mediately evade the issue by saying that "analysis of these criticisms exceeds our ambitions." This will not do. The authors should either (i) argue that "social autopoiesis" *can* engage the political dimension (although they will have a hard time of it, because to date the record of social autopoiesis is not good); or else (ii) come clean, and say that in their view politics is not important, and that science should not get mixed up in politics. In this case, our disagreement would be clear and complete.

« 2 » The authors devote a whole section (§§23–39) to criticism of Humberto Maturana and Francisco Varela's own attempts to develop a theory of social systems, in which they explicitly decline to use the concept of autopoiesis. Maturana and Varela's social theory is undeniably poor; but it does not follow *at all* that if they had used the concept of autopoiesis in their endeavours they would have fared any better. Thus, this whole section is unfortunately somewhat beside the point. Likewise is the question as to whether social systems can or cannot properly be considered as "autopoietic."

« 3 » Finally, there is the question of biology. Contemporary biology is focused on molecular biology, and it is openly gene-centred (witness the lamentable current fashion for DNA-sequencing, a mindless endeavour if ever there was one). This has induced the noted biologist François Jacob to declare openly: "Life does not exist" (see Stewart 2004). In this, he is (unfortunately) quite correct: at present, "life" does indeed not exist as an epistemologically well-constructed object of biological science. Personally, both as a biologist and as a citizen, I consider this is a scandal. There is a genuine challenge here: both to construct an epistemologically well-founded concept of "life," and to gain acceptance for this concept in the relevant scientific community. It is in this context that the concept of "autopoiesis" *does* have a key role to play. And this issue – the *sort* of biology that our society will construct and put in place – is actually, in its way, a highly *political* issue. It is in this sense that the concept of autopoiesis is, already, a highly-charged political issue. Vague speculation about "social autopoiesis" is, unfortunately, an untimely distraction from what is at stake.

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Autopoiesis Applies to Social Systems Only

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> Upshot • I reaffirm and extend the notion of social autopoiesis away from mere labels and descriptions to acting physical components of social systems and societies, ranging from subcellular to biological and human. All self-producing biological organisms are essentially societies of interacting components and therefore notions of autopoiesis and social systems are fundamentally, if not definitionally, interrelated. Some examples of real-life applications of social autopoiesis are also given. Future generations of scientists might even find the qualifier "social" redundant because there is no other autopoiesis than "social."

> *So we are continually making and marring our own lives and the lives of other people by a word, an action, a thought.*
> (Edward Phillips Oppenheim, *A Prince Of Sinners*, 1903)

« 1 » It is an unexpected pleasure to encounter two Chilean authors from the University of Chile addressing the issues of social autopoiesis – decades after their famous predecessors, Francisco Varela and Humberto Maturana. I still consider Francisco and Humberto as my teachers since the time of their first working paper, delivered into my hands when I was starting at Columbia University in the early seventies. They probably would not call me their follower since I have ignored their aversion toward social systems. The key to my departure was computer simulation of autopoiesis, motivated by meeting with Ricardo Uribe (Varela, Maturana & Uribe 1974). Only through computer simulation was I able to grasp the more general potential of autopoiesis while avoiding purely scholastic reasoning as well as mechanistic simplification. The point of my departure here is the statement by Hugo Cadenas and Marcelo Arnold (§19 in their target article): "[Zeleny & Hufford 1992] even [sic] argue, 'All autopoietic, and therefore all biological (living), systems are social systems'." In spite of that "even," my thesis remains very simple: only social systems can exhibit autopoiesis (see also §49 for affirmation).

Basic concepts

« 2 » There can be no autopoiesis without actively interacting components. In order to interact, such components must communicate. Communication is not just the passive exchange of information, but mutual stimulation and induction to real action, in time and space. Components must act, i.e., respond in direct or chained reciprocity and mutual cohesiveness of their action. Such engendered action connects the components into networks. Such networks become stronger, predictable and autonomous under the influence of repetition. Such repeated action brings forth the rules of behavioral patterns and is itself affected by the same rules it has generated. The continuous making, degrading and remaking of such patterns is the very foundation of life – cellular, individual or social. Perpetuating the network of such interactions can be referred to as a *social system*. Its components are not separate or randomly interacting entities – they form a *society*. This was addressed at an early multiauthor symposium involving Maturana (Zeleny 1980).

