Self-Organization at the Edge of Mysticism

Volkswagen Conference

Gainesville, Florida

Christoph Holzhey, March 2004

I had originally planned to entitle my presentation “New Perspectives on the Macrocosm/Microcosm Polarity,” but meanwhile I found that this title is no only rather vague, but also not entirely fitting for the project that I would like to present today – a project that will focus on theories of self-organization and their attempt to reconcile and unite physics and biology. The working title for my project is currently “Self-Organization at the Edge of Mysticism,” which I would also choose for my presentation today.

The macrocosm/microcosm polarity is but one way to approach the question of mysticism in theories of self-organization among which I include, e.g., theories of catastrophe, chaos, dissipative structures, autopoiesis, complexity, and emergence. While the relationship between the microscopic and the macroscopic is no doubt central for self-organization (and for such key-terms as entropy, information, order, and complexity that will particularly interest me), this relationship is foremost conceived as a part-whole relationship. A key question of self-organization is indeed how simple parts come together to constitute a complex whole. Theories of self-organization tend to insist that ‘the whole is *more* than its parts’ and at the same time that everything is *in* the parts insofar as nothing is added from outside. Such a tension, even paradox, seems characteristic of theories of self-organization as they seek to explain how the whole ‘emerges’ spontaneously with new qualities from local interactions of the parts.

Insofar as each part is simple, it does not constitute a microcosm, and insofar as the whole has new, ‘emergent’ qualities, there would seem to be no macrocosm-microcosm correspondence. In other words, the macrocosm-microcosm correspondence is a special kind of part-whole relationship. If theories of self-organization nonetheless feed into the macrocosm/microcosm polarity, it is because they also tend to hold out the expectation that they will ultimately explain order and organization on every scale and in essentially every field or discipline. Taken by itself, the prospect of universal applicability and validity arguably brings any theory to the vicinity of mysticism. While this would also apply, for instance, to the fundamental laws of physics, applicability on all scales engenders in the case of self-organization an even more sublime image, namely the image of an infinite series of hierarchically nested levels that are all analogous to each other. The part may be simple with respect to the complex whole, but just as the emergent whole (such as an organ made of cells) can become a part for a greater whole (such as a body made of organs), the part can itself be considered an emergent whole (here a cell made from a conglomeration of molecules). Extension in both direction establishes a homology between microcosm and macrocosm, which is however ultimately bottom-up rather than top-down: the microcosm is more than a mirror-reflection or analog of the grand cosmic order; the microscopic literally contains everything necessary to build up the macrocosm and as such the cosmic order can be said to be immanent in every piece of interacting matter.

As a brief aside, let me clarify that unlike the more famous self-proclaimed *theories of everything* such as string theory, theories of self-organization do not believe everything is 'in principle' explained once a consistent theory for the elementary constituents and their interactions is found. Instead, new qualities emerge at higher levels, requiring new theories that cannot be derived from the more fundamental theories. Emergent qualities cannot be predicted – not even 'in principle' –, but theories of self-organization nonetheless claim that something can be said about their emergence. The homology across different scales pertains therefore rather to processes of emergence or to the transitions between levels than to the levels themselves. Indeed, it does not even seem necessary that there is a cosmos on all levels: the possibility of obtaining (macroscopic) order out of (microscopic) chaos is in fact among the most exciting and puzzling aspects of theories of self-organization as the countless titles containing some combination of 'chaos' and 'order' demonstrate.[1]

Among those books, I found *Complexity: Life at the Edge of Chaos* first published in 1992 by the science journalist Roger Lewin particularly relevant for our project.[2] Lewin's book brings together scientists exploring self-organization in a variety of contexts, such as cellular automata, random Boolean cycles, artificial life, self-modifying programs, embryology, morphogenesis, ecosystems, and the natural evolution of populations and species. As guiding thread, Lewin keeps returning to Stuart Kauffman from the Santa Fe Institute and his hypothesis that self-organizing systems share a tendency of evolving towards what he calls the 'edge of chaos'. While order is sterile and true chaos destructively unstable, the 'edge of chaos', according to Kauffman, is a region where complexity, fitness, or computational ability is optimized.

