

TIME, MAGMA, CONTINUITY

SOME REMARKS ON IN-FORMATION AND THE FABRICATION OF “POIĒSIS”

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1.

The *Fabrication of Life* is probably one of the most ambitious, but at the same time one of the most controversial research fields within so-called *converging technologies*.¹ Whether *Synthetic Biology*², *Artificial Life*³, or *Bio Art*⁴ – all these fields are concerned either way with the *manipulation* or *synthesis* of living beings.

It is well known, that organisms can be manipulated to some extent by altering their gene expression and this sort of research is already placed under quite heavy, political control. What is still less well known, and long since lurking behind the scenes, is *artificial abiogenesis* – the synthesis of life “from scratch”. This type of research – strangely enough – is done almost completely unnoticed by the general public. *Bio Art*, on the other hand, seldom bothers with all those technologies – it just “applies” them, from a more or less critical stance.

A crucial question which soon comes to mind, though, is: what could “fabrication of life” actually mean? Of course – the less precise the definitions, the easier we could describe beings as “alive”. Thus, for the following, we assume that a “living being” is a “being-for-itself” (“subject”), that it is a being with its own *proper world* (“Umwelt / Innenwelt”), and that “life” is creative: that there is an emergence of “otherness”. This very process of emergence of something new – *other* – will be called “poiesis” or “in-formation” in the following. And we mean explicitly “fabrication”: bringing life into existence (what has been referred to already as *artificial abiogenesis*). We do not talk about “manipulation”.

Is such a project imaginable? Can we expect to become “life engineers” in the near future, building “Living Machines”?⁵

A lot of people think it is. Some of the most advanced projects in this respect are those which are collected under the umbrella of the *6th Framework Program* of the European Union, as there are *SynthCells*, *PACE*, *Uniroma3*, and *Protocell Assembly* for instance. All these projects are focussing on single cell organisms which, as general “building blocks” of more complex multi-cellular organisms, should, nonetheless, fit the aforementioned definitional “requirements”.

Now, in order to discuss the problem of “life engineering” we want to exclude from the very beginning any framework which relies on some sort of “vital force” or a specific “bio-substance”; we don’t want to introduce any

1 Bainbridge/Roco 2006; Roco/Bainbridge 2004

2 ETC Group 2007

3 Bedau passim

4 Kac 2006

5 Hasslacher/Tilden 1995

type of transcendental dualism either, e.g. phenomenology. We want to stay as close as possible to contemporary scientific approaches. Having said that, however, we don't think that mainstream reductionism works. Reductionism's underlying assumption is that living beings are *machinic* (in the sense of a *mechanism*). This assumption is a consequence of a much deeper reductionist belief which is that biology has to be anchored within contemporary physics; and – usually – physics is here confined to *Newtonian* physics. This reductionism is not feasible for at least two reasons: first of all, sciences cannot treat “creativity” appropriately, and secondly, sciences cannot deal properly with subjectivity. As it will turn out, the ultimate cause for this failure is a profound inability to theorise time. In physics, there seems to be no notion of time at all.⁶ And insofar as the “sciences” in general are desperately fixated on physics, they are suffering from the same problem, too. The humanities, on the other hand, are unable to bring their concepts of “subjective time” (and/or “social-historical time”) into any consistent contact with those “sciences”. As a result, the dialogue between sciences and humanities either stops, or creates amusingly bizarre “discourses” – most often, for example, in the neurosciences with its perennially recurring debates about the problem of, e.g., *freewill*.⁷

One could thus get the impression that this very problem of *fabrication of life* indicates a *paradox* – it would be simply impassable. Even within biology, doubts exist about whether this reductionist strategy will work. Robert Rosen, e.g., argues, that physics “is inherently inadequate to accommodate the phenomena at the heart of biology. No amount of sophistication within these limitations can compensate for the limitations themselves.”⁸ In particular, since Newtonian-style physics produces *analytic* knowledge (i.e. knowledge, *how* a system works), and this knowledge does “not entail how it is created”,⁹ the problem of *fabrication* simply cannot be solved.

