as follows: "The term chronopolitics is used here to emphasize the relationship between the political behavior of individuals and groups and their time-perspectives."[614] In contrast, however, *eco*-chronopolitics diverges from this formulation by departing from the psychologism and methodological individualism of Wallis' concept in order to describe a much broader set of temporal considerations and components, problems and strategies, of socio-ecological transition which are pertinent to Political Ecology by attending to, for example, the temporal logic(s) and temporalities of hegemonic and non-hegemonic politico-economic systems, temporalities of transition both in theory and in strategy, and, perhaps most importantly, to the temporality of the relation

[614] Wallis, "Chronopolitics: The Impact of Time Perspectives on the Dynamics of Change," 102. See also Klinke's efforts to highlight the importance of the concept of Chronopolitics for studies in critical geopolitics (Ian Klinke, "Chronopolitics: A Conceptual Matrix," *Progress in Human Geography* 35, no. 5 (February 2013): 673-690).

between society and nature. In this sense, eco-chronopolitics as a concept relies upon knowledge(s) from a range of disciplines, including a critical philosophical worldview able to unite seemingly disparate bodies of knowledge; critical historical knowledge of the social, political, economic, and cultural transformations that have shaped modern society; non-reductive, complex scientific understanding of ecosystems; sociological understanding of the relation between macro- and micro- systems and institutions; and (interdisciplinary) knowledge of the ecological impacts of the various part of human society and productive activity. Thus, efforts to develop a robust eco-chronopolitic will address the fact that "a transdisciplinary approach is central to a critical concept of [socio-ecological transformation]" by calling forth precisely these forms of inter- and transdisciplinary knowledge while also bringing many of the often ignored temporal aspects of the problems of our rapidly warming world into focus.[615] In this sense, perhaps even more so than an inter- or transdisciplinary approach, developing an eco-chronopolitic calls forth what Helena Sheehan terms "synthesizing systemic thinking," that is the kind of "systemic thinking demanded by these crises, not only in clarifying the causes, but pointing to the solutions."[616]

In any given strain or theory of Political Ecology, the eco-chronopolitic expresses the conception of the relation between social and natural temporalities and the theoretical understanding of the temporal logic(s) by which these spheres operate. Developing an explicit eco-chronopolitic would be to make theoretically conscious and clear the fact that society and nature are subject to very different temporal determinations and, moreover, that these determinations are related. The foundational concern in developing an eco-chronopolitic is to promote theoretical consciousness of the temporal determinations of the

[615] Görg et al., "Challenges for Social-Ecological Transformations: Contributions from Social and Political Ecology," 12.
[616] Helena Sheehan, "Marxism, Science, and Science Studies," *Monthly Review* Vol. 74, no. 1 (May 2022), https://monthlyreview.org/2022/05/01/marxism-science-and-science-studies/.

interchange/exchange with nature and therefore, on this basis, to regulate the interaction of the different temporalities. However, simply acknowledging this relation does not necessarily entail a strategy of striving for 'harmony' or 'balance' between them, or for conscious, planned regulation of their interaction; rather, as with EMT, one can quite fairly argue for the absolutization of one temporal logic and set of temporal determinations over the other, and for unconscious regulation of their interaction by market mechanisms. Nevertheless, an eco-chronopolitic plays an important role in shaping the temporality of the social relation with nature, and therefore of shaping the solutions and strategies with which we approach ecological crises.

In the warming world, the concept of eco-chronopolitics becomes extremely important, especially as we move further into the crises, because the form, organization, and temporality of our socio-ecological relation with nature will be decided upon in the political realm. Ideally, this would happen in a thoroughly democratic process in which participants are robustly and responsibly informed about the nature and stakes of the problems we currently face so as to be able to make rational decisions about the future. However, in the thoroughly stratified class societies across the world, it should be unsurprising that governments are repeatedly deferring to the eco-chronopolitics (or econo-chronopolitics) of Political Ecologies such as EMT since its 'solutions' serve generally, by enabling the uninterrupted continuation of capitalist accumulation/economic growth, to entrench the power and wealth of the ruling class - those who, in an extravagantly disproportionate manner produce the most (and the most heinous) ecological damage[617] - while doing little to

[617] Some estimates have found that "on a global basis each of the richest 1% is emitting close to 100 times more than the members of the poorest 10%," (Beatriz Barros and Richard Wilk, "The outsized carbon footprints of the super-rich," *Sustainability: Science, Practice and Policy* 17, no. 1 (October 7, 2021): 316), while a recent report conducted by Oxfam and the Institute for European Environmental policy found that "The world's richest 1% are set to have per capita consumption emissions in 2030 that are still 30 times higher than the global per capita level compatible with the 1.5ºC goal of the Paris Agreement, while the footprints of the poorest half of the world population are set to remain several times below that level" (Tim Gore, *Carbon Inequality in 2030: Per capita*

attend to the environmental problems that disproportionately affect the most severely oppressed and poorest in our societies. Developing an eco-chronopolitical alternative to that of EMT, one which does not converge with the temporal logic of capital, would enable us to begin to enact politically, economically, and socially an adherence and deference to the rhythms, cycles, and temporalities of specific ecosystem and nature more broadly. Moreover, it would enable us to attend to the metabolic rift by striving for a reconciled relationship with the natural world by recognizing both our temporal embeddedness within the rhythmic temporalities of nature and our ability to emerge out of them and differentiate social temporalities. An eco-chronopolitic must, therefore, contribute to our grasping and understanding (and ultimately adapting to) the ways in which ecological rhythms and temporalities serve as constraints on human social production and consumption.

I argue there are at least two components of a *robust and rational* eco-chronopolitic: firstly, a given strain of Political Ecology must show a clear and consistent temporal logic that is not wholly determined by the temporal logic of capital such that it incorporates only the abstract, alienated socio-temporality of capitalism (represented by abstract mechanical clock-time), but instead must recognize concrete social temporalities, such as the individual and intergenerational times of the oppressed and exploited, and the multiplicitous temporalities present in nature, such as the intersecting cycles and rhythms of an ecosystem, and the (dialectical) interconnections between these social and natural systems at both a local and global level; secondly, that political solutions to these crises must be made on the basis of a historicized, dialectical temporal logic/temporality that accounts not merely for the short-term interests in, for example, generating immediate value for shareholders, but that accounts for the long-term so as to promote intergenerational environmental justice well into the

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consumption emissions and the 1.5ºC goal (Oxford: Oxfam International and the Institute for European Environmental Policy, 2021).

future. Due to the anti-ecological nature of the short-termism of capital's temporal logic, any Political Ecology that fails in the first aspect of developing a robust eco-chronopolitic, that is, of breaking from the socio-temporal hegemony of capitalist temporality, will inevitably fail in the second aspect and therefore will only be able to provide solutions addressing the immediate interests of the capital system over the long-term ecological interests of humanity.

The issues that arise from an eco-chronopolitic which does not break from but rather adheres to or even converges with the temporal logic of capital are evidenced by the problematic solutions proposed by Ecological Modernization Theory. From the support for the expansion of the fossil fuel industry in order to maintain short-term economic growth, to the fetishization of non-scalable technologies which lead to mitigation deterrence, to the pursuit of quick 'fixes' such as bioengineering lifecycles to produce specifically capitalist use-values which serve only to propagate and deepen temporal-ecological rifts, these proposed solutions and strategies exemplify clearly the fact that subservience to the temporal logic of capital produces a flawed, 'anti-eco-chronopolitic' (or, we might say, an *econo*-chronopolitic) and which therefore necessarily gives absolute primacy to the economic over the ecological. This problematic eco-chronopolitic stems, as we have seen, from the absolutization of the category of the social (and therefore of capital) through the ontological dualism at the heart of EMT. Thus, we find the conceptualization of the relation of society and nature is fundamental in determining the content of the eco-chronopolitic of a given Political Ecology. With this in mind, in the following section I argue for a dialectical metabolic conception of the relation between nature and society as one which is necessary for a rational and robust eco-chronopolitic.

3. Metabolism: The Necessity of a Dialectical Conception Nature-Society in a Warming World

For a Political Ecology to be capable of developing a rational and robust eco-chronopolitic, I argue that it must be founded upon a *dialectical conception of the relation of nature and society* and this in turn, over against the mechanistic conception of nature, requires a view of nature based on the concept of *metabolism* (Stoffwechsel).[618] While the concept of metabolism gained analytic traction in certain physical sciences such as biochemistry and physiology in the 19th century, expressing the "complex biochemical process…through which an organism (or a given cell) draws upon materials and energy from its environment and converts these…into the building blocks of growth," it was most fruitfully applied in social analysis by Marx in his systemic analysis of labor and capitalism.[619] For Marx, the concept of metabolism captured the active "human relation to nature through labor," since labor is itself the active appropriation of nature for the satisfaction of material human needs.[620] While expressing the ontological form of metabolic interaction between the humans and nature through the active laboring relation, which is to say that human *being* is material and is thus dependent on labor which appropriates nature,[621] the concept of 'metabolism' also had a much broader, yet more historically specific import, such that Marx

> employed the concept both to refer to the actual metabolic interaction between nature and society through human labor (the usual context in which the term was used in his works), and in a wider sense (particularly in the *Grundrisse*) to describe the complex, dynamic, interdependent set of needs and relations brought into being and constantly reproduced in alienated form under

[618] "The German word '*Stoffwechsel*' directly sets out in its elements the notion of 'material exchange' that underlies the notion of structured processes of biological growth and decay captured in the term 'metabolism'" (Foster, *Marx's Ecology*, 157).
[619] Foster, *Marx's Ecology*, 160.
[620] Foster, *Marx's Ecology*, 157.
[621] "Labor is, first of all, a process between [humanity] and nature, a process by which man, through his own actions, mediates, regulates, and controls the metabolism between himself and nature" (Marx, *Capital Volume 1*, 283).

> capitalism, and the question of human freedom it raised - all of which could be seen as being connected to the way in which the human metabolism with nature was expressed through the concrete organization of human labor. The concept of metabolism thus took on both a specific ecological meaning and a wider social meaning.[622]

'Metabolism,' therefore, contains a dual meaning which captures not only the general form of the *active* reciprocal[623] relation between human society and nature which arises through human productive activity, that is, labor, but also the specific form of the *social metabolic relation* under a given historical social formation. This secondary meaning, in turn, enabled Marx to develop the concept of the 'metabolic rift':

> An essential component of the concept of metabolism has always been the notion that it constitutes the basis on which the complex web of interactions necessary to life is sustained, and growth becomes possible. Marx employed the concept of a 'rift' in the metabolic relation between human beings and the earth to capture the material estrangement of human beings within capitalist society from the natural conditions which formed the basis for their existence - what he called 'the everlasting nature-imposed condition[s] of human existence'.[624]

From the concept of metabolism, therefore, we gain two crucial components for the development of a robust eco-chronopolitic. Firstly, in terms of the relation of categories, while conceptualizing nature and society as dialectically interrelated through human labor, 'metabolism' is also able to hold these two categories as actively related yet analytically distinct. Unlike the substance dualism operative in EMT, which substantively separates nature and society and subsequently absolutizes the social thereby deriding all natural limits, Marx's metabolic conception of the relation of these categories is founded on a dialectical materialist worldview which holds that "nature and society are material substances *tout court*,

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[622] Foster, *Marx's Ecology*, 158.