---

[1] S., e.g., Bernd-Olaf Küppers, ed., *Ordnung aus dem Chaos: Prinzipien der Selbstorganisation und Evolution des Lebens*, vol. 743 (München [u.a.]: Piper, 1987), Paul McGarr, "Ordnung aus dem Chaos, " *International Socialism* 2.48 (1990), Nancy Katherine Hayles, ed., *Chaos and order: complex dynamics in literature and science* (Chicago: U of Chicago P, 1992), Günter Küppers, ed., *Chaos und Ordnung* (Stuttgart: Reclam, 1996), John H Holland, *Emergence From Chaos to Order* (Oxford: Oxford UP, 1998).

[2] Roger Lewin, *Complexity: Life at the Edge of Chaos* (Chicago: U Chicago P, 1999).

Like many of the researchers presented in the book, Kauffman is "convinced there must be something *deep* about the source of order in nature" (183). His aim is "a *deep* theory of order in life across the entire spectrum, from the origin of life itself, through the dynamics of evolution and ecosystems, through complexity in human society, and, yes, on a global scale, that of Gaia" (182).[3] Kauffman's conviction of a deep unifying order in nature not only sounds mystical, but is in fact part of his response to the question of mysticism that Lewin keeps raising in his final chapter. Lewin's questions confirm the proximity of mysticism and theories of self-organization. Together with the answers he obtains, they also indicate how 'mysticism' is understood within science, namely as a reproach, as by definition non-scientific, and as something from which a scientist must distance him- or herself in order to be taken seriously as a scientist. While we may wish to disagree with such a definition – I'll return to this issue later –, I think that it is also productive to explore how mysticism functions within science as a reproach and has thereby informed its history.

Lewin's interlocutors all reject the charge of mysticism, but some also attempt to explain it by pointing to their proximity to positions that have a long tradition of being dismissed as mystical by classical science. Self-organization may indeed be considered an heir to vitalism and its complicated rivalry with mechanism that can be traced to antiquity. Very roughly, mechanism reduces living organisms to machines that are entirely explicable by the laws of mechanics, physics, and chemistry, while vitalism insists that in order to account for life in its specificity, such as the ability to move, reproduce and regenerate itself, something else must be added to matter, such as a soul, an elan vital, a life force etc.

In Lewin's book, the theoretical biologist Brian Goodwin best illustrates the precarious proximity of self-organization and vitalism. Goodwin insists that he completely rejects vitalism, but seeks a "closer appreciation of the quality of the organism" as something "distinctive to the living thing." Asked to clarify this "fuzzy," "not very scientific" notion of 'quality', he maintains that "organisms are self-causing agencies" (180). To which Lewin responds: "Now that does sound mystical." Goodwin denies this, but does so by invoking emergent features of self-organization and biological attractors that still seem to have a "tinge of vitalism" according to Lewin. In the end, Goodwin clarifies that there is and always will be a mystery to life, but insists that one has to get rid of the idea that there is something added from the outside that is responsible for life, which is how he understands the old vitalism.

---

[3] Gaia refers to James Lovelock's hypothesis, which many biologists consider flaky nonsense and which states that the whole earth, including in particular its physical atmosphere, constitutes a giant self-regulating organism. S. James Lovelock, *The Ages of Gaia: A Biography of Our Living Earth* (Oxford: Oxford UP, 2000).

While I cannot go into details here, I would just like to mention that the proximity to 'old vitalism' becomes even greater if one considers that already in the eighteenth century, vitalists no longer invoked an immaterial soul in order to account for the irreducible specificity of living organisms. Instead, they introduced life forces in strict analogy to Newton's force of gravity, that is, as something that cannot be explained further, but must be posited in order to account for the phenomena of life. However, for opponents such a force explains nothing at all and constitutes instead an appeal to occult forces or mysticism (178). Let me just mention that opposition to self-organization and emergence happens in much the same manner.

Given the long history of heated controversy and the vehemence with which established science has rejected vitalism, it is remarkable how difficult it can be to distinguish between vitalism and mechanism in any particular case. Part of the reason is no doubt science's polemic use of vitalism, which, like mysticism, is only ever attributed to others. However, the debate itself also depends on a fundamental difficulty of reconciling life, its emergence, complex order, and evolution with modern science as it developed since the seventeenth century under the tremendously successful paradigm of Newtonian mechanics.

