Sociopoiesis: How Marx and Autopoiesis May Help Understand Our Relationship with Nature

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How Marx and Autopoiesis May Help Understand Our Relationship with Nature

by

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Paul Prew is an assistant professor at Minnesota State University – Mankato. His research interests vary widely from international political economy to the new sciences of complexity. He is very interested in issues of environmental degradation and has taken numerous trips to Ecuador to better understand how oil extraction and global economic processes are changing indigenous societies in the rainforest. At present, he is analyzing how teaching with a critical sociology perspective has negative impacts on student evaluations.

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Abstract:
Increasing concern for global climate change and other socially caused environmental issues demands a deeper understanding the relationship between society and nature. While the environment is becoming more prominent in social science analysis, the integration of social science perspectives with the natural sciences is slow to develop. Previous research in the social and natural sciences tends to ignore people's relationship with nature when combining the two disciplines. I propose a term, "sociopoiesis" to initiate an integration of the two fields that combines social analysis with the new sciences of complexity, specifically autopoiesis. With this new term, we can begin to contemplate how to create a future sustainable society.

Keywords: sustainability, environment, complexity, Marx, autopoiesis, metabolism

Introduction

The world appears to be facing an environmental crisis and potential climatic transition within the next millennium. Understanding our relationship with nature is paramount to understanding the sources of change and allowing people the potential to avoid the worst possible scenarios. While people would not knowingly and willingly rush headlong into unnecessary peril, our contemporary society provides stark examples of collectively suicidal behavior. Perhaps the most poignant illustration is the rush to exploit Arctic resources as glacial melting uncovers land and sea previously inaccessible (Krauss et al. 2005). As the connections between socially produced greenhouse gases such as carbon dioxide become ever more evident, the idea that institutions within society would pursue the extraction of more greenhouse gas emitting resources in a region ravaged by the effects of global warming would be considered pathologically irrational outside of a society that places profit above social preservation.

Opponents of the concepts of global warming and global climate change (the more precise definition of the problem) are able to capitalize on the complexity of the issue. Detractors claim that the extent, timing and causes of climate change are uncertain (Bush 2001). It is true that climate and weather patterns over thousands of years do not follow regular, *precisely* predicable patterns, but change can occur suddenly and quickly (Mayewski and White 2002). However, long-term trends are discernable even if future climatic conditions are not immediately predictable. Despite the unpredictable nature of climate change, contemporary scientific evidence is overwhelmingly stacked in support of serious climatic changes in the future as a result of social actions (Houghton et al. 2001). Some now even claim that the climate system has past a "point of no return" where change is now almost inevitable based on the changes already occurring in the atmosphere, land and sea (Solomon et al. 2009).

While global warming is but one environmental issue facing society, it illustrates the necessity of integrating the natural sciences' understanding of the environmental processes involved in environmental issues with the social sciences' analysis of how social systems bring about the problems that we currently face. I argue that this integration could be facilitated by the term, "sociopoiesis" that endemically incorporates both fields of scientific endeavor. Sociopoiesis is a term derived from the natural science term "autopoiesis" but recognizes the fundamental differences between societies and living organisms by including "socio" to represent the social aspect of our interaction with nature.

Complexity and Dialectical Thought

While understanding climate change has benefited from the expanding sciences of complexity, the integration of complexity and the role of society with respect to these issues is slow in developing. The sciences of complexity arise out of a variety of sources. While attempting to model weather patterns, Edward Lorenz (Capra 1996:134) contributed the notion of the "butterfly effect" where small changes can lead to dramatically different results. In the discipline of physics, Ilya Prigogine and Isabelle Stengers (1984) argued that non-linearity and far-from-equilibrium systems were the norm, in contrast to linear, equilibrium models. Humberto Maturana and Francisco Varela (1980) began to investigate the notion of cognition and the definition of living organisms, developing the concept of "autopoietic" systems along the way.