[623] "Through this movement [i.e., labor] [one] acts upon external nature and changes it, and in this way [one] simultaneously changes his own nature" (Marx, *Capital Volume 1*, 283). (Quote edited to remove unnecessarily gendered language.)

[624] Foster, *Marx's Ecology*, 163.

but one cannot be equated with the other."[625] In other words, the social *emerges* from the natural, yet is not reducible to it - "the relation appears to be one of dependence *and* difference," or, we might say, the relation is a dialectical unity of opposites.[626] Metabolism, understood as an "biochemical…organismic" relation, therefore, depicts the "complex, dynamic interchange between human beings and nature resulting from human labor."[627] On the basis of a conception of an active, reciprocal relation between nature and society, metabolism, unlike mechanistic paradigms or substance dualisms, which respectively posit humans as separate contemplative observers of essentially mechanical processes in nature or substantively separate the categories of society and nature, does not succumb to the problem of causality. On the contrary, by simultaneously understanding the unity and opposition at play in the dyad of nature-society that "allows us to know how they interact, what sort of damage the one does to the other and, most importantly, how the destruction can be brought to an end."[628] In the warming world, as Malm explains, this "is the truly vital theoretical task: to maintain the analytical distinction [between the natural and the social] so as to tease out how the properties of society intermingle with those of nature. *Only in this way can we save the possibility of removing the sources of ecological ruin*."[629] It is only by accurately

[625] Malm, *The Progress of this Storm,* 57.

[626] Malm, *The Progress of this Storm,* 55. The concept of emergence is particularly important for this formulation and refers to the concept of emergent properties. This is "a property of the system *resulting from the organisation of its parts*" (Malm, *The Progress of this Storm*, 61). Examples include the property of 'wetness' emerging from the combination of hydrogen and oxygen atoms in the formation of water, "Properties of society which cannot be derived from the atomistic aggregation of its members," for example, capitalist property or time relations (Malm, *The Progress of this Storm*, 61), and even life: "Life itself is recognized as an emergent consequence of organization; in fact, it embodies 'action occurring as the *result of organization*,' where 'the increasingly complex organization of higher life-forms permits the appearance (the emergence) in them of new modes of life, new functions or behaviors, impossible in less organized forms'" (Richard York and Brett Clark, "The Problem with Prediction: Contingency, Emergence, and the Reification of Projections," *The Sociological Quarterly* 48, no.4 (Fall 2007): 720). Additionally, this is precisely why Lefebvre writes "[Humanity's] world thus appears as made of *emergences*, of forms (in the plastic sense of the word) and of rhythms which are born in Nature" (Lefebvre, *Dialectical Materialism*, 130. Emphasis is my own).

[627] Foster, *Marx's Ecology,* 158-163.

[628] Malm, *The Progress of this Storm,* 61.

[629] Malm, *The Progress of this Storm,* 61.

distinguishing what is 'social' and what is 'natural,'[630] while recognizing their ontological (i.e. substance) unity and keeping the active relation through labor between them in clear analytical sight, that we are able to correctly attribute causation in cases of environmental degradation and the violation of ecological limits and also, therefore, to promote effective strategies for counteracting this damage and for broader socio-ecological transition.

Secondly, Marx's concept of metabolism, and more specifically of the metabolic *rift*, necessarily expresses a notion of ecological limits:

> The concept of metabolism, with its attendant notions of material exchanges and regulatory action, allowed [Marx] to express the human relation to nature as one that encompassed both 'nature-imposed conditions' and the capacity of human beings to affect this process.[631]

In light of recognizing the 'nature-imposed conditions' under which humans live, developing the concept of the metabolic rift that emerged between society and nature due to the capitalist mode of production enabled Marx "to argue that the nature-imposed conditions of sustainability had been violated."[632] By accounting for the autonomous necessity of nature over against the emergent contingency of human society, as the metabolic perspective does, Marx recognized that human labor takes place within the context of specific ecological conditions; by never losing sight of the material basis of society, the concept of metabolism situates human labor within the material *boundaries* of nature. Marx's concept of metabolism captures the way in which society (and human productive activity) is constrained by nature, while also accounting for the fact that, under certain conditions, social production can transgress these constraints. Taking Marx as a keenly ecological thinker (and forgetting for a

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[630] On this point, with regards to accurately distinguishing the social from the natural, I am in agreement with Malm: "If combinations [of the social and the natural arising through labor] abound, however, by what procedure do we sift out their components? We may begin by applying a crude test: have humans constructed the component, or have they not? If it is social, then it has arisen through relations between humans as they have changed over time, and then it can also, in principle, be dismantled by their actions; if it is natural, it is not a humanly created product but rather a set of forces and causal powers independent of their agency, and hence it cannot be disassembled" (Malm, *The Progress of this Storm*, 60).

[631] Foster, *Marx's Ecology*, 158.

[632] Foster, *Marx's Ecology*, 158.

moment the political context in which he wrote it), his famous dictum - "[Humans] make their own history, but they do not make it just as they please; they do not make it under circumstances chosen by themselves, but under circumstances directly encountered, given and transmitted from the past" - offers an alternative interpretation of Marx's astute ecological awareness according to which the given circumstances human society faces are precisely the 'the everlasting nature-imposed condition[s] of human existence.'[633] Once again contrary to the absolutization of the social in EMT which spurns ecological limits by insisting technological solutions enable their social transcendence, it is by a conception of society and nature as at once material in substance, yet different in properties (due to emergence), all the while actively linked by human labor, that we are able to accurately conceive of the relation between human production and environmental degradation as the product of a particular, historically specific socio-economic system. In fact, the very concept of the 'metabolic rift,' in its broader historicized formulation, because it asserts an active, reciprocal relation between human labor in specific social formations and nature, makes possible the comparison of the ecological effects of various historical modes of production and, therefore, enables us to identify more and less ecologically destructive social formations, and the reasons for this destruction differential.

Considering the temporality of the metabolic relation between society and nature, although it is clear that "different orders of determinations do exist between nature and society in terms of time and temporality" due to their different temporal logics, to theoretically impose, as EMT does, an

> *a priori* separation of these two orders, instead of the acknowledgement of their continuities and discontinuities, might have disabling effects for theoretical endeavours into the question of time, such as rendering the theory incapable of grasping the relationship between intersecting temporalities that

[633] Karl Marx and Frederick Engels, *Marx & Engels Collected Works, Volume 11, Marx and Engels 1851-53* (London: Lawrence & Wishart, 2010), 103.

> bring together bodies and their environments, social processes and biological human needs, human activities and climate, and so on.[634]

Conceiving of the relation between nature and society dialectically means necessarily conceiving of the temporal relation between them dialectically, that is, the concept of metabolism includes a conception of *a dialectical temporality*. As Lefebvre puts it, a dialectical materialist sense of temporality recognizes that there is "a human time, one side of which is in Nature and the other side independent of it," that is to say, "our rhythm is immersed in the rhythms of Nature."[635] In highlighting the temporal cycles and rhythms of nature according to a metabolic perspective, as we have in this work, we are considering the temporality of one pole of the dyad 'Nature-Society.' The notion of temporal-ecological rift, therefore, involves a recognition that "nature imposed condition[s] of sustainability [have] been violated" by a material contradiction that has arisen in this dyad between the relation of social and natural temporalities.[636] Without a conception of the dyadic metabolic relation which captures this unity of opposites, theoretically difficulties in understanding and explaining not only the specific form of the relation between social and natural temporalities, but how social temporalities, or the socio-temporality of capitalism, can come into contradiction with natural temporalities arise. By imposing an a priori substantive separation between nature and society, EMT for example, cannot conceive of such a fundamental temporal contradiction, and instead claims that solutions to ecological crises are completely *internal* to the social, with no need to consider the rhythms and cycles of nature, since these can be bent to the whim of the social by technology. Thus, EMT's eco-chronopolitic is socially reductive, leading to a broader ecological strategy revolving around engineering short-term technological 'fixes' for modernity's 'design faults,' rather than aiming for some

[634] Martineau, *Time, Capitalism, and Alienation*, 29.
[635] Lefebvre, *Dialectical Materialism*, 130.
[636] Foster, *Marx's Ecology*, 163.

form of reconciliation, on a fundamental level, of the temporal interrelations of nature and society.

Moreover, and importantly, a dialectical metabolic conception of temporality makes possible "Comparisons between different spatio-temporal frameworks [which] can illuminate problems of political choice," and therefore presents a way to think through the construction of social time as either anti-ecological and oppressive, for example capital's anti-ecological accelerative temporal logic and "dehumanizing time imperative," or ecologically sustainable and emancipatory, for example an eco- "socialist time accountancy" system which provisions disposable time for human development and bestows time for ecological regeneration.[637] What is required for this task is a Political Ecology with an eco-chronopolitic capable of offering an alternative to the eco-chronopolitics of capitalist Political Ecologies and therefore able to contest the temporal logic and socio-temporal tyranny of capital. In other words, a just and sustainable, anti-capitalist socio-ecological transition is indissolubly connected to a deep-rooted socio-temporal transition. Precisely because it involves the conscious politicization of time, temporal rifts and contradictions, and socio-ecological temporal interrelations, an eco-chronopolitic is an essential component of any Political Ecology capable of delivering this type of transition:

> Changes in the social organization of time, such as shortening wage labor, increasing the temporal space of autonomy, and the 'slowing down' of everyday life (which may be 'healthy' for humans and nature) requires a reconstitution of political, social, structural, and economic contexts in which such temporal issues are situated.[638]

For a strain of Political Ecology capable of meeting the requirements for a just and sustainable socio-ecological transition laid out above, we turn to Metabolic Rift Theory; a Political Ecology that offers a strong, ecosocialist alternative to "capital's dehumanizing time

[637] Mészáros, *The Challenge and Burden of Historical Time*, 47.
[638] Freund, "Capitalism, Time-Space, Environment, and Human Well-Being," 117.

imperative" and the temporal logics of capitalist Political Ecologies such as EMT. In the following, however, rather than present a comprehensive theoretical review of MRT, as much of this work has been done above in the section on metabolism, I will very briefly enumerate what I consider some interesting and encouraging aspects of MRT relating to matters of time and temporality.