Although eighteenth century mechanicists deemed the known forces sufficient to explain the operation of living beings, they could not, as vitalists insisted, explain how blind, mechanical forces could generate the complex order of organisms. Rejecting epigenesis or self-formation through new, more 'intelligent' life forces as too mystical, they favored instead preformation, which ultimately relegates the order of life to an intelligent designer at the beginning of time. In the nineteenth century, the difficulty of explaining the emergence of organized life and its continuous reproduction was compounded with the advent of thermodynamics and its assertion of an irreversible tendency towards greater disorder. Entropy, which can be interpreted as a measure for disorder, never decreases according to the second law of thermodynamics. Henceforth, the emergence of life and its Darwinian evolution was not only hard to explain, but also appeared forbidden by a law of physics. According to Kauffman, always in the context of asserting that theories of self-organization are not engaged in a mystical search for God, it was therefore "one of the big discoveries of the science of Complexity" to have established that the Second Law is "inadequate as a description of all systems: some systems tend toward order, not disorder" (183).

In a moment, I will turn to one of the key figures in reconciling the emergence of order with the second law of thermodynamics, namely to the chemist and Nobel prize winner, Ilya Prigogine. At this point, I would like to emphasize first that for Kauffman a good scientific understanding of some systems violating the second law seems to be sufficient to conclude that

God does not have his hands on the controls of life. And secondly, that despite all the technical difficulties involved with its proper understanding, the second law reflects such a deep scientific and commonsense intuition that claims to its contradiction seem extremely significant but should also face suspicion. The second law thus expresses the intuition that it is easier to destroy than to create, that things, when left to themselves, will break, decay and disintegrate. In short, it proclaims the necessity of death – and therefore also the improbability of life. On a more technical level, it prohibits, for instance, the possibility of constructing a perpetuum mobile – a machine running forever without external help and working for free. While in some metaphorical sense life could be regarded as a perpetuum mobile, leaving the emergence of life to supernatural causes seems as unscientific as allowing for the possibility of a perpetuum mobile in a technical sense. In other words, fundamental scientific intuitions stand in a tension on the question of the second law, necessitating its modification or qualification, but prohibiting its complete abandonment.

Even if processes of self-organization do not contradict the second law of thermodynamics and do not give rise to perpetuum mobiles, they seem to violate the spirit of entropy and defy death, which is why they, like life, may always have something mysterious about them. However, to place a tendency towards order and organization on the same footing as the entropic tendency towards disorder, to relate them causally to each other and treat them as one phenomenon, seems to amount to an equation of opposites that only mystics can achieve. Yet this is precisely, what Ilya Prigogine and Isabelle Stengers are suggesting in their book *Order out of Chaos.*

First published 1979 in France under the title *La nouvelle alliance* and known in Germany under the title *Dialog mit der Natur* (which is taken from the English subtitle), this influential book suggests that the new science of self-organization and complexity is part of a fundamental transformation in science and its conception of nature.[4] Having taken its modern and by now classical form in the seventeenth century, science followed the paradigm of Newtonian physics to search for simple, universal and immutable laws. It thereby ended up with a view of the world as a dead mechanism, a gigantic machine or clockwork whose past and future can in principle be deduced from a detailed knowledge of the present state and the mechanical laws of dynamics. Through its enormous success, this mechanicist, Newtonian science and worldview dominated far into the twentieth century, but by now, Prigogine and Stengers claim rather boldly already in the late 1970s, science has fundamentally changed to produce an image of nature as irreducibly manifold, temporal, and complex (10). Of course, there were precursors announcing this revolution, but while one might think of quantum mechanics and relativity, the authors interestingly align these with classical science and identify instead nineteenth-century thermodynamics as the first "'non-classical' science" (21) and the first "'science of the complex'" (107). The main reason for this choice is their focus on the notion of time and the claim that the most important and fundamental element of the new science of complexity is the proper acknowledgment of the "reality of time" (25) and of irreversibility, that is, of an arrow of time that implies that the future is not contained in the present. The authors repeatedly use the expression 'From Being to Becoming' and this formula indeed sums up well the essence of the radical changes in scientific worldviews that the book *Order out of Chaos* identifies and propagates.[5]

The focus on irreversible time is also how Prigogine and Stengers go beyond the demonstration that self-organization does not contradict the second law of thermodynamic, suggesting instead that it is part of the same law. In what has become a standard argument, Prigogine and Stengers show that self-organization does not contradict the second law, because this law only holds for closed systems, for which it states that they evolve towards an equilibrium state in which entropy, i.e., disorder is at a maximum. Nothing therefore prohibits open, non-equilibrium systems to develop and maintain order. To avoid misunderstandings, it should be emphasized that even then there is no exception to the second law, but in order to apply it, one must include the environment of the open, self-organizing system. In other words, order can only increase in systems at the expense of entropy production in the environment. To show that self-organization is *consistent* with the second law however seems to me very different to saying that it is *related* to it or even *follows* from it. Nonetheless, Prigogine and Stengers, and they find many followers in this, claim a close relationship between self-organization and the thermodynamic law of increasing entropy.