Stuart Kauffman also considers the possibility, that contemporary physics has to be changed to become appropriate for biology. His main concern is that for principle reasons we “cannot finitely pre-state the configuration space of a biosphere.”¹⁰ What he is speculating about is “glimmers ... of something like a fourth law, a tendency for self-constructing biospheres to enlarge ... the dimensionality of their adjacent possible.”¹¹ We can't go into the details

6 Barbour 1999

7 There is no doubt that the life sciences can produce results of some (limited) use, despite their dubious conceptual and methodological premises, e.g. in medicine with its often spectacular progress in diagnostic and therapeutic technologies, particularly in the neurosciences, see Hagner 2006.

8 Rosen 2000, p. 256

9 Rosen 2000, p. 258

10 Kauffman 2000, p. 135

11 Kauffman 2000, p. 244

here, but we just mention in passing that Kauffman expects a “new physics” – which eventually respects biological phenomena – to be a physics carrying on the ambitious efforts tackling the challenges of *quantum gravity*.¹²

Both Rosen and Kauffman, in a way, suggest that we have to change the underlying conceptual framework of mainstream reductionism, and, most important, have to explore alternate ontologies, the main emphasis of which is on being-for-itself, creativity, and “becoming”. We can go even further. Why should we conceptualise nature in terms of a “state space”, introducing a “mind-body-problem” – just to “reduce” it to “materialism” or “idealism”? And why should we continue rendering the “ego” as a spectator of an external “world” – mirroring predictable trajectories and desperately trying to stay the course? There is no compelling reason at all to believe in these somewhat accidentally sedimented clichés, acting – at the best – as a common-sense “doxa”.

We should be aware, though, that taking non-reductionist frameworks into consideration often means to be accused of “vitalism”, “speculative thinking”, et cetera – as we already mentioned above. Authors like Spinoza, Nietzsche, and Bergson are usually condemned as belonging to the “bastard line of philosophers” (Deleuze), and there is rarely a chance to engage mainstream “scientists” in a profound debate.¹³ An exception might be A. N. Whitehead, whose “process philosophy” happens to be discussed as an alternate ontological framework for quantum physics.¹⁴ But Whitehead is still seen as quite an esoteric thinker.

Among the (maybe) less suspicious philosophical authors who are deeply concerned with the problem of “creativity” Castoriadis comes to mind. A reading of Castoriadis seems to be rewarding from at least two points of view. As is well-known,¹⁵ he advocates the crucial role of “radical imagination” in human subjectivity. And, additionally, he develops an ontology of the “magma”, which – as will hopefully be shown in this paper – allows a rethinking of “creativity” in such a way that it sheds a new, interesting light on “fabrication of life”.

12 Kauffman 2000, p. 243ff

13 See the pubertal and amazingly ignorant “discussion” by Sokal/Bricmont 1998.

14 See, for instance, Hättich 2004.

15 Castoriadis 1986, 1997, 1998, 2007; Curtis 1997

2.

Castoriadis' philosophy, and especially his ontology, remained unfinished. It always had a strong momentum, most notably in his late writings,¹⁶ which, as I would suggest, can even be read as constituting first "building blocks" for a proprietary *process philosophy*.

From its very beginning his philosophy is centred around the concept of *autonomy*. Autonomy is the result of a process of self-constitution or self-creation, both on the individual and the social-historical level. We will only briefly touch on this topic here, although it opens many opportunities for criticising current approaches in neuro-, brain and cognitive sciences, first and foremost in neuropsychanalysis.

The genealogy of autonomy is driven by *imagination*, "radical" as well as social-historical. Imagination as *radical* turns out to be the "differentia specifica" of human beings, compared with animals in general, which exhibit imagination in a functional organic context only. Humans, in contrast, have their imaginative capacities detached from any functionalisation – imagination becomes free floating; *radical*. During *individuation* – a process of psychical "sense- or meaning-making" – radical imagination evolves into both an "interior" (psychical) and an "exterior" (social-historical) equilibrium of *representational pleasure*, implying a compossible coupling with the underlying organic functions as well as a proper embedding into social-historical imagery. This "individuation" might fail – in the worst case resulting in psychosis.¹⁷

Thus, subjectivity of humans is anything but a fixed, rationally behaving "agency"; this might be the case, according to Castoriadis, with animals and their "hard-wired" (yet still representational!) *pleasure*, entwined with organic functionalities. Whereas with human beings, it's just the opposite: subjectivity is the felicitous result of an emergent creative process of radical imagination, susceptible to failure, but also open to revolutionise the world by creating "other" imageries.