4. Metabolic Rift Theory: The Case for a Dialectical, Anti-Capitalist Eco-chronopolitic

Theoretically rooted in the dialectical materialist method of the foundational texts of Marxism, particularly Marx's *Capital* and Engels' *Dialectics of Nature*, Metabolic Rift Theory is a dynamic strain of Political Ecology capable, precisely because of its dialectical materialist method, of grasping and analyzing the active and qualitative relationship between society and nature in flux. While Marx himself focused most closely on the degradation of soil fertility levels as a specific form of ecological rift generated by the capitalist mode of production and, more specifically, the contradictory division of town and country, MRT has developed and expanded the concept of 'metabolic rift' out of Marx and Engels' work and applied it to the society-nature relation in general.[639] Contrary to readings of Marx and Engels which have labeled them 'productivist' or simply inattentive and unaware of ecological issues,[640] by an exegesis of the dialectical materialist concept of metabolism in their work, MRT has corrected vulgar antecedent interpretations and reconstituted Marxism as a powerfully ecological method of analysis known as Ecological Marxism (or, Eco-Marxism):

> It was in *Capital* that Marx's materialist conception of nature became fully integrated with his materialist conception of history. In his developed political economy, as presented in *Capital*, Marx employed the concept of 'metabolism' (*Stoffwechsel*) to define the labor process as a 'process between man and nature, a process by which man, through his own actions, mediates, regulates

[639] Brett Clark and John Bellamy Foster, "Marx's Ecology in the 21st Century," *World Review of Political Economy* 1, no. 1 (March 2010): 144-6.

[640] For example, contemporary scholars Ted Benton and Reiner Grundmann maintain that Classical Marxism is mired in a promethean and/or productivist outlook - see, Ted Benton, "Marxism and Natural Limits: An Ecological Critique and Reconstruction," *New Left Review*, no. 178 (November 1, 1989): 51-86, and Reiner Grundmann, "The Ecological Challenge to Marxism," *New Left Review*, no. 187 (May 1991): 103-120.

> and controls the metabolism between himself and nature.' Yet an 'irreparable rift' had emerged in this metabolism as a result of capitalist relations of production.[641]

The particular analytical strengths of Marx's theory of socio-metabolism of nature and of the (now global) metabolic rift opened up by the capitalist mode of production, and thus of MRT, are summarized well by Clausen, Clark, and Longo in the following passage which, considering that Marx and Engels developed this method over a century ago, proves not only remarkably modern given its affinity with the views of contemporary Earth and Climate Science, but extremely relevant in our rapidly warming world[642]:

> Marx's metabolic analysis illuminates the social relation between material conditions (e.g., land) and producers, as well as the relationship between producers and those who appropriate surplus value. This approach provides the means to understand changes in the relationships of production, transformations in the nature–society dialectic, and the socioeconomic forces that influence the organization of labor. A metabolic analysis highlights the structures and regulatory processes that influence the degradation and/or regeneration of natural cycles. Marx argued that there are specific nature-imposed regulative laws of the universal metabolism that had to be abided by in order to maintain the conditions of nature in a state that could provide for human longevity. His analysis revealed how specific economic operations and interactions undermined the metabolic regulatory processes that support the regeneration and/or continuance of specific natural systems and cycles—creating a metabolic rift in a natural system.[643]

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[641] Foster, *Marx's Ecology*, 141.

[642] It is unsurprising, then, that Ilya Prigogine would write that "The idea of a history of nature as an integral part of material-ism was asserted by Marx and, in greater detail, by Engels. Contemporary developments in physics, the discovery of the constructive role played by irreversibility, have thus raised within the natural sciences a question that has long been asked by materialists. For them, understanding nature meant understanding it as being capable of producing man and his so-cieties. Moreover, at the time Engels wrote his *Dialectics of Nature*, the physical sciences seemed to have rejected the mechanistic world view and drawn closer to the idea of an historical development of nature. Engels mentions three fundamental discoveries: energy and the laws governing its qualitative transformations, the cell as the basic constituent of life, and Darwin's discovery of the evolution of species. In view of these great discoveries, Engels came to the conclusion that the mechanistic world view was dead," (Prigogine and Stengers, *Order Out of Chaos*, 252-3), and moreover, as Helena Sheehan reports, that "Loren Graham of MIT, who has spent his whole professional life studying Soviet and post-Soviet science and philosophy of science has said of dialectical materialism: 'This philosophy of science is actually quite a sensible one and corresponds to the implicit views of many working scientists all over the world,'" adding: "Graham…incidentally, is not a marxist" (Sheehan, "Marxism, Science, and Science Studies").

[643] Rebecca Clausen, Brett Clark and Stefano B. Longo, "Metabolic Rifts and Restoration: Agricultural Crises and the Potential of Cuba's Organic, Socialist Approach to Food Production," *World Review of Political Economy* 6, no. 1 (Spring 2015): 8.

In Political Ecology, therefore, the dialectical and metabolic perspective of MRT which recognizes both ecological boundaries and the interconnectedness of nature and society as a unity of opposites, offers a compelling alternative to the current theoretical and political dominance of EMT and its mechanistic and dualistic perspective which, in emphasizing a widening separation between nature and society, absolutizes society and denigrates the material reality of ecological boundaries. Under any set of conditions, but especially in a rapidly warming world, MRT offers an analytical perspective in Political Ecology that not only more accurately captures the dynamic relation between nature and society, but which, I argue, theoretically moves us beyond abstract and alienated temporal logics. In fact, while EMT presents a mechanistic, dualistic, and reductionist temporal logic by reifying capitalism's subsumption of concrete social and ecological temporalities and thereby treating abstract, alienated capitalist clock-time as a singular and totalizing form of time, MRT attempts to move beyond the limitations of this paradigm by incorporating a broader, more dynamic notion of temporality as dialectically constituted by the metabolic relation of nature and society.[644] In this alone, MRT looks beyond the singularity of capitalist socio-temporality by theoretically accounting for and analytically incorporating concrete social and ecological times and temporalities, and their interconnections. Below, then, I will outline some important temporal aspects of MRT which exemplify its ecologically-grounded, dialectical conception of temporality and show how this conception helps move us beyond the stultifying temporal logic of capital and the flawed conceptions of temporality in green capitalist strains of Political Ecology.

[644] As Levins and Lewontin have stated, the pertinent contemporary theoretical division within the natural and social sciences is no longer the 19th century debate "between idealism and materialism" but now consists of "a new alignment...in which the opposing sides are reductionism and dialectics" (Richard Levins and Richard Lewontin, *The Dialectical Biologist* (Delhi: Aakar Books, 2009), 253-4).

4.1 A Temporalized and Historicized Conception of Nature

The dialectical materialism of MRT, being predicated on the materialist conception of history and the materialist conception of nature, offers *a thoroughly temporalized and historicized conception of nature and society in reciprocal development*, as opposed to theoretically treating nature as a-historical and given *gratis* and positing the relation between "nature and society as static and unchanging."[645] This temporalized and historicized materialist conception of nature was capable of incorporating, then, without contradiction, important temporally-reorienting scientific discoveries which followed its initial development chronologically, such as, for example, the concepts of Geological Time and Deep Time. In fact, Marx and Engels' dialectical materialism, given its historicized view of nature, was entirely congruent with the "revolution in ethnological time" which occurred in the mid-19th century through Darwin's theory of evolution.[646] Intimately tied to the 18th century work of Scottish scientist James Hutton and his "development of geology" which made possible accurate dating of the major periods of the Earth's history by examination of the stratification of the rock bed, this temporal revolution also enabled an "understanding of paleontological succession…[which] destroyed the old biblical clock of Genesis," and thus engendered a "sense of almost infinite time" in nature and the cosmos.[647] Geological Time, first conceptually laid out by Hutton in the 18th century, would later become Deep Time, which expanded upon the former to include not only the geological development of the Earth, but the cosmological development of the universe and the 'dating' of Earth at around 4.5 billion years old. These discoveries served to vindicate in a major way Marx and Engels' thoroughly historicized method and conception of nature. As Engels well knew, his and Marx's dialectical philosophy was by and large correct and would be proven so with further

[645] York & Mancus, "Critical Human Ecology," 132.
[646] Foster, *Marx's Ecology*, 212.
[647] Foster, *Marx's Ecology*, 212.

discoveries in time. Thus, while deprived of the relevant scientific information in his own time, Engels "insisted on explaining the world from the world itself and left the justification in detail to the natural science of the future," which, by developing the concept of Deep Time, duly obliged his request.[648] In contrast, bourgeois science, especially bourgeois physics and the theories of Political Economy and Political Ecology built upon this paradigm, offer a conception of an "atemporal world which, if created, must have been created in one fell swoop," that is, an ahistorical and detemporalized conception of nature and society.[649] Arising out of the dialectical materialist method, the historically temporalized conception of nature and society in MRT provides a stark conceptual contrast to the atemporal mechanism of bourgeois theory, particularly that of Political Ecologies such as EMT, and the dehistoricizing socio-temporality of capitalism which seeks to eternalize and absolutize the capital system, and thus functions to ideologically extricate both the evolutionary development of nature and the temporal complexities of human social development from their context within social, Geological, and Deep Time. As such, it is only through the proper historical and temporal lens of MRT that we can come to accurately understand the dialectics of nature and society and the ecological crises produced by the capitalist mode of production.