Many of the fundamental ideas of complexity are not new, but the advent of computers and a renewal of previous research have germinated a relatively coherent body of literature recognized as "new sciences," "chaos," or "complexity" studies (Bird 2003; Briggs and Peat 1990; Gleick

1987; Nicolis and Prigogine 1989). Many complexity authors openly express a struggle against the mechanism of traditional science (Capra 1996:5; Lovelock 2006:5; Prigogine and Stengers 1984:7), but the debates are not new between the purported dichotomies of mechanism-complexity, reductionism-holism, and quantity-quality. Some early social philosophers contemplated the notion that we cannot understand the parts without understanding how they are situated in the complex interactions of the whole. While some authors like Stuart Kauffman (1995:69) resonate with Immanuel Kant, I hear an echo of Karl Marx (1973:100) from over 150 years ago. "Thus if I were to begin with the population, this would be a chaotic conception of the whole, and I would then, by means of further determination, move analytically towards ever more simple concepts, from the imagined concrete towards ever thinner abstractions until I had arrived at the simplest determinations. From there the journey would have to be retraced until I had finally arrived at the population again, but this time not as a chaotic conception of a whole, but as a rich totality of many determinations and relations." This "dialectical" approach not only attempts to understand the parts and the relationship between the parts, it attempts to develop an understanding of the totality of the object being studied as a complex interaction of those parts. In addition, the reality of a world is understood only by studying both the material (structural) and relational components.

Intimately connected with this dialectical method is the understanding that society can only be comprehended in its interchange with nature. As Marx (1977:173) argues, people are conditioned by the environment they encounter, while at the same time they change their own environment. These socially mediated changes, and naturally shifting environmental circumstances, prompt social responses in a dialectical movement between nature and society, neither determining the other, but intimately tied in mutually influencing relations.

Even in the mid-nineteenth century, understanding this relationship was central to Marx's analysis of his contemporary society. At present, recognizing our "dialectical" relationship with nature is of utmost importance in an era of biotechnology, socially induced climate change, chemical pollution, and geographical expansion into nearly every corner of the earth.

To offer a glimpse of what Marx had to offer with respect to our understanding of the environment, perhaps it would be beneficial to provide a few select quotes from Marx and his writing partner and editor, Frederick Engels:

> "Labor is, first of all, a process between [people] and nature, a process by which [people], through [their] own actions, mediate, regulate, and control the metabolism between [themselves] and Nature" (Marx 1977:283).

> "The life of the species, both in [people] and in animals, consists physically in the fact that [people] (like the animal) live on inorganic nature" (Marx 1971a:112).

> "Thus nature becomes one of the organs of [people's] activity, which [they] annex to [their] own bodily organs" (Marx 1977:285).

> "The universality of [people] appears in practice precisely in the universality which makes all nature [their] *inorganic* body–both inasmuch as nature is (1) [their] direct means of life, and (2) the material, the object and the instrument of [their] life activity. Nature is [people's] *inorganic body*–nature, that is, in so far as it is not itself the human body. [People] *live* on nature–means that nature is [their] *body*, with which [they] must remain in continuous interchange if [they are] not to die. That [people's] physical and spiritual life is linked to nature means simply that nature is linked to itself, for [people are] a part of nature" (Marx 1971a:112 italics in original).

> "[People] also react on nature, changing it and creating new conditions of existence for [themselves]" (Engels 1940:172).

> "Through this movement [people] act upon external nature and change it, and in this way [people] simultaneously change [their] own nature" (Marx 1977:173).

Karl Marx and Frederick Engels' contributions to the understanding of people's relation with nature are both invaluable but also severely compromised by a long history of misappropriation and counter-productive erroneous interpretation, if not outright ignorance. Marx's contribution to our understanding of the environment has recently been reinvigorated (Burkett 1999; Foster

1997a; Foster 1997b; Foster 1999; Foster 2000), and the integration of complexity sciences with social issues is also on the rise (Kiel and Elliott 1997). However, a number of interpretations of complexity sciences exist, and it is not without its critics (Clark and York 2005; Levins and Lewontin 1985). Agreement on the basic concepts is not a given in all of the various literatures. The literature of complexity studies is wide ranging and deep and is often confused with its predecessors in ecology and other sciences focusing on complex network models.