The first lesson we can learn from Castoriadis, therefore, concerns the processual character of subjectivity, thwarting the mainstream caricature of rational agency. If at all, the latter turns out to be a (cynical) zoomorphism, turning the creative capacities of human imagination into pre-determined sensor-actor-circuits, receptive for computational or dynamicist models. And Castoriadis even gives us arguments against a naive adaption of the Freudian project. Whereas the latter confines psychoanalysis to the private context of the doctor's couch, Castoriadis emphasises the role of the social-historical mediation of imagination. That which happens at the border of

16 Adams 2003

17 Castoriadis 1997a

“Unconscious” and “Consciousness” is not just the “personal” fluctuation of imageries; both its genealogy and its actual virulence are deeply entangled with the exterior, social-historical. The subject is always “a bastard construct, combining in various proportions elements of the psyche, of the social-historically instituted understanding and reason, and of the self-reflecting activity of the social individual at a certain stage of history.”¹⁸

As mentioned already, Castoriadis’ philosophy needs to be thought of “in terms of a shift from a regional ontology of the social-historical towards a transregional ontology of *physis*”, as Suzi Adams puts it.¹⁹ What becomes the main concern throughout Castoriadis’ later writings is the logical as well as ontological difference between *determinacy* and *indeterminacy*. In order to unfold the complex interplay of both these “dimensions” of being, we first have to become aware of the stratified character of his “transregional” ontology. *Physis* subsists as a dynamic multiplicity of (strata of) being, which “is an irreducible, primary datum.”²⁰ As such multiplicity “formally entails unity”.²¹ Without unity, multiplicity would cease to be multiplicity, and would become an “in itself dispersed and disconnected Infrachaos”.²² Now, there are actually two ways *how* multiplicity exists – as *difference*, and as *otherness*. This distinction belongs definitely to the core of Castoriadis’ conceptual apparatus, and it is immediately entangled with determinacy and indeterminacy, respectively.

Let us start with an example: a square is *different* from a rectangle, but Kafka’s “The Castle” is not different from the Rolling Stone’s “Satisfaction” – they are *other*. According to Castoriadis, two forms are different “if there is a set of *determinate* transformations (‘laws’) allowing the deduction or production of this form.”²³ “Determination” has to be taken in its most general reading, as being an *identitary element of an ensemble* – i.e. set-theoretically. Because of its overarching importance Castoriadis coined a new term for this “ensemblistic-identitary” logic: *ensidic*. This logic is “hard-wired” into our language; it is the basis for all mathematical constructions, and is the underlying logic of our sciences.²⁴ Theorising along ensidic lines results in a construction of hierarchies of sets, equipped with relations and rules of deduction. Ensidic thinking “spatialises” multiplicities insofar as it constructs unities by *identifying* elements and collecting them as an *ensemble*. It neglects any intrinsic

18 Castoriadis 1997b, p. 377

19 Adams 2003, p. 106

20 Castoriadis 1997b, p. 400

21 Castoriadis 1997b, p. 399

22 Castoriadis 1997b, p. 399

23 Castoriadis 1997b, p. 392 (with the author’s emphasis)

24 Castoriadis 1997c, p. 295

characteristics and figures these elements *simultaneously*, yet coexisting as *different* ones just by external organisation.

There is no depreciation of ensidic descriptions (in contrast, e.g. with Heidegger's "Vorhandenheit"), rather the opposite is the case – they constitute the dominant form of our world representation. Because the "first natural stratum" itself *allows* for ensidic constructions, social-historical imagination, individual humans are capable of instituting viable representations of their respective worlds. The problem arises if we *exclusively* turn our attention to ensidic narratives, reducing the multiplicity of being to simply a *differential* one. A world made up only out of differences wouldn't change anymore, and nothing *new* would happen. All is *determined*, only differences exist: the repetition of the same. But the "new is not the unforeseeable, unpredictable, nor the undetermined."²⁵ The (unpredictable) next number in roulette, for instance, still remains "the trivial repetition of a form", as does the undetermined, "sheer repetition of a given form" in quantum mechanics.²⁶ The "new" requires the *indeterminate*, the *magma*, which allows for the emergence of *new determinations*, of *new laws*; this "is the meaning of form – *eidos*."²⁷

How does this in-formation (poiesis), the emergence of the "other", arise? We already mentioned the second way of how multiplicities exist: as *otherness*. Otherness cannot occur out of ensidic space. Ensidic space only knows of *differences*, forms, where each form can be derived or produced from other forms, by determinate laws. No *new* forms emerge. Hence, we might consider *time*. New forms emerge in time, don't they? – It depends.