4.2 Thermodynamics and Systemic Time

A further way in which MRT moves theoretically beyond the limitations of the abstract, alienated capitalist temporality stems, again, from its divergence from the mechanistic worldview. As we have seen, the mechanistic and reductionist worldview, perpetuated in Political Ecology by EMT, and upon which Classical and Neoclassical Political Economy (i.e., capitalist economics) have been built, leads to a view "of the economic process as a mechanical analogue consisting - as all mechanical analogues do - of a

[648] Engels, *Dialectics of Nature*, 7.
[649] Prigogine and Stengers, *Order Out of Chaos*, 49.

principle of conservation (transformation) and a maximization rule. The economic science itself is thus reduced to a *timeless* kinematics."[650] These mechanistic premises lead, in turn, to the "complete failure" of capitalist Political Economics "to incorporate as basic a phenomenon as entropy into its understanding of the process of production and reproduction," and, as a result "economics is incapable of making even the first few steps toward understanding nature's changing qualitative states."[651] On the contrary, as Paul Burkett has argued, Marx's dialectical and conception of metabolism, on which MRT is founded, means that "thermodynamic and entropic concerns can be handled by a Marxian analysis of capitalist exploitation and accumulation."[652] In fact, Foster and Burkett have argued that Marx and Engels, "the founders of historical materialism…incorporated the first and second laws of thermodynamics into their analysis of capitalism," precisely through their "concept of labor power [which] was introduced in Germany by Helmholtz," one of the founders of the study of thermodynamics.[653] Indeed,

> The fact that Marx adopted the concept of labor power and used it both in its material–energetic sense and in relation to economic value analysis (i.e., the way labor power was translated into a commodity that generated surplus value for the capitalist) has led such analysts as Rabinbach and Wendling to refer to the "marriage of Marx and Helmholtz" in Marx's work and in particular in Engels's. Rabinbach points out that Marx always emphasized the energetic basis of labor power and saw it connected to thermodynamics because labor involved mechanical work.[654]

Thus, "Marx is increasingly being recognized as one of the founding figures of ecological economics."[655] The centrality of thermodynamics in Marxism has two important consequences for the development of MRT and its eco-chronopolitic: on the one hand, "the

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[650] Georgescu-Roegen, "Energy and Economic Myths," 348.
[651] Foster, *Ecology Against Capitalism*, 54.
[652] Burkett, *Marxism and Ecological Economics*, 5.
[653] John Bellamy Foster and Paul Burkett, "Classical Marxism and the Second Law of Thermodynamics: Marx/Engels, the Heat Death of the Universe Hypothesis, and the Origins of Ecological Economics," *Organization & Environment* 21, no. 1 (March 2008): 24.
[654] Foster and Burkett, "Classical Marxism and the Second Law of Thermodynamics," 25.
[655] Foster and Burkett, "Classical Marxism and the Second Law of Thermodynamics," 27.

discovery of the constructive role played by irreversibility"[656] in thermodynamics gives an energetic (i.e. material) basis to our conceptions of concrete times, in contrast to the reversibility of mechanisms such as the Newtonian paradigm, such that we can now refer to the 'arrow of entropic time' and, on the other, gives an energetic basis to Marx and Engels broader "dialectical-ecological view" of "nature and the cosmos as a complex, open, dynamic, contingent system."[657] The first consequence marks the first step to overcoming the '*timeless* kinematics' of mechanistic Political Economy, and thus to incorporate not simply a conception of temporality into economics, but a robust conception of temporality that enables us to engage with and theorize nature's changing qualitative states in a dynamic model of production and reproduction. This second consequence opens up the possibility of developing a non-linear time concept - which in certain cases contemporary physics is already adopting - known as 'systemic time.' The concept of systemic time is not "a way to conceive time from a systemic perspective, but [refers] more fundamentally to the systemic features of reality itself and thus to a grounded time."[658] This systemic time concept, sometimes called "thermodynamic time," is a "qualitative...process-related time" and "essentially systemic and internal, in contrast to the external and abstract time of the clock."[659] In other words, systemic time is the concrete time of nature, of ecosystems, as opposed to the abstract ideal of Newton's Absolute time concept which becomes the alienated time of capitalism. By recognizing nature and society as two interconnected complex thermodynamic systems, MRT can begin to theorize with a scientifically-grounded concept of dialectical temporality that enables us to contest the ways that the temporal logic of capital subsumes and/or negates the thermodynamic and biospheric temporalities of nature, and therefore enables us to develop an

[656] Prigogine and Stengers, *Order Out of Chaos*, 252.
[657] Foster and Burkett, "Classical Marxism and the Second Law Of Thermodynamics," 31.
[658] Stahel, "Time Contradictions of Capitalism," 103.
[659] Stahel, "Time Contradictions of Capitalism," 102-3.

eco-chronopolitic on the basis of a scientifically accurate, systemic understanding of the interrelation of social and natural temporalities *via* the process of socio-metabolic interaction and exchange.

4.3 Metabolic Rift Theory: An Eco-chronopolitic for Genuine Freedom, Disposable Time, and Ecological Regeneration for the Long-Term

In light of the preceding, but also importantly on the basis of the anti-capitalist perspective through which it seeks to break from and provide an ecosocialist alternative to the temporal logic and socio-temporality of capital, MRT presents a strain of Political Ecology that enables us to think of and plan for the socio-ecological long-term. Contrary to EMT, which does not seek to move beyond the bounds of capitalist accumulation and time-accounting, market forces, and the mechanistic worldview, such that its theoretical outlook, ecological solutions, strategies, and eco-chronopolitic are locked into the short-termism of capital's restricted systemic temporal horizon and so can "not think of the future, only of the immediate profit," MRT breaks from this form of temporal logic and is therefore premised on an entirely different conception of temporality and history.[660] Through a metabolic perspective, MRT conceives of social history as grounded in natural history, and although analytically differentiated by emergent social properties, always bound to the laws and boundaries of ecosystems and nature:

> Nature is [humanity's] inorganic body - nature, that is, in so far as it is not itself the human body. [Humanity] *lives* on nature - means that nature is his *body*, with which [they] must remain in continuous intercourse if [they are] not to die. That [humanity's] physical and spiritual life is linked to nature simply means that nature is linked to itself, for [humanity] is a part of nature.[661]

Contrary to this, due to its mechanistic theoretical roots, EMT substantively separates natural and social history. In the course of its development, and in accordance with the temporal logic

[660] Pannekoek, "The Destruction of Nature."
[661] Marx, "Economic and Philosophic Manuscripts of 1844," in *The Marx-Engels Reader*, 75.

of capital, bourgeois social and socio-ecological science has "reacted to an earlier Newtonian mechanism that saw nature primarily in terms of timeless, immutable laws" by declaring itself independent of natural science, which has generally led to the view that "nature stands for what is fixed and unchanging, or changing too slowly to be of direct relevance to human society."[662] MRT, in contrast, is entirely theoretically aligned with the "development of ecology and today's earth system (including climate) science [which] reflects the movement toward complex, historical, materialist, holistic forms of analysis, taking account of contingency" is thus "very far removed from the supposed mechanistic laws of Newtonian science."[663] Complementing this scientific paradigm shift, MRT, by working toward an understanding of the metabolism of society and nature as a complex, discontinuous, historical, dialectical interchange shaped the logic of a historically specific mode of production, rather than conceptualizing nature as a-historically given *gratis* and the relation of "nature and society as static and unchanging," as we have seen above, has the analytical advantage of a genuinely *historicized* conception of the nature-society relation.[664] This is extremely important, especially at this moment in our rapidly warming world, because although "natural processes have often been viewed as operating according to principles of geological time...this is rapidly changing."[665] Now, even the pace of geological time seems to belong to the past and "the air is heavy with time" as historical and extreme 'once in a generation' climate and weather disasters seem to occur at an ever-increasing rate.[666] Indeed, "Now more than ever, we inhabit the diachronic, the discordant, the inchoate...History has sprung alive, through a nature that has done likewise."[667] Thus, by temporalizing and historicizing the

[662] Foster, Clark and York, *The Ecological Rift*, 33.
[663] Foster, Clark and York, *The Ecological Rift*, 35.
[664] York & Mancus, "Critical Human Ecology," 132.
[665] Foster, Clark and York, *The Ecological Rift*, 35.
[666] Malm, *The Progress of this Storm*, 5.
[667] Malm, *The Progress of this Storm*, 11.

relationship of nature and society, MRT attempts to grasp the interconnections "between the ahistorical constraints of nature (e.g., solar input and its connection to net primary productivity) and the historically dynamic nature of social change," which itself, under capitalism, is happening at an increasingly accelerating rate.[668] Through MRTs temporal-theoretical reorientation, therefore,

> we can become aware of the thwarting caused by the immediate intended consequence of profitability, that capitalistic iron cage of calculability which consistently blinkers our awareness and realisation of remote ecological consequences of our intended economic actions.[669]

MRT, unconstrained by the temporal logic of capital, free from the short-termism of capital's restricted systemic temporal horizon, untethered from the economistic ideology that incessantly prioritizes profits over people, presents an eco-chronopolitic that can develop a temporal horizon able to consider the long-term. Further, by diverging from EMT's neoliberal faith in market forces as a reparative strategy in the face of climate collapse, MRT proposes and makes possible the conscious and intentional planning of our socio-metabolic interaction with nature, through a conscious and rational organization of production, in order to meet the material needs of people in the long-term.

A planned economy, under which the reign of capital as absolute, its temporal logic and accumulation imperative are ended, and in which the ecological boundaries and the cycles and rhythms of nature are incorporated as effective delimitations of production, opens up the possibility of organizing human labor with a view to the long-term in order to ensure the inter-generational sustenance of humanity. This would entail, necessarily, *decelerating* productive activity, and even ending a great deal of irrationally wasteful production, particularly the anti-ecological production of specifically capitalist use-values, on a mass

[668] York & Mancus, "Critical Human Ecology," 137.
[669] Eamonn Slater, "As 'Nature Works Dialectically', Explicating how Engels and Marx Analysed Climate and Climate Change Dialectically," (Maynooth: Maynooth University Social Sciences Institute, 2017): 26.

scale by "a *conscious* break with capital's mode of social metabolic control," thereby conversely increasing "the production of *free time*…as the necessary condition of emancipation," and thus turning the historical "emancipatory potentials of humanity into the liberating actuality of everyday life."[670] In this way, we can create a form of emancipation that stretches

> Beyond the mere physical necessities of food, shelter, clothing, clean water, clean air, and so on, [to] include love, family, community, meaningful work, education, cultural life, access to the natural environment, and the free and equal development of every person.[671]

Moreover, a wide-ranging deceleration and decrease in production makes possible the *bestowing of time* upon nature to allow its regeneration and recovery. In this way, through the expansion of the "*disposable time* of social individuals," genuine human freedom, freedom from the realm of natural necessity, can be socially expanded while simultaneously the relation of society and nature can be reconciled as the temporal rhythms and cycles of human production are brought more closely into line with those of nature.[672] The current ecological crises, therefore, call for a wide-ranging reorganization of social and productive time; but, again, this is only possible by a "*conscious break*" from "the tyranny of *capital's time imperative*" and its "alienating *time-accountancy*" and the implementation of "the socialist emancipatory alternative…mode of social metabolic control."[673] This set of goals must become a major component of the political agenda of ecosocialists looking to create a sustainable society in the 21st century. In a rapidly warming world, one which demands the radical transformation of every aspect of our societies, only by organizing a socio-ecological struggle on the basis of a strain of Political Ecology with an ecosocialist eco-chronopolitic capable of accounting for genuine freedom beyond natural necessity in the long-term for the

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[670] Mészáros, *The Challenge and Burden of Historical Time*, 59.
[671] Foster, "The Long Ecological Revolution."
[672] Mészáros, *The Challenge and Burden of Historical Time*, 59.
[673] Mészáros, *The Challenge and Burden of Historical Time*, 56-8.

masses can we achieve a socio-ecological transition that ensures a just, sustainable society in the present *and* for future generations. Only on this basis might we meet and transcend the challenge and burden of historical time, reconcile the metabolic rift, and thus achieve, "a conscious and rational treatment of the land [and nature] as permanent communal property, as the inalienable condition for the existence and reproduction of the chain of human generations."[674]

[674] Marx, *Capital Volume 3*, 949.