Critical Assessment of Complexity

Richard Levins and Richard Lewontin (1985:16-21) offer a trenchant critique of complexity in evolutionary theory. First, the authors contend certain evolutionary theorists use the notion of complexity to state more "complex" organisms are more advanced. Second, they argue complexity implies stability. Although Levins and Lewontin's analysis represent an arguably valid criticism of certain strains of evolutionary biology, it is certainly not an accurate critique of many of the ideas contained under the rubric complexity studies such as dissipative and autopoietic structures (Maturana and Varela 1980; Prigogine and Stengers 1997) or symbiogenesis (Margulis and Sagan 2002). Those not familiar with the alternative uses of the concept "complexity" may develop distorted perceptions about its validity and applicability when reading critiques by authors like Levins and Lewontin. The variety of research that falls under the general rubric of complexity studies needs to be confronted critically, but it must also be analyzed and understood as a diverse body of literature which has made significant contributions to understanding the physical, and possibly the social, world.

The intersection of complexity and social sciences is potentially a source of groundbreaking research. The application of complexity ideas to social systems is not new, given that some central authors, such as Maturana and Varela (1980), attempted to analyze the relation between the two in their very earliest works. Contemporarily, the integration of the two disciplines is occurring by authors who hail from both the social and complexity fields (Buchanan 2002; Capra 2002; Harvey and Reed 1994; Johnson 2001; Kauffman 2000; Kiel and Elliott 1997; Luhmann 1995). There are a number of pitfalls when attempting this integration: focusing on the symbolic nature of societies, using uncertainty as an excuse for inaction, ahistoricizing society by applying complexity concepts, and using definitions from one branch of science in ways that are not consistent with their original use.

The first is a common problem to most of the literature: focusing on the symbolic nature of people's social organization to the exclusion of the material-energetic exchange with nature (Buchanan 2002; Byrne 1998; Capra 2002; Faber and Koppelaar 1994; Gregersen and Sailer 1993; Johnson 2001; Kiel and Elliott 1997; Loye and Eisler 1987; Luhmann 1995; Reed and Harvey 1992) with some notable exceptions (Georgescu-Roegen 1971; Prew 2003; Straussfogel 1997; Worster 1997). As one example of the symbolic focus, the work of Niklas Luhmann (1995) uses the concept of autopoiesis as a means to theorize social interaction. Luhmann attempts to argue that social systems are autopoietic, but focuses on the symbolic nature of human interaction. Autopoietic systems are defined physically, although they comprise a cognitive component. Autopoietic systems "structurally couple" with their environment. In other words, organisms sense and respond to elements and conditions in their environment. Luhmann follows closely Maturana and Varela's focus on cognition and the concept of structural coupling. Maturana and Varela (1980xxviii) specifically discuss structural coupling of individuals to society, "[t]o grow as a member of a society is to be structurally coupled to it," but no discussion in Luhmann or Maturana and Varela detail or address the structural coupling of a society to their environment. While critique and discussion of the relevance of the concept of autopoiesis to social interaction is potentially illuminating, the debate and discussion tends to avoid the fundamental issue for Maturana and Varela which is the structural coupling with the environment. The point of interchange between society and the environment is where I believe the most enlightening work is to be accomplished, and it is regrettable that authors from the physical sciences have succumbed to the fallacy inherent in most prior endeavors of the social sciences that people are somehow abstracted from their relation with the environment (Catton and Dunlap 1978).

Few authors who integrate complexity and social sciences acknowledge the material/energetic relationship with nature as a part of human society. The vast majority of the fault lies with mainstream sociology, political science and economics that do not include the environment in their equations, let alone recognize social systems as part of the environment, being shaped by the environment and shaping it. Naturally, physical scientists wishing to add "social" factors to their studies assume society is merely symbolic - a set of social relations in the cognitive realm - since social scientists have tended to exclude, neglect or externalize the environment in their own analyses (Catton and Dunlap 1980; Catton and Dunlap 1978).

