Energy Connections

Living Forces in Creative Inter/Intra-Action

edited by Manuela Rossini

Introduction: Energy as a Nomadic Concept

Pourqui certains concepts scientifiques connaissent-ils une vie nomade, d'une science à l'autre? Que deviennent-ils lorsqu'ils passent d'une science 'dure' à une science 'molle', ou inversement? Conservent-ils le même sens? Contribuent-ils à unifier le champ des sciences? Ou bien en compliquent-ils plus le relief? - Isabelle Stengers, 1987

(Translation by Manuela Rossini: *Why do certain scientific concepts lead a nomadic life, from one science to the next? What do they become as they travel from a 'hard' science to a 'soft' science, or the other way round? Does their meaning stay the same? Do they help to unify the field of the sciences? Or do they rather complicate the picture?)*

While I am writing this Introduction, the meltdown of the three reactors at the Fukushima Daiichi Nuclear Power Plant that took place in March 2011 is apparently still not under control. It made new energysaving technologies the centre of attention at CEATEC, Japan's largest information technology and electronics fair, in October of the same year. Environmentally-conscious scientists are starting to hope that better management of the island's many forests and policy reinforcements will allow for the sustainable use of woody biomass (Sasaki *et al*., 2011) or any other freely available natural resource (as documented by the non-profit organization Japan for Sustainability or the German Energy Rich Japan Project) in order to generate the 858.5 billion kWh the Japanese population currently consumes per year. The techno-natural disaster under discussion has recharged the empty batteries of the anti-nuclear movement, and not just in Japan, and has also fuelled calls by political parties of almost all creeds for an 'energy turn' world-wide. (Yet on June 16, 2012, Japanese Prime Minister Yoshihiko Noda prompted the restarting of the reactors at Oi after a shut-down of all the nuclear power plants, while in my home country, Switzerland, higher than expected costs have overshadowed any green optimism about, and political will for, a quick nuclear exit.)

In order to write the above paragraph, dozens of google clicks were needed, each requiring an amount of energy equivalent to letting a 60 watt light bulb burn for 18 seconds. Many dozens of clicks more were needed to search for open-access articles and other information for the production of this living book. Like all digital practices and social media, the Living Books about Life project depends upon energy-intensive infrastructures, partly coal-powered data centres (see dirty-data report by Greenpeace) and an equally energy-intensive cooling system for servers that never sleep. But this is not a book about renewable energies and ways of turning the land of the rising sun into the Kingdom of Solar

Energy, or about how to join hands with Cheeky Cloud and make windmills turn round and round while unfriending Facebook's Dirty Coal -- as promoted by the Greenpeace campaign and video. Moralistic finger-pointing at big Western corporations, greedy capitalists or, worse perhaps, nature as an evil force will not do any longer – if ever it did. An energetic (r)evolution depends on a climate change occurring on all levels of the material, social and cultural fabric of the world, including the micro level of the individual and his or her life-style, 'energy mentality' and values, and not just on a technological fix and a call for new legislation. A more connected and prismatic (not just green) ecological approach, moreover, entails not only a political and ethical awareness of the fact that energy use, capitalism, imperialism and anthropocentrism are hard-wired into each other but also that reactors, tsunamis, electricity, and transmission cables, among other 'things', each have an agency of their own, affecting and being affected by each of the other aforementioned elements (see Chapter 2 on the North American blackout of August 2003 in Bennett, 2010: 20-38).

This book is hence not exclusively about the *E(*nergy) of scientific equations, such as Einstein's famous formula $E = mc^2$. Nor is it primarily about energy as an un/limited resource and consumer good. It is, rather, a book about energy as a nomadic concept and – on the basis of its defining capacity – a material-semiotic agent of trans/formation which is capable of shaping not only 'technologies, politics, societies and cultural world views' (Möllers & Zachmann, 2012: Introduction) but each and every life. Travelling through time, a concept has a history and different names in different periods. It will therefore be useful to consider earlier terms such as 'vis viva' (Leibniz) or 'élan vital' (Bergson), and non-Western notions such as the Chinese principle 'qì', as well as 19th-century artistic expressions of vibratory forces, as residual elements of the conceptual frame that has shaped what we mean by 'energy' in its broadest sense today. Tapping into energy as an idea, a relation and a dynamic substance, or perhaps rather an intensive flow and affect, I hope to add another atom to Vicki Kirby's 'quantum-anthropological' proposition for a 'meta-physis of life at large' (2011). More broadly and theoretically speaking, my aim here is to contribute to the project of critical posthumanism. We could call it a modest proposal to embrace a cosmopolitics (Stengers, 2010 and 2011) in order to sustain the good vibrations of all that matters.