REFERENCES CITED

Adam, Barbara. *Time*. Cambridge: Polity Press, 2004.

Adam, Barbara. "Comment on 'Social Acceleration' by Hartmut Rosa." In *Constellations* 10, no.1 (2003): 49-52.

Adam, Barbara. "The Gendered Time Politics of Globalization." *Feminist Review*, no. 70, Globalization, (2002): 3-29.

Aglietta, Michel. *A Theory of Capitalist Regulation: The US Experience*. Translated by David Fernbach. New York: Verso, 1979.

Aiewsakun, Pakorn, and Aris Katzourakis. "Time-Dependent Rate Phenomenon in Viruses." *Journal of Virology* 90, no. 16 (2016), 7184–7195. doi:10.1128/jvi.00593-16.

Alcott, Blake. "Jevons' Paradox (Rebound Effect)." In *DEGROWTH: A Vocabulary for a New Era*, edited by D'Alisa, Giacomo, Federico Demaria, and Giorgos Kallis, 121-124. London: Routledge, 2015.

Altvater, Elmar. *The Future of the Market: An Essay on the Regulation of Money and Nature after the Collapse of 'Actually Existing Socialism'*. Translated by Patrick Camiller. New York: Verso, 1993.

Altvater, Elmar. "Ecological and Economic Modalities of Time and Space." In *Is Capitalism Sustainable? Political Economy and the Politics of Ecology*, edited by Martin O'Connor, 76-90. New York: The Guilford Press, 1994.

Amnesty International. "UN Landmark Case for People Displaced by Climate Change." Accessed 13 August, 2021. www.amnesty.org/en/latest/news/2020/01/un-landmark-case-for-people-displaced-by-climate-change/.

Ancient Forest Alliance. "Myths & Facts." Accessed August 26, 2018. https://ancientforestalliance.org/learn-more/myths-facts/.

Apostolidis, Paul. "Theorizing Neoliberalism with Day Laborers: The Body-Time of Dangerous Work." *Race and Ethnic Politics Colloquium*, UCLA, March 2016.

Arnold, Carrie. "Evolution Runs Faster on Short Timescales." *Quanta Magazine*, March 1, 2019. www.quantamagazine.org/evolution-runs-faster-on-short-timescales-20170314/.

Asafu-Adjaye, John, Linus Blomqvist, Stewart Brand, Barry Brook, Ruth DeFries, Erle Ellis, Christopher Foreman, David Keith, Martin Lewis, Mark Lynas, Ted Nordhaus, Roger Pielke, Jr., Rachel Pritzker, Joyashree Roy, Mark Sagoff, Michael Shellenberger, Robert Stone, and Peter Teague. *An Ecomodernist Manifesto*. Breakthrough Institute, 2015. www.ecomodernism.org/.

Bacon, J.M. "Settler Colonialism as Eco-Social Structure and the Production of Colonial Ecological Violence." *Environmental Sociology* 5, no. 1 (May 28, 2018): 59-69.

Barros, Beatriz and Richard Wilk. “The outsized carbon footprints of the super-rich.” *Sustainability: Science, Practice and Policy* 17, no. 1 (October 7, 2021): 316-322.

Baudrillard, Jean. *The Consumer Society: Myths and Structures*. London: SAGE Publications, 1998.

Beckerman, Debbie. “Wilfred Beckerman obituary.” *The Guardian*, 26 April, 2020. https://www.theguardian.com/education/2020/apr/26/wilfred-beckerman-obituary.

Benjamin, Walter. *Illuminations*. Translated by Harry Zohn. New York: Schocken Books, 2007.

Bennet CE et al. “The Broiler Chicken as a Signal of a Human Reconfigured Biosphere.” *Royal Society Open Science* 5, no.12 (December 2018): 1-11.

Benton, Ted. “Marxism and Natural Limits: An Ecological Critique and Reconstruction.” *New Left Review*, no. 178 (November 1, 1989): 51-86.

Biehl, Janet and Peter Staudenmaier. *Ecofascism Revisited: Lessons from the German Experience*. Norway: New Compass Press, 2011.

Borkenau, Franz. *Der Übergang vom feudalen zum bürgerlichen Weltbild: Studien zur Geschichte der Philosophie Manufaktur-period*. Paris: Félix Alcan, 1934.

Bracaletti, Stefano. "Temporality in Capital." In *The Government of Time*, edited by Vittorio Morfino and Peter D. Thomas, 78-116. Leiden: Brill Academic Publishers, 2017.

Bratspies, Rebecca. “Owning All the Seeds: Consolidation and Control in Agbiotech.” *Environmental Law* 47, no.3 (Summer 2017): 583-608.

Browne, Paul Leduc. “Disposable Time, Freedom, and Care.” *Science and Society* 75, no. 3 (July 2011): 297-324.

Bukharin, Nikolaĭ. *Philosophical Arabesques*. Delhi: Aakar Books, 2007.

Burkett, Paul. *Marx and Nature: A Red and Green Perspective*. Chicago: Haymarket Books, 2014.

Burkett, Paul. *Marxism and Ecological Economics: Toward a Red and Green Political Economy*. Leiden: Brill Academic Publishers, 2006.

Bustos, Keith. “Sowing the Seeds of Reason in the Field of the Terminator Debate.” *Journal of Business Ethics* 77, no. 1, Ethical Issues in the Biotechnology Industry (January 2008): 65-72.

Buttel, F.H. “Ecological Modernization as Social Theory.” *Geoforum* 31, no. 1 (February 2000): 57–65.

Caudwell, Christopher. *Studies in A Dying Culture*. London: John Lane The Bodley Head, 1938.

Caudwell, Christopher. *The Crisis in Physics*. New York: Verso, 2017.

Chappell, Bill. "Bayer To Pay More Than $10 Billion To Resolve Cancer Lawsuits Over Weedkiller Roundup." *NPR*, June 24, 2020. https://www.npr.org/2020/06/24/882949098/bayer-to-pay-more-than-10-billion-to-resolve-roundup-cancer-lawsuits.

Chatzidakis, Andreas, Jamie Hakim, Jo Littler, Catherine Rottenberg, and Lynne Segal. *The Care Manifesto: The Politics of Interdependence*. New York: Verso, 2020.

Clark, Brett and John Bellamy Foster. "Marx's Ecology in the 21st Century." *World Review of Political Economy* 1, no. 1 (March 2010): 142-156.

Clark, Colin W. "The Economics of Overexploitation." *Science* 181, no. 4100 (August 1973): 630-634.

Clausen, Rebecca, Brett Clark and Stefano B. Longo. "Metabolic Rifts and Restoration: Agricultural Crises and the Potential of Cuba's Organic, Socialist Approach to Food Production." *World Review of Political Economy* 6, no. 1 (Spring 2015): 4-32.

Coffey, Brian, and Greg Marston. "How Neoliberalism and Ecological Modernization Shaped Environmental Policy in Australia." *Journal of Environmental Policy & Planning* 15, no. 2 (January 2013): 179–199.

Curran, Giorel. "Is Renewable Energy Still Green? Shaping Australia's Renewable Energy Enterprise in an Age of Ecological Modernisation." *Environmental Politics* 28, no. 5 (August 2018): 950-969.

Dawson, Ashley. *Extinction: A Radical History*. New York: OR Books, 2016.

Dinda, Soumyananda. "Environmental Kuznets Curve Hypothesis: A Survey." *Ecological Economics* 49 (July 2004): 431-455.

Dunlap, R.E., and W.R. Catton. "Environmental Sociology." *Annual Review of Sociology* 5, no. 1 (1979): 243–273.

Duthoit, Bertille. "The Five: Genetically Modified Fruit." *The Guardian*, January 13, 2019. https://www.theguardian.com/science/2019/jan/13/the-five-genetically-modified-fruit-edited-bananas-tomatoes.

Editorial Board, The. "Eating with Our Eyes Closed." *The New York Times*, April 9, 2013. https://www.nytimes.com/2013/04/10/opinion/eating-with-our-eyes-closed.html.

Einhorn, Catrin. "Tree Planting Is Booming. Here's How That Could Help, or Harm, the Planet." *The New York Times*, March 14, 2022. https://www.nytimes.com/2022/03/14/climate/tree-planting-reforestation-climate.html.

Elden, Stuart. “Rhythmanalysis: An Introduction.” In *Rhythmanalysis: Space, Time and Everyday Life* by Henri Lefebvre. Translated by Stuart Elden, 1-10. London: Bloomsbury Academic, 2019.

Engels, Frederick. *Dialectics of Nature*. Translated by Clemens Dutt. New York: International Publishers, 1960.

Engels, Frederick. *The Condition of the Working Class in England: From Personal Observation and Authentic Sources*. London: Granada Publishing, 1981.

Engels, Friedrich. “Socialism: Utopian and Scientific.” In *The Marx-Engels Reader, Second Edition*, edited by Robert C. Tucker, 683-717. New York: W.W. Norton & Company, 1978.

Er, K.B.H and J.L Innes. “The Presence of Old-Growth Characteristics as a Criterion For Identifying Temperate Forests of High Conservation Value.” *The International Forestry Review* 5, no. 1 (March 2003): 1-8.

Fernández, Lucía. “Monsanto - statistics & facts.” *Statista*, Jul 6, 2021. https://www.statista.com/topics/2046/monsanto/#topicHeader__wrapper.

Forbes. “Profile: Weyerhaeuser Family.” 2015 America's Richest Families. Accessed May 1, 2022. https://www.forbes.com/profile/weyerhaeuser/?sh=51bce61535ec.

Foster, John Bellamy and Paul Burkett. “Classical Marxism and the Second Law Of Thermodynamics: Marx/Engels, the Heat Death of the Universe Hypothesis, and the Origins of Ecological Economics.” *Organization & Environment* 21, no. 1 (March 2008): 3-37.

Foster, John Bellamy, Brett Clark and Richard York. *The Ecological Rift: Capitalism’s War on the Earth*. New York: Monthly Review Press, 2010.

Foster, John Bellamy, Brian M. Napoletano, Brett Clark & Pedro S. Urquijo. “Henri Lefebvre’s Marxian ecological critique: recovering a foundational contribution to environmental sociology.” *Environmental Sociology* 6, no. 1 (2020): 31-41.

Foster, John Bellamy. *Ecology Against Capitalism*. New York: Monthly Review Press, 2002.

Foster, John Bellamy. *Marx’s Ecology: Materialism and Nature*. New York: Monthly Review Press, 2000.