Castoriadis' extensive analyses first show us why "creation", the emergence of "otherness", can't be described by physics and related sciences. The reason is simple: they see "time" exclusively as *ensidic time* – social identity time, which leans on the ensidic dimension of the first natural stratum.²⁸ This, in turn, implies the *spatialisation* of time in the sciences, and results in the reduction of temporal multiplicities to *differential* ones.

Therefore, time in general does not really help. We have to take into account the *magmatic* dimension of time. The emergence of forms (in-formation) is *the ultimate character of time*. The "before" and "after", the irreversibility of *poietic* time, is "given through the scansion of creation and destruction."²⁹ Poietic time forces a self-deployment of new forms in *ensidic* space and time as receptacles of the first natural stratum, where they become organised through subjective – both social-historical *and* individual – constructions. Forms as forms are not caused by something, in the sense of determinate necessary and

25 Castoriadis 1997b, p. 392

26 Castoriadis 1997b, p. 392

27 Castoriadis 1997b, p. 392

28 Castoriadis 1997b, p. 387

29 Castoriadis 1997b, p. 397

sufficient conditions; they emerge – given appropriate (innumerable, but only necessary) conditions. “The conditions allow the emergence of the form – but the converse is meaningless.”³⁰ In-formation is *ex nihilo*, which does not mean in *nihilo*, or *cum nihilo*. The magma allows for in-formation, but it cannot be exhausted; the ensidic is indefinitely “dense” in the magmatic.

3.

As previously suggested, we could start reading the late Castoriadis as process philosophy. In particular, if we focus on his text “Time and Creation”,³¹ we will detect a clear prominence of time over space – the two “receptacles”. When Castoriadis asks whether there is “a possibility for an essential distinction between time and space”³², in the end he gives priority to time: without time there would be “no thing (nothing)”³³. Nonetheless, time and space are intimately entangled for multiplicity exists both as difference and as otherness, and “otherness entails difference”³⁴. This, in turn, implies that every form – in order *to be* – has to be “identical to itself”, it has to *persist* for a while, qua pure repetition in ensidic time – differing with itself “only by being placed in a different (identitary) time”³⁵. Thus, every form has “necessarily an ensidic dimension”. And Castoriadis’ ontology establishes a clear priority: *being is time*. “The fullness of being is given – that is, simply is – only in and through the emergence of otherness which is solidary with time.”³⁶

Finally, then, *in-formation* (or *poiesis*) – the “surging forth” of *otherness* as characteristic for being – forces the *fragmentation* and *stratification* of being. Qua self-deployment, being forces the proliferation of otherness, dispersing new forms both in *poietic* and *ensidic* space and time. As poietic receptacles, space and time ensure alterity; as ensidic, they establish the Being of being at all. Thus, the emergence of otherness, in-formation, does not contradict determinism; it rather contradicts “the paradoxical, if not absurd, idea of a homogeneous universal determinism that could reduce level or strata of being (and their corresponding laws) to a single ultimate and elementary level.”³⁷ Creation ruptures the smoothness and *continuity* of being, it foils reductionism.

30 Castoriadis 1997b, p. 397

31 Castoriadis 1997b

32 Castoriadis 1997b, p. 397

33 Castoriadis 1997b, p. 399

34 Castoriadis 1997b, p. 400

35 Castoriadis 1997b, p. 400

36 Castoriadis 1997b, p. 401

37 Castoriadis 1997b, p. 393

It might be worthwhile looking at contemporary sciences with respect to *their* concept of emergence. *Emergence* – as is well-known – is currently often seen as a new “weapon” in the hand of reductionists. Teeth-gnashing, physicists are beginning to accept that there are “levels” or “strata” of being – probably forced by their very problems with thermodynamics and quantum mechanics. Yet ideally, these strata are communicated as hierarchically ordered, with a one-way determinism from the bottom up. For example, the (phenomenological) variables of thermodynamics (like “temperature”), which constitute a “higher level” of description, are reduced to the movement of molecules – a “lower” descriptive level, more “fundamental”, and thus *explaining* the macroscopic phenomenon. This example illustrates exactly what Castoriadis complains of as “homogeneous universal determinism”. Admittedly, more advanced conceptualisations of “emergence” are “emerging”³⁸ – it might be promising to relate them with Castoriadis’ “Logic of Magmas”³⁹.