« 3 » Such societies can persist autonomously – either for fleeting moments or for millennia, depending on the reliability (rules) and repeatability (components renewal) of their interactions. These societies can be small or huge, autonomous or semi-autonomous, sharply or fuzzily delineated or separable from their environment. Among the examples, we can list societies of cells (and intracellular interactions), multicellular organs and organisms, societies of insects (ants, bees, termites, etc.), societies of

animals (swarms, herds, schools, interacting populations, etc.) and of course, societies of humans (families, tribes, groups, natural institutions such as markets, communities, self-government, etc.).

« 4 » It should be quite obvious that individual autopoietic entities (cells, organs, organisms) can only be sustained if their interacting networks (groups, collectivities, societies) are equally self-sustainable and autopoietic (even before heteropoietic interventions of humans). Autopoiesis of an entity (or component) cannot be separated from the autopoiesis of the entire sustaining network/system. Therefore, pointing to the autopoiesis of individuals cannot be fully comprehended and completed while denying the autopoiesis of their interacting networks, i.e., societies. There is not a single living organism that exists outside its requisite social system. Once the natural social system loses its autopoiesis and breaks down, its individuals cannot survive – except in heteropoietic (i.e., man-made) enclosures of man such as camps or prisons. They can be heteropoietically sustained, but they are not autopoietically self-sustainable. Autopoiesis of individuals is naturally interconnected with the autopoiesis of their social system (Zeleny & Hufford 1991).

« 5 » A society's cohesiveness and autonomy is determined by the internal intensity, repetitiveness and density of its network of interactions, not by an enclosure, wall, boundary or membrane. A system's autonomy comes from activity within rather than separation or isolation without. Protective or filtering membranes are system components that interact with their environment – i.e., the result of autopoiesis, not its causation. An autopoietic system is not defined through its enclosure, but the other way around: strong and sustainable autopoiesis generates its own protective organs (such as membranes, skins or physical enclosures) internally and naturally, and, as our computer simulation showed, those can be strengthened or weakened artificially, from without, by determined action.

Holism

« 6 » Autopoiesis certainly existed way before the emergence of man and his specific ability to perceive, label, differentiate, classify, divide, separate, (to) language or draw distinctions. Nature and natural processes, as well as autopoiesis, were unclassified and not divided into hierarchies, domains, specialties, divisions, disciplines, vantage points and points of view. Physical, chemical, biological, biophysical, social, ecological and similar distinctions did not exist, because nobody needed them (Boden 2000; Zeleny 1981). Yet, life, living organisms and their collective and social interdependencies emerged through self-production, development, adaptation and evolution. There were no atomic, cellular, organic and social domains. Self-production of systems had been taking place before being unraveled, constructed and labeled by man. It is therefore pointless to insist that autopoiesis can take place only in certain domains or levels of natural hierarchy. Nature, including living organisms (and humans), is *holistic*.

« 7 » "Holism" is the most misused and exploited cliché-label in current human intellectual discourse. I prefer the interpretation of Jan Christiaan Smuts (1926), emphasizing the circularity of mutual effects and influences between micro and macro, i.e., between components and system. By "holism" we understand that behavior of components determines the behavior of the whole, while behavior of the whole determines the behavior of components. That is, there are no components without the whole as well as no whole without the components. The circularity of this influence is the foundation of autopoiesis. Circular (holistic) organization of systems (components and the whole) is necessary for autopoiesis. Whatever in nature is so organized could become autopoietic and whatever is autopoietic could become alive. In other words: all living systems must be autopoietic, but not all autopoietic systems have to be alive.