Foster, John Bellamy. *The Return of Nature: Socialism and Ecology*. New York: Monthly Review Press, 2020.

Foster, John Bellamy. “The Ecology of Marxian Political Economy.” *Monthly Review* 63, no. 4 (September 2011), https://monthlyreview.org/2011/09/01/the-ecology-of-marxian-political-economy/#fn33.

Foster, John Bellamy. “The Long Ecological Revolution.” *Monthly Review* 69, no. 6 (November 2017), https://monthlyreview.org/2017/11/01/the-long-ecological-revolution/.

Fracchia, Joseph. “The Capitalist Labour-Process and the Body in Pain: The Corporeal Depths of Marx’s Concept of Immiseration.” *Historical Materialism* 16, no. 4 (January 2008): 35-66.

Fraser, Nancy. “Contradictions of Capital and Care.” *New Left Review* 100, no. 99 (August 1, 2016): 99-117.

Freund, Peter. “Capitalism, Time-Space, Environment, and Human Well-Being: Envisioning Ecosocialist Temporality and Spatiality.” *Capitalism Nature Socialism* 21, no.2 (June 2010): 112-121. https://doi.org/10.1080/10455752.2010.489684.

Friedman, Michael. “GMOs: Capitalism’s Distortion of Biological Processes.” *Monthly Review* 66, no. 10 (March 1, 2015). https://monthlyreview.org/2015/03/01/gmos-capitalisms-distortion-of-biological-processes/.

Fukuyama, Francis. “The End of History?” *The National Interest* 16 (Summer 1989): 1-18.

Gault, Richard. “In and Out of Time.” *Environmental Values* 4, no. 2 (May 1995): 149-166.

Georgescu-Roegen, Nicholas. *The Entropy Law and the Economic Process*. Massachusetts: Harvard University Press, 1971.

Georgescu-Roegen, Nicholas. “Energy and Economic Myths.” *Southern Economic Journal* 41, no. 3 (January 1975): 347-381.

Gibbs, David. “Sustainability Entrepreneurs, Ecopreneurs and the Development of a Sustainable Economy.” *Greener Management International*, no. 55 (Autumn 2006): 63–78.

Glover, Dominic. “Monsanto and Smallholder Farmers: A Case Study in CSR.” *Third World Quarterly* 28, no. 4, Beyond Corporate Social Responsibility? Business, Poverty and Social Justice (2007): 851-867.

Gordon, David. “The Socialists' Plan for ‘Ecological Leninism’.” *Mises Institute*. 15 December, 2020. https://mises.org/wire/socialists-plan-ecological-leninism.

Gore, Tim. *Carbon Inequality in 2030: Per capita consumption emissions and the 1.5ºC goal*. Oxford: Oxfam International and the Institute for European Environmental Policy, 2021. https://oxfamilibrary.openrepository.com/bitstream/handle/10546/621305/bn-carbon-inequality-2030-051121-en.pdf.

Görg, Christoph, Ulrich Brand, Helmut Haberl, Diana Hummel, Thomas Jahn and Stefan Liehr. “Challenges for Social-Ecological Transformations: Contributions from Social and Political Ecology.” *Sustainability* 9, no. 7 (June 2017): 1-21.

Gorz, André. “The Social Ideology of the Motorcar.” In *Ecology as Politics*. Translated by Patsy Vigderman and Jonathan Cloud, 69-76. Boston: South End Press, 1980.

Greiner, Patrick Trent. “Time, Power and Environmental Impact.” *Human Ecology Review* 25, no.1 (2019): 43-68.

Grundmann, Reiner. “The Ecological Challenge to Marxism.” New Left Review, no. 187 (May 1991): 103-120.

Hall, Jonathan, Joseph Galarraga, Isabelle Berman, Camryn Edwards, Niya Khanjar, Lucy Kavi, Rianna Murray, Kristen Burwell-Naney, Chengsheng Jiang, and Sacoby Wilson. "Environmental Injustice and Industrial Chicken Farming in Maryland." *International Journal of Environmental Research and Public Health* 18, no. 21, From Environmental Health Inequalities to Environmental Health Justice (October 2021): 11039.

Hannigan, John. “Contemporary theoretical approaches to environmental sociology.” In *Environmental Sociology*, second edition, 16-36. London: Routledge, 2006.

Harootunian, Harry. *Marx After Marx: History and Time in the Expansion of Capital*. New York: Columbia University Press, 2017.

Harvey, David. *Spaces of Global Capitalism: Towards a Theory of Uneven Geographical Development*. New York: Verso, 2006.

Harvey, David. “The Dialectics of Spacetime.” In *Dialectics for the New Century*, edited by Bertell Ollman and Tony Smith, 98-117. New York: Palgrave Macmillan, 2008.

Hassan, Robert. *Empires of Speed: Time and Acceleration of Politics and Society.* Leiden: Brill Academic Publishers, 2011.

Hayek, Friedrich von. “Individualism: True and False.” In *The Essence of Hayek*, edited by Chiaki Nishiyama and Kurt R Leube, 131-159. Stanford: Hoover Institution Press, 1984.

Hayek, Friedrich. *The Fatal Conceit: The Errors of Socialism*. London: Routledge, 1988.

Hayek, Friedrich. “The Pretence of Knowledge.” In *The Essence of Hayek*, edited by Chiaki Nishiyama and Kurt R Leube, 266-277. Stanford: Hoover International Press, 1984.

Hessen, Boris. “The Social and Economic Roots of Newton’s Principia.” In *The Social And Economic Roots Of The Scientific Revolution: Texts by Boris Hessen and Henryk Grossmann*, edited by Gideon Freudenthal and Peter Mclaughlin, 41-102. Boston: Springer, 2009.

Hicken, Margaret T., Lewis Miles, Solome Haile, and Michael Esposito. “Linking History to Contemporary State-Sanctioned Slow Violence through Cultural and Structural Racism.” *The ANNALS of the American Academy of Political and Social Science* 694, no. 1 (March 2021): 48-58.

Hirschman, Albert O. *The Passions and the Interests: Political Arguments for Capitalism before Its Triumph*. New Jersey: Princeton University Press, 1977.

Holland, John H. *Complexity: A Very Short Introduction*. Oxford: Oxford University Press, 2014.

Hornborg, Alf. "Ecological economics, Marxism, and technological progress: Some explorations of the conceptual foundations of theories of ecologically unequal exchange." *Ecological Economics* 105 (June 6, 2005): 11-18.

Huber, Joseph. "Ecological Modernization: Beyond Scarcity and Bureaucracy." In *The Ecological Modernisation Reader: Environmental Reform in Theory and Practice*, edited by Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren, 42-55. London: Routledge, 2009.

Huber, Joseph. "Ecological Modernization: Beyond Scarcity and Bureaucracy." In *The Ecological Modernisation Reader: Environmental Reform in Theory and Practice*, edited by Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren, 42–55. London: Routledge, 2009.

Huber, Joseph. "Upstreaming Environmental Action." In *The Ecological Modernisation Reader: Environmental Reform in Theory and Practice*, edited by Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren, 334-358. London: Routledge, 2009.

Huffstutter, P.J. "Sprouting a New Line of Produce Seeds." *The LA Times*, October 20, 2011. https://www.latimes.com/archives/la-xpm-2011-oct-20-la-fi-monsanto-vegetables-20111020-story.html.

Ibrahim, Darian M. "Return To Descartes: Property, Profit, and the Corporate Ownership of Animals." *Law and Contemporary Problems*, 70, no. 1, Animal Law and Policy (Winter, 2007): 89-115.

Jalas, Mikko. "The Temporal Orientations of Ecological Modernization and Sustainable Consumption." *Proceedings, Sustainable Consumption: The Contribution of Research* no. 1, edited by Hertwich, Edgar, Tania Briceno, Patrick Hofstetter, and Atsushi Inaba, 309-320. Trondheim: Norwegian University of Science and Technology, Program for Industriell Økologi, 2005.

Jameson, Fredric. *Postmodernism, or, The Cultural Logic of Late Capitalism*. New York: Verso, 1991.

Jameson, Fredric. *Representing Capital: A Commentary on Volume One*. New York: Verso, 2011.

Jameson, Fredric. "The End of Temporality." *Critical Inquiry* 29, no. 4 (Summer 2003): 695-718.

Jensen, J. Granville. "Tree Farming in The Douglas Fir Region: An Evaluation." *Yearbook of the Association of Pacific Coast Geographers* 17 (1955): 21-26.

Johnston, Adrian. “Real Reduction: The Antinomy of Georg Lukacs.” Streamed live on YouTube on February 2, 2022, at Philosophy and the Rise of Fascism - Symposium on Lukács's Destruction of Reason (Day Two). Video, 1:57:45. https://www.youtube.com/watch?v=RsP51XHFlqs.

Jorgenson, Andrew K. “The sociology of ecologically unequal exchange, foreign investment dependence and environmental load displacement: summary of the literature and implications for sustainability.” *Journal of Political Ecology* 23, *Special Edition: Ecologically Unequal Exchange and Ecological Debt*. Edited by Hornborg, Alf, and Joan Martinez-Alier (2016): 328-491.

Juday, Glenn Patrick. “Old Growth Forests: A Necessary Element of Multiple Use and Sustained Yield National Forest Management.” *Environmental Law* 8, no. 2, A Symposium On Federal Lands Forest Policy (Winter 1978): 497-522.

Kaplan, E. Ann. *Climate Trauma Foreseeing the Future in Dystopian Film and Fiction*. New Jersey: Rutgers University Press, 2016.

Kavi L, Sinisterra J, Bodenreider C, Bellay M, Ayub K, Ravichandran V, Archer J-M and Wilson S. “Environmental Justice and the Food Environment in Prince George's County, Maryland: Assessment of Three Communities.” *Frontiers in Built Environment* 5, no. 121 (October 18, 2019): 1-13.

Keen, Steve. “The appallingly bad neoclassical economics of climate change.” *Globalizations* (September, 2020): 1-29.

Klinke, Ian. “Chronopolitics: A Conceptual Matrix.” *Progress in Human Geography* 35, no. 5 (February 2013): 673-690.

Kolinjivadi, Vijay, Diana Vela Almeida, and Jonathan Martineau. “Can the planet be saved in Time? On the temporalities of socionature, the clock and the limits debate.” In *Environment and Planning E: Nature and Space* 3, no. 3 (2020): 904-926.

Koseff, Alexei. “What would Michael Shellenberger do as California governor?” Cal Matters, Elections 2022. June 6, 2022. https://calmatters.org/politics/2022/06/michael-shellenberger-california-governor/.

Landes, David S. *Revolution in Time: Clocks and the Making of the Modern World*. Cambridge: Belknap Press, 1983.