Another possible problem arises when authors use the notion of uncertainty to justify inaction with respect to some issue. The logic goes, "the world is too complex, so whatever actions we take may have detrimental effects." Complexity and uncertainty are used as a means to argue that the future is so uncertain that any action attempting to solve problems could result in greater harm than continuing our current means of interaction with nature. In fact, George W. Bush posits this very excuse to move cautiously regarding global climate change, "For example, our useful efforts to reduce sulfur emissions may have actually increased warming because sulfate particles reflect sunlight, bouncing it back into space" (Bush 2001:635).

Another problem occurs when authors (typically natural scientists) attempt to apply complexity concepts to social issues. Complexity concepts are used to attempt to explain social phenomena, but in doing so, the author strips the social phenomena of its historical specificity and causal understanding. For example, emergence is used to understand why a story involving Gennifer Flowers and Bill Clinton received extensive press coverage (Johnson 2001). According to Steven Johnson, the cable explosion of the 1980's led to a feedback that "started to reverberate on its own" (Johnson 2001:145). Johnson's argument fails to explain how very similar issues receive systematiclly inequitable coverage. "A Nexis search, for example, reveals that 13,641 stories focused on Clinton avoiding the military draft but a mere 49 stories featured Bush having his powerful father use influence to get him into the Texas Air National Guard instead of the draft" (McChesney 2004:118). Emergence alone cannot explain the obvious discrepancy in these two figures. To understand the gaping divide in press coverage between Clinton and Bush, one must rely on social-historical theory and analysis.

Frijof Capra provides another example of the limitations of relying solely on complexity explanations. Capra (2002:140) compares the economic panic and collapse during the Asian crisis in 1997 to living systems. While the instability of the market could be compared to "multiple feedback loops operating far from equilibrium," application of complexity concepts could never divine why specifically Thailand at this historic moment in time experienced economic crisis as opposed to Iceland, Belgium or Mexico. The instability in social systems is a result of the tide of a variety of forces including social movements, media manipulation, economic imperialist pressures and even natural events like the 2004 tsunami. The Asian crisis was in no way inevitable as a result of the laws of complexity, even if the pattern of the crisis mimics certain concepts in complexity studies.

There are very real reasons why there are so many connections between social issues and these ideas, but what is not apparent is that physical systems and social systems are qualitatively different systems. For example, the aggregation of slime mold at times of resource depletion could be compared to a food riots. Slime mold cells respond in a positive feedback loop to hunger that drives their aggregation (Johnson 2001:13). Very little distinguishes one aggregation phase from another. Food riots could be viewed as simple aggregation phases and positive feedbacks, but a food riot is part of a complex set of social relations and may have many causes. In Haiti, the riot may be the result of IMF policies that dramatically increase the price of food, while in India, people may be responding to the planting of genetically modified trees in regions of threatened food self-sufficiency. Both are riots, but their causal mechanisms are distinct, and even the responses by "legitimate" power may be quite different. By complexity standards, it could be mathematically argued that the formation of a riot is an illustration of positive feedback, but what it does not tell the social theorist is why, when, and where these riots will occur. These issues are all part of historical contingency.

Another pitfall of integrating the different disciplines is the use of terminology in ways that are contrary to their disciplinary-specific definitions. Terminology has its own problems including the use of terms without acknowledging their sometimes nefarious origins (Malthusian population analysis (Foster 1998), for example), creating language so specific that lay persons and other disciplines are excluded from the conversation, and the use of the same terms by different disciplines with radically different interpretations. Luhmann (1995), for example, uses the term autopoietic in a sense that deviates from the original usage by Maturana and Varela

(1980). I must urge a certain degree of strictness when applying the language and concepts of complexity studies to the social sciences. Too often, metaphor supplants scientific rigor. Below, I will more thoroughly analyze the term autopoiesis in relation to social systems.

True interdisciplinary work integrates the various elements, social and physical, in a singular woven rug as opposed to a crazy patchwork quilt of loosely conjoined conceptual frameworks. Perhaps this is the beauty of Marx who wrote prior to the fracturing of political economy into insular disciplines such as political science, sociology and "vulgar political economy," as he called economics (Marx 1971b). Political economy included issues of agriculture, population, trade, class, the state, ecology, as well as others in its social analysis.