Autopoiesis as emergent

« 8 » Simplistic equalizing of autopoiesis with life is misleading. Autopoiesis cannot be an all-or-nothing proposition. It emerges from non-autopoietic precursors; it weakens, is arrested or fades out. There are at least fifty shades of assorted autopoietic precursors, post-autopoietic (or allopoietic) fade-outs and systems too fast, too slow or too vast for humans (being components themselves) to be perceived (or established) as autopoietic. There are also partial

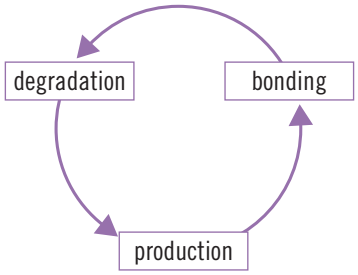

Figure 1 • The three necessary processes of autopoiesis.

or constrained autopoiesis (heteropoietic interventions[1]), autopoietic processes in inorganic milieus (synthetic biology in the sense of Stéphane Leduc 1912), etc. Autopoietic systems emerge, and their process of becoming, not just being, is yet to be addressed. Pre-autopoietic systems have to attain self-sustainability (not just sustainability) of their autopoietic processes in order to be recognized as "living."

« 9 » In addition to self-sustainability, there has to be a requisite equilibrium (or balancing) among all constitutive processes of autopoiesis. The circularity of concatenated processes is not sufficient for autopoiesis. Autopoiesis is fundamentally about equilibrium. Even the smallest deviations in constitutive processes have to be compensated and the equilibrium restored. Otherwise, the system lapses into one of the fade-outs, such as dissolution or death, allopoietic arrest or heteropoietic maintenance of sustainability. How such equilibrium is attained, maintained and repaired/restored has not yet been sufficiently addressed. Unfortunately, the simulation models in Zeleny & Pierre (1976) and Zeleny (1977) have been neglected and thus useful insights weakened.

Circularity of social systems

« 10 » Figure 1 shows the minimal cycle of processes necessary for autopoiesis: Production → Bonding → Degradation → Production. This scheme is the fundamental key to autopoiesis. The circularity is crucial in many

1| All man-made interventions are heteropoietic (produced by another, not by itself). Any such intervention in autopoiesis could curtail its manifestations or appearance, even its sustainability, and thus deceive an uninformed observer.

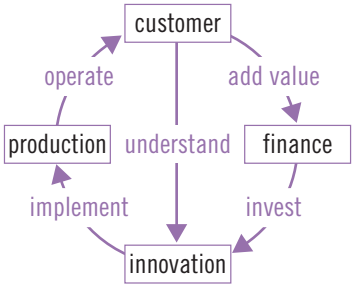

Figure 2 • Model of a self-sustaining corporate organization.

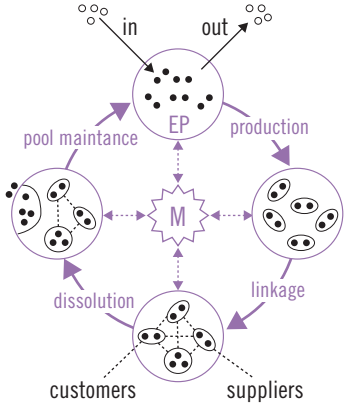

Figure 3 • Model of an autopoietic internal market (amoeba system). M refers to management.

domains, regardless of the labels. Complex and sophisticated simulations (including cell division, multicellularity, heteropoietic interventions, etc.) can be constructed based on this simple scheme. Notice that no a priori introduction of "membrane" is needed, because it is a natural (by)product of autopoiesis, in multitudes of forms, across all domains. Exclusion (or weakening) of any one of the three constitutive processes (i.e., production, bonding and degradation) can lead to fadeout (dissipation), two-state pulsation or allopoiesis.

« 11 » The houseleek or *Sempervivum* (also known as *liveforever* or *hens and chickens*) is a good example of an autopoietic cycle. Individual rosettes multiply vegetatively and form a tightly packed community on a rock, roof or patch of soil. After older rosettes flower, they die and provide a new space for the new plantlets to enter. The community is thus being continually renewed, maintaining its self-production for decades, as long as all three constitutive processes of autopoiesis remain viable. Autopoiesis of a social system lasts longer than that of its components. Similar social networks would be large and tightly packed communities of penguins or sparse and vastly loose communities of wolverines – all surviving for hundreds or thousands of years, in spite of the ceaseless turnover of individual members (Zeleny 1996, 1997). Some readers may find it unusual to call plants social (yet, they form communities, communicate across large distances and are parts of complex physical networks, with animals, insects and humans). Therefore, please allow me to discuss this is in the remainder of my commentary.