Castoriadis tried several times to elucidate his concept of “magma”, the most detailed attempt probably is his paper “The Logic of Magmas and the Question of Autonomy”.⁴⁰ I don’t want to comment on this paper here explicitly; rather I would like to emphasise his reference to quantum mechanics. In this paper he mentions Mugur-Schächter, a physicist, talking about her reflections during theory-building in quantum mechanics. In the end, she finds herself within a “semantic mud”, and “it is only here, in this mud, and when we force our gaze to make out the moving forms, that we can perceive the contrasts between what is not done and what is partially done and thus initiate something anew.”⁴¹ Mugur-Schächter alludes to their problems with the vanished subject-object separation in quantum physics, and the difficulties of handling these problems semiotically.

This reminds us – and that is probably the reason why Castoriadis quotes her – of his account of subjectivity. Again, in his paper “Time and Creation”⁴², Castoriadis develops his concept of space and time, and how they relate to subject and object. Just remember: the world is socially constituted (via imaginary institutions), and it “appears as the deployment of two receptacles, social space and social time, filled with objects organized according to relations, etc., and vested with meaning.”⁴³ Receptacles *appear* to a subject. But they lean on the first natural stratum with “respect to [their] ensidic dimension”⁴⁴. Every living being (being-for-itself) “know(s) ... at least some-

38 Bishop/Atmanspacher 2006

39 Castoriadis 1997c

40 Castoriadis 1997c

41 Castoriadis 1997c, p. 303

42 Castoriadis 1997b

43 Castoriadis 1997b, p. 386

44 Castoriadis 1997b, p. 387

thing of the world.” This implies that the world “is knowable”; but it has to be “constructible” as well.⁴⁵ The world “must contain the ... equivalent of an identitary dimension.”⁴⁶ We don’t have a *chasm* between “subject” and “object”, however – as is still the case in mainstream thinking, as long as it relies on Newtonian physics. It is rather a *chiasmus* (Merleau-Ponty) of subject and object; their respective parts of these constructions cannot be disentangled. Yet, our effort to separate them is not “... meaningless, on the contrary; but it is bound to be interminable.”⁴⁷

We might understand better now, why Castoriadis was seduced by quantum physics: the latter turns out to be the *reference* for our *interaction with the world*. The fundamental interactional pattern between subject and object is quantum mechanical, and *not* Newtonian. Our world is a world of “Zing!”⁴⁸ Jean-Yves Girard is one of the first logicians who strongly emphasises that we have to stop imposing an ensidic logic (to use Castoriadis’ term) in theorising about nature (as so-called quantum logic does); rather we should take non-commutativity seriously, and create a new logic which picks up the insights of quantum physics, and develop a logic along the lines of the principal imbrication of observer and system.⁴⁹ One of the most fascinating results of this approach is the relativisation of set theory – it simply becomes “local”, a subjective “viewpoint” of an observer. If we recall Castoriadis’ attempt to describe the interplay between the magmatic and the ensidic, the emergence of “new” determinations during the interaction of being-for-itself and its proper world – maybe with Girard’s “Geometry of Interaction”⁵⁰ we have found a promising departure for the conceptualisation of the “everywhere dense” *ensidic* within the *magmatic* – in-formation.

4.

If we now turn back to our very question – How is fabrication of life possible? – we should first stress the fact that Castoriadis’ philosophy/ontology *in general* seems to be an attractive, competitive framework for theorising about life and technology – from single cell organisms up to the attempts of the neurosciences to model human behaviour. Unlike Heidegger, or other philosophers in the phenomenological tradition – with their often exposed technophobic attitude – , Castoriadis has a brilliant background both in mathemat-

45 Castoriadis 1997b, p. 387

46 Castoriadis 1997b, p. 389

47 Castoriadis 1997b, p. 389

48 Fuchs 2002

49 Girard 2007a, 2007b

50 Girard 2006, 2007b

ics and in the sciences, which often allows him to avoid bizarre conclusions and misinterpretations.