Lazzarato, Maurizio. “War, Capitalism, Ecology: Why Can’t Bruno Latour Understand Anything about Them?” *Ill Will*, April 3, 2022. https://illwill.com/war-capitalism-ecology.

Le Goff, Jacques. *Time, Work, & Culture in the Middle Ages*. Translated by Arthur Goldhammer. Chicago: The University of Chicago Press, 1980.

Leder, Drew. “Old McDonald’s Had a Farm: The Metaphysics of Factory Farming.” *Journal of Animal Ethics* 2, no. 1 (Spring 2012): 73-86.

Lefebvre, Henri. *Dialectical Materialism*. Translated by John Sturrock. Minneapolis: University of Minnesota Press, 2009.

Leiss, William. *The Domination of Nature*. Boston: Beacon Press, 1974.

Lenin, Vladimir. *V.I. Lenin Collected Works, Vol. 38*. Moscow: Progress Publishers, 1972.

Lenton, Timothy M., Hermann Held, Elmar Kriegler, Jim W. Hall, Wolfgang Lucht, Stefan Rahmstorf, and Hans Joachim Schellnhuber. "Tipping elements in the Earth's climate system." *Proceedings of the National Academy of Sciences* 105, no. 6 (February 2008): 1786-1793.

Levins, Richard and Richard Lewontin. *The Dialectical Biologist*. Delhi: Aakar Books, 2009.

Levins, Richard and Richard Lewontin. "Dialectics and Reductionism in Ecology." *Synthese* 43 (1980): 47-78.

Levins, Richard. *Talking About Trees: Science, Ecology and Agriculture in Cuba*. New Delhi: LeftWord Books, 2011.

Levins, Richard. "Dialectics and Systems Theory." In *Dialectics for the New Century*, edited by Bertell Ollman and Tony Smith, 26-49. New York: Palgrave Macmillan, 2008.

Liu, Corsa Lok Ching, Oleksandra Kuchma, Konstantin V. Krutovsky. "Mixed-species versus monocultures in plantation forestry: Development, benefits, ecosystem services and perspectives for the future." *Global Ecology and Conservation* 15 (July 2018): 1-13.

Lorenz, Edward N. "Deterministic Nonperiodic Flow." *Journal of the Atmospheric Sciences* 20 (March 1963): 130-141.

Loustaunau, Lola, Mauricio Betancourt, Brett Clark & John Bellamy Foster. "Chinese contract labor, the corporeal rift, and ecological imperialism in Peru's nineteenth-century guano boom." *The Journal of Peasant Studies* 49, no. 3 (May 2022): 511-535.

Luxemburg, Rosa. *The Crisis in the German Social-Democracy*. New York: The Socialist Publication Society, 1919.

Luyssaert, Sebastiaan, E. -Detlef Schulze, Annett Börner, Alexander Knohl, Dominik Hessenmöller, Beverly E. Law, Philippe Ciais & John Grace. "Old-Growth Forests As Global Carbon Sinks." *Nature* 455 (September 11, 2008): 213-215.

MacLean, John. "Time-saving and Karl Marx." *Justice* (14 December 1907). https://www.marxists.org/archive/maclean/works/1907-tsm.htm

Malm, Andreas and Wim Carton. "Seize the Means of Carbon Removal: The Political Economy of Direct Air Capture." *Historical Materialism* 29, no. 1 (March 2021): 3-48.

Malm, Andreas. *Corona, Climate, Chronic Emergency: War Communism in the Twenty-First Century*. New York: Verso, 2020.

Malm, Andreas. *Fossil Capital: The Rise of Steam Power and the Roots of Global Warming*. New York: Verso, 2016.

Malm, Andreas. *The Progress of this Storm: Nature and Society in a Warming World*. New York: Verso, 2018.

Martineau, Jonathan. *Time, Capitalism and Alienation: A Socio-historical Inquiry into the Making of Modern Time*. Leiden: Brill Academic Publishers, 2015.

Martineau, Jonathan. *Time, Capitalism and Alienation: A Socio-Historical Inquiry into the Making of Modern Time*. Leiden: Brill Academic Publishers, 2016.

Marx, Karl and Frederick Engels. *Marx & Engels Collected Works, Volume 11, Marx and Engels 1851-53*. London: Lawrence & Wishart, 2010.

Marx, Karl and Frederick Engels. *Marx & Engels Collected Works, Volume 20, Marx and Engels 1864-68*. London: Lawrence & Wishart, 2010.

Marx, Karl and Frederick Engels. *Marx & Engels Collected Works, Volume 25, Engels*. London: Lawrence & Wishart, 2010.

Marx, Karl and Friedrich Engels. "The German Ideology: Critique of Modern German Philosophy According to Its Representatives Feuerbach, B. Bauer and Stirner, and of German Socialism According to Its Various Prophets." In *Marx & Engels Collected Works, Volume 5, Marx and Engels 1845-47*, 19-93. London: Lawrence & Wishart, 2010.

Marx, Karl. *Capital: A Critique of Political Economy, Volume 1*. Translated by Ben Fowkes. New York: Penguin Books, 1990.

Marx, Karl. *Capital: A Critique of Political Economy, Volume 3*. Translated by David Fernbach. New York: Penguin Books, 1991.

Marx, Karl. *Grundrisse: Foundations of the Critique of Political Economy*. Translated by Martin Nicolaus. New York: Penguin Books, 1993.

Marx, Karl. *The Poverty of Philosophy: Answer to the Philosophy of Poverty by M. Proudhon*, translated by the Institute of Marxism-Leninism. Moscow: Progress Publishers, 1955. https://www.marxists.org/archive/marx/works/download/pdf/Poverty-Philosophy.pdf

Marx, Karl. "Economic and Philosophic Manuscripts of 1844." In *The Marx-Engels Reader, Second Edition*, edited by Robert C. Tucker, 66-125. New York: W.W Norton & Company, 1972.

McGee, Julius Alexander and Patrick Trent Greiner. "Racial Justice is Climate Justice: Racial Capitalism and the Fossil Economy." *Hampton Institute* (May 2020): 1-21.

McGee, Julius. “The Treadmill of Alternatively Fueled Vehicle Production.” *Human Ecology Review* 23, no. 1 (2017): 81-100.

McLaughlin, Paul. “Ecological Modernization in Evolutionary Perspective.” *Organization & Environment* 25, no. 2 (June 2012): 178-196.

McNally, David. “The Dual Form of Labour in Capitalist Society and the Struggle over Meaning: Comments on Postone.” *Historical Materialism* 12, no. 3 (November 2004): 189-208.

Meadows, Donella H., Dennis L. Meadows, Jørgen Randers, and William W. Behrens III. *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*. New York: Universe Books, 1972.

Mercker, David. *A Glossary of Common Forestry Terms*. Tennessee: Institute of Agriculture, University of Tennessee. https://extension.tennessee.edu/publications/Documents/W428.pdf.

Mészáros, István. *The Challenge and Burden of Historical Time: Socialism in the Twenty-First Century*. New York: Monthly Review Press, 2008.

Mészáros, István. *The Necessity of Social Control*. New York: Monthly Review Press, 2015.

Mishan, EJ. “Reviewed Work: In Defence of Economic Growth by Wilfred Beckerman.” In *Journal of Political Economy* 83, no.4 (1973): 873-878.

Mitchell, Melanie. *Complexity: A Guided Tour*. Oxford: Oxford University Press, 2009.

Mitchell, Melanie. “How can the study of complexity transform our understanding of the world?” *BigQuestionsOnline.com*. January, 2014, 1-5. https://melaniemitchell.me/EssaysContent/MitchellBigQuestionsEssay.pdf.

Mol, Arthur P.J. and Gert Spaargaren. “From Additions And Withdrawals To Environmental Flows: Reframing Debates in the Environmental Social Sciences.” *Organization & Environment* 18, no. 1 (March 2005): 91-107.

Mol, Arthur P.J., and David A. Sonnenfeld. “Ecological modernisation around the world: An introduction.” *Environmental Politics* 9, no.1 (2000): 1-14.

Mol, Arthur P.J., and Gert Spaargaren. “Ecological Modernisation Theory in Debate: A Review.” *Environmental Politics* 9, no. 1 (2000): 17–49.

Mol, Arthur P.J., and Martin Jänicke. “The Origins and Theoretical Foundations of Ecological Modernisation Theory.” In *The Ecological Modernisation Reader: Environmental Reform in Theory and Practice*, edited by Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren, 17-27. London: Routledge, 2009.

Mol, Arthur P.J., Gert Spaargaren, and David A. Sonnenfeld. "Ecological Modernization Theory: Taking Stock, Moving Forward." In *Handbook of Environmental Sociology*, edited by Lockie, S., D.A. Sonnenfeld, and D. Fisher, 15-30. London: Routledge, 2013.

Monbiot, George. "Meet the ecomodernists: ignorant of history and paradoxically old-fashioned." *The Guardian*, September 24, 2015. https://www.theguardian.com/environment/georgemonbiot/2015/sep/24/meet-the-ecomodernists-ignorant-of-history-and-paradoxically-old-fashioned.

Moore, Jason W. *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism*. Oakland: PM Press, 2016.

Moynihan, Colin. "A New York Clock That Told Time Now Tells the Time Remaining." *New York Times*, 20 September, 2020. https://www.nytimes.com/2020/09/20/arts/design/climate-clock-metronome-nyc.html.

Mumford, Lewis. *Technics and Civilization*. London: Routledge & Kegan Paul Ltd, 1955.

Neate, Rupert. "Elon Musk Pledges $100m to Carbon Capture Contest." *The Guardian*, 8 February, 2021. www.theguardian.com/environment/2021/feb/08/elon-musk-pledges-100m-to-carbon-capture-contest.

Newton, Isaac. *Newton's Philosophy of Nature: Selections from His Writings*, edited by H.S. Thayer. New York: Hafner Publishing Company, 1960.

Newton, Isaac. *Newton's Principia: The Mathematical Principles of Natural Philosophy*. Translated by Andrew Motte. New York: Daniel Adee, 1846.

Niiler, Eric. "Terminator Technology Temporarily Terminated." *Nature Biotechnology* 17, (November 1999): 1054.

Nixon, Rob. *Slow Violence and the Environmentalism of the Poor*. Massachusetts: Harvard University Press, 2011.

Osborne, Peter. *The Politics of Time: Modernity and Avant-Garde*. New York: Verso, 1995.

Pannekoek, Anton. "The Destruction of Nature." In *Zeitungskorrespondenz* 75 (10 July 1909). Translator unknown. https://www.worldsocialism.org/spgb/socialist-standard/2010s/2019/no-1380-august-2019/the-destruction-of-nature-by-anton-pannekoek/

Pineault, Eric. "Growth and Overaccumulation in Advanced Capitalism: Some Critical Reflections on the Political Economy and Ecological Economics of Degrowth." *DFG-Kolleg Postwachstumsgesellschaften*, no. 5 (2016).