We are an intimate part of our environment and, importantly, do not interact with our environment as mere rational calculating *individuals* as "vulgar" economists would have us believe. With only the rarest exceptions, people interact with the environment solely in a social context. How we interact (I hesitate to use the term structurally couple at this point) with the environment is governed by our social relations, which are not, in fact, merely symbolic but derived from a dialectical relationship with nature as argued by Marx (stated above). Societies, as collections of people who are individually autopoietic entities, maintain their complexity due to the flux of matter and energy through the social structure. The totality of the contemporary society's environmental flux greatly exceeds the productive capacity of the biosphere by most accounts of matter/energy flow, for example Net Primary Productivity (Dukes 2003; Vitousek et al. 1986), Social Metabolism (Fischer-Kowalski 1998; Fischer-Kowalski 1999), and Ecological Footprint (Wackernagel et al. 1999; Wackernagel and Rees 1996; Wackernagel et al. 2002).

Not only is the current society "overshooting" (Catton 1980) the finite limits, it is creating an extensive and intensive "metabolic rift" (Foster 1999; Marx 1977:637; Marx 1981:431; Prew

2003). Extensively as one example, various nutrients in the soil are depleted in the agricultural regions of the world to be cycled through urban areas and deposited as waste in landfills and various environmental "sinks." Intensively, use of fossil fuels takes advantage of the energetic properties of carbon sequestered hundreds of millions of years ago, releasing the stored carbon in a time frame that is orders of magnitude shorter than it took to produce. Because of the rifts generated by these social activities, both of these processes disrupt (or perturb) systems, namely soil composition and climate, that have coevolved over millennia.

Sociopoiesis: Are Societies Autopoietic?

In an attempt to better understand why our society is overshooting the limits of its material-energetic sources, I propose to integrate the concepts of metabolism in Marx (1977) and autopoiesis by Maturana and Varela (1980). To begin this integration, we must first answer the question, "are social systems autopoietic systems?" To be considered autopoietic by the authors who coined the term, a number of criteria must be met. In addition, the notion of a social system being autopoietic must meet these criteria on the terms in which they were initially defined.

Autopoiesis is a term coined by Maturana and Varela (1980) to address the question, "What is life?" They attempted to outline what describes a living system. Gail Fleischaker has distilled the ideas of Maturana and Varela into three basic criteria. To be considered autopoietic, a system must be "self-bounded, self-generating, and self-perpetuating" (Capra 1996:208). Self-bounding refers to the existence of a boundary to the system that is integrally related to the network. Self-generation is the production, within the network itself, of all of the components necessary for the system's operation. To be self-perpetuating, the system must be capable of replacing and maintaining the components of the system. Another element crucial to autopoietic systems relates to their nature as dissipative structures. Lynn Margulis (1997:267-9) argues that an external supply of raw materials and energy are necessary for the functioning of the system through the process of metabolism. “Autopoietic systems metabolize, whereas nonautopoietic systems do not” (Margulis 1997:269).

Taking these criteria one by one, how do societies compare to autopoietic systems? The first question involves the issue of self-boundedness is probably the most challenging. What is the boundary to a society? Social sciences have always had difficulty precisely defining the limits of concepts such as nation state, culture, society, family, etc. One could argue that what defines the boundaries of “society” is the when the interaction with nature is guided under a single, unitary logic. A unitary logic is not an “ethic” or ideal, but a specific set of relationships of production, distribution and exchange based on a singular, underlying principle of organization. Under capitalism, accumulation for accumulation’s sake drives the production, distribution and exchange processes. Within a gather/hunter community, the production, distribution and exchange processes are governed by the accessibility of varied sources of food and shelter. While capitalists, and capitalism, can go merrily along after decimating a local ecosystem, gather/hunter societies cannot be as nonchalant about their local environment. Unfortunately, using this definition describes the *type* of society and its interaction with nature. The type of society is very important for understanding people’s relation with nature, but it does not solve the problem of boundedness.

The above definition leaves open the possibility for distant, and even isolated, groups to be considered part of the same society. Should a gather/hunter community in Australia be considered within the same society as another community of gather/hunters in Madagascar? The problem of isolated communities of the same “society” also illustrates the second problem.