Secondly, there exists an explicit examination of Varela's approaches to biology,⁵¹ focussing mainly on the concepts of *autonomy* and *being-for-itself*. The crucial question is whether we can think "the living being as a *fully* ensemblistic-identitary automaton"; an automaton, that "has in itself the principles of its generation and corruption as well as of its alteration."⁵² Castoriadis simply does not know. Yet he doubts that it could be possible, for the following reasons. Even if it would be possible to create a complete ensidic description (and construction) of a dog – including an isomorphism between the dog's own significations and constructions within its proper world, and the external ensidic description of the automaton – even then, this "artificial" dog wouldn't be "new", it would be just a replica of an already existing system, whether this is "in the head" of the engineer, or a natural "template". And this, according to Castoriadis, seems to be implicit in ensidic logic: we would never have the reason, nor the criterion for fabricating the dog, if "the dog did not already exist."⁵³

We could go beyond Castoriadis (and Varela), and might consider *implicit* fabrication. This would generally imply the ensidic determination of a "parameter space" – whether discrete or continuous. It would need a (determinate) "quality measure" as well as a (determinate) "procedure", driving the system through the parameter space. Eventually, a being-for-itself might "evolve". Two cases can be considered. First, the system "emerged", it worked as intended, and nothing "extra" happened. This wouldn't change the scenario at all, the same arguments as before would still be valid. In the second case, though, we could imagine that this being-for-itself does *not* match the "target requirements" (or perhaps there were no requirements in the first place), but beyond exhibiting its proper world, it would also exploit the magmatic dimension of the world during the construction of this very world – due to the (potential) exploitation of this magmatic dimension during "evolution". Yet, what we have got now is a completely different concept of *fabrication*. There is almost no control anymore – neither of the "result", nor of the schedule of the process itself. And this leads us to the last issue.

Populating the world with beings-for-itself is just a special, though very prominent, case of the emergence of otherness – *poiesis*. Thus, the question of the fabrication of life entails the question of the fabrication of *poiesis*, and as we have just seen, this implies a change of the concept of fabrication. With fabrication we have actually two choices: we can lean on the ensidic, or we

51 Castoriadis 1997d, pp. 337-339, 1997c, pp. 308-310

52 Castoriadis 1997c, p. 309

53 Castoriadis 1997c, p. 310

adhere to the magmatic dimension of being. In the first case we start creating ensidic constraints, determining “primitives”, production rules, and try to minimise alterity – producing forms by repetition and difference. We try to *occupy* the magmatic dimension of the world, so to speak, and substitute it by our own radical and social-historical imagination, eventually blowing out the *poiesis* of the world. We should be honest: as cowardly as we are (as a species), this world would end up in an eternal return of the ever same – boredom.

The second choice we have would be to *exploit* the poiesis of the world. We would “listen” to the world – intensifying the emergence of otherness, enjoying the fecundity, and subversively reinforcing the overwhelming proliferation of different strata of being, disrupting continuity and thereby undermining the totalitarian pretense of the *ensidic*.

Fabrication of poiesis, then, means keeping open the *surging forth* of *physis*: *alloiōsis*. It works out to be simply waiting for the right moment, the *kairos* – with *Gelassenheit*.

If you want – an *ethics* of in-formation.