While there are many interesting, more or less technical aspects to their argument, the basic rationale seems to be that in both cases one deals with irreversible processes. Entropy provides an arrow of time – there can be no doubt about the direction in which a film depicting a shattering glass has to be shown –, but so does the emergence of structures in systems far from equilibrium. Prigogine and Stengers repeatedly refer to the Bénard-instability, that is, to the

---

[4] Ilya Prigogine and Isabelle Stengers, *Dialog mit der Natur: neue Wege naturwissenschaftlichen Denkens*, 5 ed. (München: Piper, 1990). References are to this edition and translations are mine.

[5] S. also Ilya Prigogine, *Vom Sein zum Werden: Zeit und Komplexität in den Naturwissenschaften*, 6 ed. (München: Piper, 1992).

emergence of well-structured convection currents in a liquid held between different temperatures. When the conditions are right – such as the temperature difference – the random motion of molecules irreversibly yields to a regular convection pattern. In this case, one can see quite well how the lower entropy of the liquid is compensated by a greater flow of heat and therefore also of entropy across the liquid. Yet, Prigogine and Stengers seem to engage in both a tautology and a quasi-mystical leap when they induce from this a connection between irreversible processes, establish a congruence between entropy and self-organization, and say: "as soon as the conditions for self-organization are fulfilled, life is as predictable as the Bénard-instability or a falling stone" (198). Of course, I take this quote out of context, and of course, anything is predictable at the moment the conditions for it are fulfilled. Nonetheless, the comparison of life with gravity seems so strange that, oscillating between a mystification of the falling stone and a demystification of life, it conveys a sense of unity overcoming the distinction between life and death.

Such an effect does not seem unintended. Prigogine and Stengers raise high hopes and expectations for the new science of becoming. They accept the criticism that science has isolated us human beings and made us lonely in a disenchanted, mechanistic and deterministic universe, in which we cannot recognize ourselves. They furthermore accept that modern science thereby created a deep rift between nature and humanity, between 'practical' freedom and 'theoretical determinism' (25), – a rift that is well represented by the polarization of the two cultures, the natural sciences and the humanities. However, they argue that this criticism only holds for modern-classical science as we know it since the times of Newton, whereas the new science that they herald will achieve a reconciliation between the two cultures and between humanity and nature as it finally learns to understand complex processes and the reality of time and becoming (42).

There seem to be many elements here that at least border mysticism, and to my ears the enthusiastic proclamation of the new science does have a distinctive mystic ring, for instance, when the authors describe the first steps towards the new conception of nature as follows: "Darwin's doctrine means that we are connected with all forms of life; the expanding universe [according to Einstein] means that we are connected with the whole universe" (16). However, it must be stressed that Prigogine and Stengers emphatically remain on the side of science and are strongly opposed to all irrational, anti-scientific, metaphysical, animist tendencies and conceptions of nature. At one point, they also explicitly reject as harmful a mystical attitude towards science, by which they mean the fascination with a secret science that is intelligible only to a small elite, but produces results that could radically change our whole thinking and shatter common conceptions of time, space, causality, spirit and matter (40). They consider the choice between an alienating science and an anti-scientific, metaphysical conception of nature not only "tragic" (12), but also dangerous. After mentioning the irrational tendencies of the German 1920s, they observe: "When science disregards experiences that are significant for human beings and are connected with notions such as freedom, fate or spontaneity, it can happen that these notions are attributed to the realm of the irrational and then unfold a terrifying power" (17). Although they do not go so far as to identify the humanities with science's irrational other (let alone with fascism), it nevertheless seems as if the gap between the two cultures is to be closed primarily through a vast expansion of science such that even freedom, fate, and spontaneity become legitimate objects of science, indeed of physics. Despite their rhetoric of radical change, Prigogine and Stengers' scientific approach arguably remains rather traditional,[6] and despite their engagement with philosophers from Plato and Aristotle to Kant, Hegel, and Bergson they repeatedly insist that the new science emerges strictly from within science and not from philosophical critique (62) or the abandonment of scientific methods (100).