Societies do not have *physical* boundaries. Maturana and Varela (1980) were speaking of truly physical boundaries such as a cell wall in a unicellular organism or the epidermis of a mammal. Self-bounding requires a regulation of the interchange between the organism and the surrounding environment that crosses a physical barrier. Societies simply lack a true physical boundary that demarcates and regulates the exchange between the society and the surrounding environment.

Raw material and energy are cycled through societies based on their organizing logic, but the boundaries of the society are not physical. Exchange may occur between two communities whether they are organized in the same manner or not, but the exchange does not occur across a physical barrier. Likewise, the productions of nature do not cross a physical barrier in order to be transformed by society into its necessary constituent parts. Even if materials are brought within a factory, the factory does not contain the society and is not integral to the functioning of the totality of the society. Another possible way to approach the boundary issue is to view all of the world's human inhabitants as part of the same society. The boundaries of the world social system could be argued to include the earth and the atmosphere, but this would also be stretching the concept of boundary as defined by Maturana and Varela (1980). If societies had physical barriers that were integral parts of the societies, it would be easy to distinguish societies with similar unitary logics, but they do not, hence there exists a significant problem of applying the concept of autopoiesis to societies. Luhmann's (1995) application of autopoiesis to society does not acknowledge the boundary condition in the original definition. Luhmann relies on the notion of "organizational closure" described by Varela (Capra 1996:212), but does not resolve the fundamental problem of physical boundaries. The previous arguments about society being an autopoietic system do not diminish the potential for looking at society in new ways, but it illustrates the problem with adapting material science terms whole-cloth to the social sciences.

The second criterion addresses the issue of whether societies are capable of generating all of the components necessary for the system's operation within the society. Self-generation of the elements necessary for a society may also pose a difficult question. What is meant by an element necessary for a society? Obviously this would depend greatly on the society in question. In capitalist society, there exist a number of structural elements necessary for the reproduction of its members including markets, transportation systems, production facilities, urban shelter, etc. What elements do we consider in a gather/hunter community that produces little beyond what is necessary to obtain food and temporary shelter? By definition, gather/hunter communities do not "produce" their own food, but collect it from nature. Despite the simple nature of production in these communities, we can see that they develop and transform nature to meet their individual and social needs. Even in gather/hunter communities, labor and a number of tools are put to social use in order to transform nature's produce into usable items. In this respect, societies do indeed generate the necessary elements for the operation of the society.

The next criterion deals with self-perpetuation. Societies are certainly capable of self-perpetuation and are continually remaking the elements necessary for the continuation of the society. Despite the fact that individuals do not produce their own food, society is able to, in theory at least with a capitalist system, produce enough food for all members of society on a recurring seasonal basis. Likewise, shelter is also rebuilt to protect members from the vagaries of weather. Physical infrastructure is also constantly being transformed. In other ways, the social organization of production continues despite wars, natural disasters and social upheaval. Societies are remarkably resilient, but also evolve into different forms and structures. It could easily be argued that societies are capable of reproducing the deteriorated physical and social forms necessary for the continued existence of the society.

Of the three criteria outlined by Fleischaker, only two of the three can truly be applied to societies. On the issue of societies as autopoietic systems, Maturana and Varela (1980:118) had contemplated the possibility early in their formulations. “What about human societies, are they, as systems of coupled human beings, also biological systems? Or, in other words, to what extent do the relations which characterize a human society as a system constitutively depend on the autopoiesis of the individuals which integrate it? If human societies are biological systems the dynamics of a human society would be determined through the autopoiesis of its components. If human societies are not biological systems, the social dynamics would depend on laws and relations which are independent of the autopoiesis of the individuals which integrate them ... since we - Maturana and Varela - do not fully agree on an answer to the question posed by the biological character of human societies from the vantage point of this characterization of the biological organization, we have decided to postpone this discussion.” Varela tended to be more definite in the application of autopoiesis to society, “Frankly, I do not see how the definition of autopoiesis can be *directly* transposed to a variety of other situations, social systems for example” (Varela 1981:38).