References

- 6th Framework Program of the European Union (2008). Online available: <<http://cordis.europa.eu/fp6/>> (last access: June 2008).
- Adams, Suzi (2003): »Castoriadis' Shift Towards Physis«. Thesis Eleven 74, 105-112.
- Bainbridge, William Sims/Roco, Mihail C. (Eds.) (2006): *Managing Nano-Bio-Info-Cogno Innovations: Converging Technologies in Society*, New York: Springer. Online available: <http://www.wtec.org/ConvergingTechnologies/3/NBIC3_report.pdf> (last access: June 2008).
- Barbour, Julian B. (1999): *The End of Time*, New York: Oxford University Press.
- Bedau, Mark A. (Ed.) (1993ff.): *Artificial Life (Journal)*, Cambridge: MIT Press.
- Bishop, Robert C./Atmanspacher, Harald (2006): »Contextual Emergence in the Description of Properties«. *Foundations of Physics* 36(12), 1753-1777.
- Castoriadis, Cornelius (1986): *Crossroads in the Labyrinth*, Cambridge: The MIT Press.
- Castoriadis, Cornelius (1997): *World in Fragments: Writings on Politics, Society, Psychoanalysis, and the Imagination*, Stanford: Stanford University Press.
- Castoriadis, Cornelius (1997a): »The Construction of the World in Psychosis«. In: Cornelius Castoriadis, *World in Fragments: Writings on Politics, Society, Psychoanalysis, and the Imagination*, Stanford: Stanford University Press, 196-210.
- Castoriadis, Cornelius (1997b): »Time and Creation«. In: Cornelius Castoriadis, *World in Fragments: Writings on Politics, Society, Psychoanalysis, and the Imagination*, Stanford: Stanford University Press, 374-401.
- Castoriadis, Cornelius (1997c): »The Logic of Magmas and the Question of Autonomy«. In: David Curtis (Ed.), *The Castoriadis Reader*, Oxford: Wiley-Blackwell, 290-318.
- Castoriadis, Cornelius (1997d): »Phusis and Autonomy«. In: Cornelius Castoriadis (1997): *World in Fragments: Writings on Politics, Society, Psychoanalysis, and the Imagination*, Stanford: Stanford University Press, 331-341.
- Castoriadis, Cornelius (1998): *The Imaginary Institution of Society*, Cambridge: MIT Press.
- Castoriadis, Cornelius (2007): *Figures of the Thinkable*, Stanford: Stanford University Press.
- Curtis, David (Ed.) (1997): *The Castoriadis Reader*, Oxford: Wiley-Blackwell.
- ETC Group (2007): *Extreme Genetic Engineering: An Introduction to Synthetic Biology*. Online available: <<http://www.etcgroup.org/upload/publication/602/01/synbioreportweb.pdf>> (last access: June 2008).
- Fuchs, Christopher A. (2002): *Quantum Mechanics as Quantum Information (and only a little more)*. Online available: <<http://lanl.arxiv.org/abs/quant-ph/0205039v1>> (last access: June 2008).
- Girard, Jean-Yves (2006): *Le Point Aveugle: Tome 1. Cours De Logique, Vers La Perfection*, Hermann. Online available (english): <<http://iml.univ-mrs.fr/~girard/coursang/coursang0.pdf.gz>> (last access: June 2008).

- Girard, Jean-Yves (2007a): »Truth, modality and intersubjectivity«. Online available: <<http://iml.univ-mrs.fr/~girard/truth.pdf>> (last access: June 2008).
- Girard, Jean-Yves (2007b): *Le Point Aveugle: Tome 2. Cours De Logique, Vers Limperfection*, Hermann. Online available (english): <<http://iml.univ-mrs.fr/~girard/coursang/coursang0.pdf.gz>> (last access: June 2008).
- Hagner, Michael (2006): *Der Geist bei der Arbeit: Historische Untersuchungen zur Hirnforschung*, Göttingen: Wallstein.
- Hasslacher, Brosi/Tilden, Mark W. (1995): »Living Machines«. *Robotics and Autonomous Systems* 15(1-2), 143-169.
- Hättich, Frank (2004): *Quantum Processes. A Whiteheadian Interpretation of Quantum Field Theory*, Münster: agenda.
- Kac, Eduardo (2006): *Signs of Life: Bio Art and Beyond*, Cambridge: MIT Press.
- Kauffman, Stuart A. (2002): *Investigations*, New York: Oxford University Press.
- PACE. Online available: <<http://www.istpace.org/>> (last access: June 2008).
- Proteome Assembly. Online available: <<http://proteome.lanl.gov/>> (last access: June 2008).
- Roco, Mihail C./Bainbridge, William Sims (Eds.) (2004): *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science*. Berlin/New York: Springer. Online available: <http://www.wtec.org/ConvergingTechnologies/1/NBIC_report.pdf> (last access: June 2008).
- Rosen, Robert (1991): *Life Itself*, New York: Columbia University Press.
- Rosen, Robert (1999): *Essays on Life Itself*, New York: Columbia University Press.
- Sokal, Alan/Bricmont, Jean (1998): *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science*, New York: Picador.
- SynthCells. Online available: <<http://www.synthcells.org/>> (last access: June 2008).
- Uniroma3. Online available: <http://www.plluisi.org/grl_res_index.html> (last access: June 2008).