Does this commitment to science exclude the possibility of a mystic dimension in theories of self-organization, at least as presented by Prigogine and Stengers? The answer depends not only on whether an internal distinction within science suffices to resolve the paradox of turning to science in order to remedy the alienation, disenchantment, and cultural divisions produced by science. It also depends on how precisely mysticism is defined, especially in relation to science. Within science, it is not uncommon to refer to mysticism or to mystical tendencies and forms of explanations. However, the point of such an attribution is always an exclusion from science. In other words, there seems to be a consensus that mysticism is by definition non-scientific. This need not mean that scientists cannot be mystics, nor that mystic experiences cannot motivate them and shape their inquiry. On the contrary, it means precisely that mysticism is a private affair that can have no weight in scientific arguments. To exclude by definition mysticism from science also does not mean that science cannot arrive at similar results or figures of thought as mystics, but rather that their legitimation obeys different rules.

Such a science-biased definition of mysticism may be both too narrow and too large for our project – too narrow, because it excludes by definition the possibility of mystical elements in science, and too large, because any invocation of transcendence, for example, would be considered mystical. We might thus be inclined to identify mystical elements in all the interlocutors in Lewin's book, while what they reject under the heading of mysticism are such

---

[6] Cf. Günter Altner, ed., *Die Welt als offenes System: eine Kontroverse um das Werk von Ilya Prigogine*

diverse things as assuming purposefulness in nature, looking for the meaning of life, thinking that God has “his hands on the controls of life” or acted as a watchmaker (183), or assuming all kinds of emergent properties of nature “that you couldn’t understand, weren’t meant to understand, and if you could, they were considered to be no longer important” (119).

Yet, rather than insisting on a definition of mysticism that is both larger and smaller and would allow for a conclusive demonstration of precise mystical elements in some modern sciences, I would like to propose exploring science’s bordering region with its mysticism. This would mean accepting science’s definition of mysticism and focussing on those domains that are in contact with it.

What I have been trying to suggest today and is the basis for my future investigations, is that the sciences of self-organization lie in such a bordering region with mysticism. As some of the more speculative literature shows, their theories can easily be appropriated to cross the border. A slight shift of tone or extrapolation often seems sufficient for self-organization to flip into mysticism. To be sure, this can also happen in scientific texts themselves, especially in popularizations, but one may say then that they cease to be scientific, at least at that moment. The suggestion that self-organization has the same status as the second law of thermodynamics, which has been applied to theories of natural evolution, seems to me such a case. In its own language, one could perhaps say that sciences of self-organization lie in the critical region of a phase transition between mysticism and science, or in short: at the edge of mysticism. My point in this appropriation of Kauffman’s phrase of the ‘edge of chaos’ is not to equate mysticism with chaos, but rather to adopt the notion of an intermediate, bordering region that is productive and creative, but also precarious. A region, where science extends its reign of disenchantment, but may also loose or find itself in mysticism.

References

Altner, Günter, ed. *Die Welt als offenes System : eine Kontroverse um das Werk von Ilya Prigogine*. Frankfurt am Main: Fischer, 1986.

Hayles, Nancy Katherine, ed. *Chaos and order: complex dynamics in literature and science*. Chicago: U of Chicago P, 1992.

Holland, John H. *Emergence From Chaos to Order*. Oxford: Oxford UP, 1998.

Küppers, Bernd-Olaf, ed. *Ordnung aus dem Chaos: Prinzipien der Selbstorganisation und Evolution des Lebens*. Vol. 743. München [u.a.]: Piper, 1987.

Küppers, Günter, ed. *Chaos und Ordnung*. Stuttgart: Reclam, 1996.

(Frankfurt am Main: Fischer, 1986) 44.

Lewin, Roger. *Complexity: Life at the Edge of Chaos*. 1992. Chicago: U Chicago P, 1999.

Lovelock, James. *The Ages of Gaia: A Biography of Our Living Earth*. 1988. Oxford: Oxford UP, 2000.

McGarr, Paul. "Ordnung aus dem Chaos." *International Socialism* 2.48 (1990).

Prigogine, Ilya. *Vom Sein zum Werden: Zeit und Komplexität in den Naturwissenschaften*. 1979. 6 ed. München: Piper, 1992.

Prigogine, Ilya, and Isabelle Stengers. *Dialog mit der Natur: neue Wege naturwissenschaftlichen Denkens*. 1979. 5 ed. München: Piper, 1990.