While Maturana and Varela were not able to resolve the question of society as autopoietic, it may be useful to include their contributions in an attempt to understand people’s relationship with nature. Maturana and Varela’s comments above may actually point to the resolution of the problem. While they point to a dichotomy between biological systems and non-biological systems, societies are actually both. Human societies are both determined “through the autopoiesis of its components” and “laws and relations which are independent of the autopoiesis of the individuals” (Maturana and Varela 1980:118). The integrity of individual autopoietic person is dependent on a metabolic interchange with nature determined by the social relations governing the society of which the person is a part. Survival of the individuals in society, and by extension society, requires a metabolic interchange with nature, but this metabolic interchange occurs in a social context and is not bounded physically, but socially. This brings us to the final element of autopoietic systems outlined by Margulis (1997:269), the requirement that autopoietic systems metabolize.

Autopoietic systems require a dissipative flow of materials and energy that are metabolized in order to maintain the complexity of the system. Social systems are no different, and this is the brilliance of Marx's analysis of our relationship with nature. His analysis points out that it is very important that we understand societies in terms of their relationship with nature. The specific type of unitary logic governing the society determines the metabolism of society with the environment. If we are to understand how our impact on the environment may be minimized while at the same time maximizing social good (a highly contentious goal), we must understand the logic of our society, or any proposed alternative societies. The concept of metabolism in Marx's work and the notion of autopoiesis could prove helpful in understanding our relationship with the environment of which we are part.

The combination of Marx's historical analysis of society with the concept of autopoiesis can overcome the problem of ahistoricizing social issues while attempting to understand them in terms of the complexity sciences. In order to avoid obfuscation of Maturana and Varela's definition with an understanding of people's relation with nature, I suggest the use of the term "sociopoiesis." While autopoiesis means self-making, we can think of sociopoiesis as socially and historically made. Given the problem of boundary, I cannot assert that societies are truly autopoietic, but the relationship people have with the environment in which they exist does conform to the same thermodynamic principles guiding the rest of life. This does not mean that our interaction with nature is mechanical, unilinear or predictable in the standard sense, but it must be admitted that people must live within the material and energetic bounds that they are given. This relationship changes over time and is dependent on the society in which people live.

Under sociopoiesis, societies maintain the lives of the individual members through an interaction with nature. The reproduction of the components necessary for the continued reproduction of the individuals in a society is accomplished socially. The creation of the elements necessary for the existence of society takes place within the society itself. Each person does not grow all of their own food, nor do they produce their own shelter without the aid of others. Increasingly, people are not even producing their own entertainment and are reliant on socially produced means of psychic and emotional fulfillment. Thus, the external supply of raw materials and energy necessary for the functioning of the components of the society are taken in from the environment, metabolized by the society and the waste reintroduced into the environment. The "complexity" of society is a result of this dissipative flow of elements from nature through the society and expel the waste back into nature.

While the concept of social metabolism by Marx is a very substantial starting point for understanding our relationship with nature, it is my intent that sociopoiesis bridge the gap between social sciences and contemporary physical and biological sciences to return to the political economy of the past. Sociopoiesis adds the concept of autopoiesis to Marx's concept of metabolism. By including Marx's concept of metabolism, the metabolism discussed by Margulis is no longer lacking in historical and social context. The basis of society is the interaction with nature. Its sociopoiesis is not constant, but varies by the organization of society. As Marx argued that the system of production is the basis for our interaction with the environment, we can understand this relationship as sociopoiesis, a living, social system that conditions the necessary metabolism with nature necessary for the generation and self-perpetuation of society. The metabolism with nature is necessarily a dissipative structure, meaning that the form, elements and process of society is dependent on the flow of material and energy through the society and the subsequent generation of waste, or entropy, as a result. Thus, all of the elements of autopoiesis can be found in society except the boundary condition. Societies metabolize, produce all of their necessary elements within the society itself, and maintain and reproduce the elements necessary for their existence.