Precursors of autopoiesis

« 12 » It is then not surprising that the first ideas of self-production emerged in social systems rather than in biology. Examples abound, e.g., Giambattista Vico's *corso e ricorso*, Adam Smith's *invisible hand*, Joseph Schumpeter's *creative destruction*. Social systems of autopoietic components must themselves be autopoietic – they are necessary for autopoiesis in the sense of holism because autopoiesis itself is the necessary condition for adaptation, development and evolution.

« 13 » When the scholastic debate about social autopoiesis reached its intellectual nadir, I had opted out from the discussion of its descriptions of action (information) in favor of coordination of action itself (i.e., knowledge and wisdom); I devoted myself to corporate consulting, mentoring and coaching, using social autopoiesis as the underlying guide to action. Examples of some very successful constructs are outlined in Figures 2 and 3.

Figure 2 shows the underlying model of circular organization of a business corporation. While the organization is persistant, circular and autopoietic, the structure is a temporary allopoietic "snapshot" of underlying autopoiesis. In Figure 3 an internal market of the Kyocera "amoeba system" of continuous building and rebuilding of an intracompany market is depicted.

Why autopoiesis only applies to social systems

« 14 » Maturana and Varela drove an unsustainably mechanical wedge between social systems and their components by contradicting holism. They excluded a most remarkable autopoiesis of natural social systems, such as termites, bees, ants, amoebas, and ignored the obvious social nature of both multicellular and unicellular organisms, as well as organs such as brains, neural systems, etc. Organisms and their components are themselves social systems *ad infinitum*. By "social systems," they referred to human political systems, but had not recognized ubiquitous spontaneous social orders. They confounded social autopoiesis with dictatorship ("system of tyranny"); or even worse, with Luhmann's humans-free (non-physical) virtual networks of symbolic communications (Zeleny 1995).

« 15 » By the end of the 1990s, Varela had developed divergent thoughts. He recognized the age-old observation of John Amos Comenius, Adam Smith and Friedrich von Hayek – he called it "relatively recent (and stunning!)" (Varela 1999: 52) – that even simple social systems "give rise to … a purposeful and integrated whole, without the need for central supervision" (ibid) – even citing "the most compelling of these examples is the social insect colony." Varela appeared to be puzzled and genuinely surprised by his "discovery" of social autopoiesis: "…its separate components are individuals and it has no center or localized 'self'" (ibid: 53). To his astonishment, "[t]he import of this model of how complex systems exhibit emergent properties through the coordinated activity of simple elements is, in my eyes, quite profound…" (ibid).

« 16 » In 1975, Stafford Beer wrote the preface to *Autopoietic Systems* (Maturana & Varela 1975), where he presents a number of insights into social systems, which are relevant to our argument.

- The necessity of physical components: "The notion of coding is a cognitive notion which represents the interactions of the observer, not a phenomenon operative in the physical domain" (ibid: 10).
- Before human observers emerge: "Nature is not about codes: we observers invent the codes in order to codify what nature is about" (ibid: 11). This could be

applied to the target paper on Luhmann's conception of "social system."

- Without doubts: "Yes, human societies *are* biological systems" (ibid: 12).
- On Maturana: "…presumably at least one of the originators of autopoietic theory disagrees…" (ibid: 12).
- Finally, "…any cohesive social institution is an autopoietic system…" (ibid: 13).[2]

The rest of Beer's argument I paraphrase because, undoubtedly, the reader got the message about his stand on social autopoiesis. What is puzzling is why do Maturana & Varela not follow this line of development themselves? Why do they not write about the nature and adaptation of social institutions and the evolution of society itself? In this commentary I have tried to provide some answers. The fact is that if a social institution is autopoietic, then according to the authors' own argument (autopoiesis is necessary and sufficient to characterize the organization of living systems), it is necessarily alive.