Postone, Moishe. *Time, Labor, and Social Domination: A Reinterpretation of Marx's Critical Theory*. Cambridge: Cambridge University Press, 2003.

Powell, Lisa M., Sandy Slater, Donka Mirtcheva, Yanjun Bao, Frank J. Chaloupka. "Food Store Availability and Neighborhood Characteristics in the United States." *Preventative Medicine* 44, no. 3 (March 2007): 189-195.

Prigogine, Ilya and Isabelle Stengers. *Order Out of Chaos: Man's New Dialogue with Nature*. New York: Bantam Books, 1984.

Proyect, Louis. "Review - Philosophical Arabesques." Review of *Philosophical Arabesques* by Nicolai Bukharin. *Marxists.org*, October 30, 2011. www.marxists.org/history/etol/revhist/backiss/vol9/no2/proyect.html.

Pulido, Laura. "Geographies of Race and Ethnicity II: Environmental Racism, Racial Capitalism and State-Sanctioned Violence." *Progress in Human Geography* 41, no. 4 (August 2017): 524-533.

Rifkin, Jeremy. *Time Wars: The Primary Conflict in Human History*. New York: Henry Holt and Company, 1987.

Rockström, Johan, Will Steffen, Kevin Noone, Åsa Persson, F. Stuart Chapin, III, Eric F. Lambin, Timothy M. Lenton, et al. "A safe operating space for humanity." *Nature* 461, (24 September 2009): 472–475. https://doi.org/10.1038/461472a.

Romm, Joe. "Carbon Capture and Storage: One Step Forward, One Step Back." *Resilience* (October 2013). https://www.resilience.org/stories/2013-10-15/carbon-capture-and-storage-one-step-forward-one-step-back/.

Rosa, Hartmut. *Social Acceleration: A New Theory of Modernity*. Translated by Jonathan Trejo-Mathys. New York: Columbia University Press, 2013.

Rosa, Hartmut. "Social Acceleration: Ethical and Political Consequences of a Desynchronized High-Speed Society." *Constellations* 10, no. 1 (2003): 3–33. doi:10.1111/1467-8675.00309.

Ruffing, Kenneth. "Indicators to Measure Decoupling of Environmental Pressure from Economic Growth." *The OECD Environment Programme*. https://www.oecd.org/env/indicators-modelling-outlooks/1933638.pdf.

Salleh, Ariel. "Climate Strategy: Making the Choice Between Ecological Modernisation or Living Well." *Journal of Australian Political Economy* 66 (December 2010): 118-143.

Sanghera, Gulzar S. et al. "Engineering Cold Stress Tolerance in Crop Plants." *Current Genomics* 12, no. 1 (March 2011): 30-43.

Schibler, Ueli, Juergen A. Ripperger and Steven A. Brown. "Chronobiology: Reducing Time." *Science: American Association for the Advancement of Science* 293, no. 5529 (July 2001): 437–38. http://www.jstor.org/stable/3084076.

Sheehan, Helena M. “J D Bernal: philosophy, politics and the science of science.” *Journal of Physics* Vol. 57, Issue 1, Conference Series; Bristol (Feb 2007): 29-39. doi:10.1088/1742-6596/57/1/003.

Sheehan, Helena M. “Marxism, Science, and Science Studies.” *Monthly Review* Vol. 74, no. 1 (May 2022). https://monthlyreview.org/2022/05/01/marxism-science-and-science-studies/.

Sheehan, Helena. *Marxism and the Philosophy of Science: A Critical History, The First Hundred Years*. New York: Verso, 2017.

Skuce, Andy. “‘We’d have to finish one new facility every working day for the next 70 years’ - Why carbon capture is no panacea.” *Bulletin of the Atomic Scientists* (October 4, 2016). https://thebulletin.org/2016/10/wed-have-to-finish-one-new-facility-every-working-day-for-the-next-70-years-why-carbon-capture-is-no-panacea/.

Slater, Eamonn. “As ‘Nature Works Dialectically’, Explicating how Engels and Marx Analysed Climate and Climate Change Dialectically.” (Maynooth: Maynooth University Social Sciences Institute, 2017): 1-31.

Smil, Vaclav. “Energy at the Crossroads.” *OECD Global Science Forum: Conference on Scientific Challenges for Energy Research* (May 2006): 1-27.

Smil, Vaclav. “Global Energy: The Latest Infatuations.” *American Scientist* 99, no. 3 (May 2011): 212-219.

Smith, Adam. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Oxford: Oxford university Press, 1993.

Spaargaren, Gert, and A.P.J. Mol. “Sociology, Environment, and Modernity: Ecological Modernization as a Theory of Social Change.” In *The Ecological Modernisation Reader: Environmental Reform in Theory and Practice*, edited by Mol, A.P.J., D.A. Sonnenfeld, and G. Spaargaren, 56-79. London: Routledge, 2009.

Specter, Michael. “Seeds of Doubt: An Activist’s Controversial Crusade Against Genetically Modified Crops.” *The New Yorker*, August 18, 2014. https://www.newyorker.com/magazine/2014/08/25/seeds-of-doubt.

Srinivasan, C.S., and Colin Thirtle. “Potential Economic Impacts of Terminator Technologies: Policy Implications for Developing Countries.” *Environment and Development Economics* 8, no. 1 (February 2003): 187-205.

Stahel, Andri W. “Time Contradictions of Capitalism.” *Capitalism, Nature, Socialism* 10, no. 1 (March 1999): 101-132.

Steffen, Will, Johan Rockström, Katherine Richardson, Timothy M. Lenton, Carl Folke, Diana Liverman, Colin P. Summerhayes, et al. “Trajectories of the Earth System in the Anthropocene.” *Proceedings of the National Academy of Sciences* 115, no. 33 (August 2018): 1-8.

Steffen, Will, Wendy Broadgate, Lisa Deutsch, Owen Gaffney, and Cornelia Ludwig. “The trajectory of the Anthropocene: The Great Acceleration.” *The Anthropocene Review* 2, no. 1 (January 2015): 81-98.

Stern, David I. “The Rise and Fall of the Environmental Kuznets Curve.” *World Development* 32, no. 8 (August 2004): 1419-1439.

Strittholt, James R., Dominick A. Dellasala and Hong Jiang. “Status of Mature and Old-Growth Forests in the Pacific Northwest.” *Conservation Biology* 20, no. 2 (April 2006): 363-374.

Taylor, Frederick Winslow. *The Principles of Scientific Management*. New York: Harper & Brother Publishes, 1919.

Thompson, E.P. “Time, Work-Discipline, and Industrial Capitalism.” *Past & Present*, no. 38 (December, 1967): 56-97.

Tomba, Massimiliano. *Marx’s Temporalities*. Translated by Peter D. Thomas and Sara R. Farris. Leiden: Brill Academic Publishers, 2013.

Tomba, Massimiliano. “Time.” *The SAGE Handbook of Marxism Volume 1*, edited by Beverley Skeggs, Sara R. Farris, Alberto Toscano and Svenja Bromberg, 491-506. Los Angeles: SAGE, 2022.

Toulmin, Stephen. “Criticism in the History of Science: Newton on Absolute Space, Time, and Motion, I.” *The Philosophical Review* 68, no. 1 (January 1959): 1-29.

United States Department of Agriculture, Forest Service Old-Growth Definition Task Group. *Interim Definitions for Old-Growth Douglas-Fir and Mixed-Conifer Forests in the Pacific Northwest and California*. July 1986. https://www.fs.fed.us/pnw/pubs/pnw_rn447.pdf.

Vadéna, T., V. Lähde, A. Majava, P. Järvensivu, T. Toivanen, E. Hakala, and J.T. Eronen. “Decoupling for ecological sustainability: A categorisation and review of research literature.” *Environmental Science and Policy* 112 (July 2020): 236-244.

Wallis, George W. “Chronopolitics: The Impact of Time Perspectives on the Dynamics of Change.” *Social Forces* 49, no. 1 (1970): 102-108. doi:10.2307/2575743.

Wan, Poe Yu-ze. *Reframing the Social: Emergentist Systemism and Social Theory*. London: Routledge, 2011.

Wan, Poe Yu-ze. “Dialectics, Complexity, and the Systemic Approach: Toward a Critical Reconciliation.” *Philosophy of the Social Sciences* 43, no. 4 (2012): 411-452. DOI: 10.1177/0048393112441974.

Westminster Abbey. “Sir Isaac Newton.” Accessed April 26, 2022. https://www.westminster-abbey.org/abbey-commemorations/commemorations/sir-isaac-newton.

Weyerhaeuser Company. “History. Since 1900.” Accessed May 1, 2022. https://www.weyerhaeuser.com/company/history/#23.

Whyte, Jessica. *The Morals of the Market: Human Rights and the Rise of Neoliberalism*. New York: Verso, 2019.

Wilson, Wilbor O. “Poultry Production.” *Scientific American* 215, no. 1 (July 1966): 56-67.

Wood, Charles H. “Time, Cycles and Tempos in Social-Ecological Research and Environmental Policy.” *Time & Society* 17, no. 2/3 (2008): 261–282. doi:10.1177/0961463x08093425.

Wood, Roger J., and Vítězslav Orel. “Scientific Breeding in Central Europe during the Early Nineteenth Century: Background to Mendel’s Later Work.” *Journal of the History of Biology* 38, no. 2 (2005): 239–72.

York, Richard and Brett Clark. “The Problem with Prediction: Contingency, Emergence, and the Reification of Projections.” *The Sociological Quarterly* 48, no.4 (Fall 2007): 713-743.

York, Richard and Julius Alexander McGee. “Understanding the Jevons Paradox.” *Environmental Sociology* (December 2015): 1-11.

York, Richard and Julius Alexander McGee. “Understanding the Jevons Paradox.” *Environmental Sociology* 2, no. 1 (December 2015): 1-11.

York, Richard and Philip Mancus. “Critical Human Ecology: Historical Materialism and Natural Laws.” *Sociological Theory* 27, no. 2 (June 2009): 122-149.

York, Richard, and Eugene A. Rosa. “Key Challenges to Ecological Modernization Theory: Institutional Efficacy, Case Study Evidence, Units of Analysis, and the Pace of Eco-Efficiency.” *Organization & Environment* 16, no. 3 (September 2003): 273–288.

York, Richard, Eugene A. Rosa, and Thomas Dietz. “Footprints on the Earth: The Environmental Consequences of Modernity.” *American Sociological Review* 68, no. 2 (April 2003): 279-300.

York, Richard. “Carbon metabolism: Global capitalism, climate change, and the biospheric rift.” *Theory and Society* 34, no. 4 (August 2005): 391-428.