Implications for Sustainability

All societies are dissipative meaning that they create disorder in the surrounding environment to maintain their own integrity, but the social system of production, sociopoiesis, determines the rate of flow of material and energy taken from nature and cycled through the society. As Marx argues, this metabolism is conditioned by the logic central to the operation of the society. For Marx, this metabolism in capitalism "undermin[es] the original sources of all wealth-the soil and the worker (Marx 1977:638). Sociopoiesis that is inherently expansionary, as capitalism is, will always exceed its thermodynamic bounds and lead to environmental degradation and societal collapse. Only societies that are organized based on a logic that minimizes energetic and material throughput will have the potential to avoid socially induced environmental crisis. Therefore, the most crucial aspect to understanding environmental degradation is the organization of a society with respect to its interaction with nature, sociopoiesis. A society like the contemporary capitalist society that demands self-destructive behavior such as the exploration of oil resources where socially induced global climate change has made these resources available is certainly headed for crisis and potential catastrophe unless measures are taken immediately to change the underlying logic of the system.

To understand the problem of capitalism relative to other societies, it may be helpful to return to the problematic issue of boundaries. While societies do not have physical boundaries, they do have geographic boundaries. What is so destructive about capitalism is its ability to spread to every corner of the world. Prior social systems were bounded by their local environmental circumstances. The health of the society is dependent on the health of the local ecosystem. Empires rose and fell as a result of their environmental exploitation and degradation. Even significant environmental degradation, however severe, tended to be contained to the local region. With the expansion of capitalism, a social system developed that not only became divorced from the local ecological conditions, it began to have global impacts. In the early stages of capitalism, Europe was in the process of destroying its local ecosystem, but Europe ameliorated this destruction by incorporating other regions of the world to replenish the destroyed environmental stocks (Dunaway 1994).

If we are to avoid the most destructive effects of climate change and other socially caused environmental degradation, we must understand how our current sociopoiesis is inherently environmentally destructive. By developing a science of sociopoiesis, we are more capable of demonstrating the weaknesses in proposed environmental reforms. Subtle changes that reduce environmental impacts without significantly challenging the fundamental problem will do little to solve the environmental crises we face. Electric cars, for example, do not challenge the commodification of individualized transportation and the environmental impacts of expanding access to these commodities. Electric cars are still cars that require a massive transportation infrastructure and presuppose an expanding consumer demand. The marginal savings to environmental degradation realized by shifting cars from fossil fuels to renewable electricity will not offset the expanding use of resources necessary to perpetuate the capitalist automobile infrastructure globally.

Identifying the current problem is only half of the battle. We must also understand that the sociopoiesis that we propose to replace our current relationship with nature must not contain the same inherent expansionary flaw. In order to develop a society that does not exceed the local and global material energy flux of our finite world, we must understand how we organize relations within society to maintain its continued existence. If the organization is based on a logic of ever increasing expansion, it is certain to collide with the finite limits of earth's resources, and the ability of environmental metabolic processes to absorb the perturbation of our interchange with nature. Sustainability means that we develop a sociopoiesis that operates within its thermo-dynamic boundaries. We cannot continue to risk overshooting our environmental limits by developing a new sociopoiesis that follows the flaws of capitalism. Part of the solution may be to seek out a transition to a sociopoiesis that is more local in nature. By localizing our metabolism with nature, people in society can better witness and respond to the negative ecological consequences of their actions. Localizing environmental metabolism is not the only solution, but may be a step in the right direction to developing an environmentally sustainable sociopoiesis. Ultimately, we have to develop a sociopoiesis that is not based on growth. Shifting to a social system that is not predicated on growth is a significant challenge, but a necessary transition if we are to avoid the worst consequences of our present behavior.

Just as there are sociological reasons why the number of stories regarding Clinton avoiding the draft far outnumbered stories documenting Bush avoiding the draft, there are also sociological reasons why capitalism is so environmentally destructive. We cannot understand the issues capitalism creates for the environment with a strictly complexity worldview. To fully comprehend why environmental threats to social stability grow under capitalism, we have to understand the social forces as well as the natural influences. The concept sociopoiesis integrates both of these factors. The next step is to integrate the natural science data with respect to environmental flows with the social science understanding of social organization and metabolism. This understanding can then be used to begin a shift to a new more sustainable sociopoiesis with nature.

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