« 17 » Beer concludes: "It seems to me that the authors are holding at arms length their own tremendously important discovery" (ibid: 15). One simple logical step and they could claim a "tremendously important discovery." They did not. It also explains why the current author has since 1975 devoted all his efforts to the development of social autopoiesis.

« 18 » Another poorly defended claim was their belief that all living systems are autopoietic and all autopoietic systems are living, without actually proving the latter. Simulation models of autopoiesis show that autopoiesis is a systems property acquired only gradually – it is incorrect to claim that autopoiesis either is or is not; there are different developmental stages, only differentially compatible with life. This was well understood by their computer expert Ricardo Uribe, later "removed" from the original troika. The autopoiesis stage can be too fleeting to be observed, especially when taking place with inorganic components. The origins of life emerge from the non-living, through autopoiesis, gradually, not suddenly.

« 19 » Their insistence on a visible and physical membrane as a constitutive attribute of the autopoietic process ignores the fact that the membrane is only one of the produced components. Membranes are often invisible (detectable only through behavior), or too sparse and distributed to be detected. Again, some computer simulation is indispensable for understanding *physical* autopoiesis (Boden 2000; Zeleny 1977).

« 20 » Many decades have been spent on scholastic discourse about the essential inapplicability of autopoiesis to social systems. But it is our economic, social and political systems that are now undergoing historical transformation and metamorphosis. As Cadenas and Arnold's target article demonstrates, social autopoiesis must be about physical entities (e.g., humans), not just human concepts or labels. Self-production, for sure, had existed before humans emerged with their labeling, construction and reconstruction.

« 21 » We are currently all suffering from ineffective applications of the mechanistic machine-like paradigm in addressing the long-term effects of secular stagnation and upheavals. Instead, we could have applied autopoiesis as an excellent tool and necessary ingredient for shifting towards a more biological, organism-like paradigm of adaptive and learning social systems – towards evolutionary economics (Zeleny 2010, 2012), treating autopoietic social systems as self-produced organisms rather than man-made mechanisms.

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2| Maturana's views of social systems, as well as his own descriptions and understandings of autopoiesis, are engagingly explained, in his own words, in the excellent book from 2004. There he discloses the reasons for Beer's remarks: "I was not prepared to accept all the consequences of my own theory" (Maturana & Poerksen 2004: 106).

Explaining Social Systems without Humans

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> Upshot • I argue in favor of not eliminating humans from social theory. My argumentation is based on the "mechanistic" perspective that emerged in the interdisciplinary context of systems theory but that is lacking in Luhmann's work. Based on defining communication in the constructivist-mechanist tradition, I claim that research on human (near-) universals contributes to solving the constructivist problem of how understanding among individuals is possible. I also argue against the author's critique of an "utilitarian" approach and for maintaining the individual and social level in systems theory. Finally, I address the observer-problem in Luhmann's theory.

« 1 » In the early 1970s, following Heinz von Foerster's recommendation, I became familiar with the writings of Humberto Maturana. Together with Gerhard Roth and Wolfram K. Köck, we discussed Maturana's papers and finally translated his "Biology of Cognition" (1970) into German. In the meantime, I had started working on my doctoral thesis following an invitation by Niklas Luhmann. In August 1975 I sent our Maturana translation to Luhmann, who initially was quite skeptical about the aspects linked to Maturana's concept of "circularity" of the processes in living systems. But some discussions later in March 1976 he changed his mind with respect to what was to be called the theory of autopoiesis. During the following years I co-organized a number of conferences (Hejl, Köck & Roth 1978; Benseler, Hejl & Köck 1980; Roth & Schwegler 1981). However, even though he had begun to embrace autopoiesis, Luhmann did not attend any of them. Despite numerous discussions, Luhmann's and my views differed with respect to the central question Hugo Cadenas and Marcelo Arnold address in their target article: Should social systems be modeled as autopoietic (Luhmann) or should social systems be constructed as resulting from a