Energy Forms: TransForming Dynamics

In the era of classical thermodynamics, the cultural allegory of energy forms proceeded from the universal moralization of heat into the relativistic decoding of light, preparing both matter and energy for further metamorphoses into the chaotic orders of information. - Bruce Clarke, 2001

As a cosmopolitan nomad, energy takes a ride in many forms and means of transport to travel (in)between subatomic particles, neurons, organic and inorganic bodies, societies, cultures, stories, and disciplines. Having no passport, it belongs to none of the countries it traverses, yet it leaves its footprints everywhere, while also being trans/formed by what it encounters and interacts with – or, more appropriately, *intra*-acts with: material agents do not meet as already constituted and discrete entities, separated in space and time, but only emerge as seemingly individual forms through and from their mutual quantum entanglements in spacetime (Barad, 2010; see also section 'Energy Matters' below). Energy is no exception in this matter. The online *Encyclopedia of Human Thermodynamics* (see Energy) explains that while the term 'energy' was only spelt in this way for the first time in 1599, its etymological roots can be found in Artistotle's *Metaphysics* (c. 350 BC), where a state of functioning but also the ability 'to bring about something else' are foregrounded. Yet, ἐνέργεια in the Greek philosopher's ethical treatises also meant 'activity' (to denote more than simply a disposition or state) as well as, in his *Rhetoric*, 'a vigorous style'. From the beginning, then, the concept has implied that physical as well as discursive powers are in charge of 'the ceaseless transformation of the potential into the actual'. What I would therefore like to emphasise in *Energy Connections* is that life – whether human or nonhuman, organic or inorganic – is a crea(c)tive becoming, with energy in its various states and forms (including narrativizations) being vital to its dynamics.

The dynamic definition and interdisciplinary use of energy I want to draw on and promote here was set in motion by polymath Gottfried Wilhelm Leibniz (1646-1716) in his 1695 paper 'Specimen dynamicum'. In that paper Leibniz introduced the term 'vis viva' as a relational concept to complement a more mechanical, Cartesian notion of energy as a *dead* force, with the idea of a *living* force, or what is now called kinetic energy. Leibniz believed that a collision between two bodies transferred 'vis viva' from one to the other, giving each of them a kind of 'life' by putting it in motion. He argued that even when the two colliding objects seemed to come to an apparent halt, 'vis viva' was always conserved in the form of small chaotic motions invisible to the eye – in the form of heat, in other words. Leibniz was thus the first to recognize the conservation of energy, which was formulated as the first law of thermodynamics (i.e., as the conversion of mechanical energy into heat) in 19th-century physics and then became a dominant principle in other scientific fields. His *Monadology* of 1714 can also be credited with endowing matter – even inanimate matter – with life. In this book he assumes that an infinite number of substances, which he calls 'monads', make up any entity as an arrangement that is liable to continuous rearrangement and change through internal action. Since every composite is different, it can unfold in a singular manner depending on its inner energy or potentiality. Accordingly, evolution is seen as the actualisation of these individual potentialities. This foreshadows the epigenetic propositions about the origin of life at the end of the 18th century, propositions that challeged the preformation theory of organisms articulated in natural history thus far. While preformationists denied nature an energy of its own and saw all forms of life corresponding exactly to the way God had supposedly designed them when He created the world, epigenesis postulated a generative and form-shaping power *within* nature and bodies (epigenesis/preformation). As with Leibniz, the focus of analytical interest was thus on the *becoming* of forms and a living and driving force *immanent* to a system.

The articulations listed above can be regarded as prescursors of the intra-active dynamism of matter-energy, or 'microscopic forms of energy' (Dincer & Cengel, 2001: 120), that we find in post-classical physics, an umbrella term for atomic physics, quantum mechanics and theories of relativity, from the 1920s onwards. Diametrically opposed to the dominant mechanistic and deterministic views of natural phenomena and the universe as a perfect clockwork set in motion by and running on divine power, these 18th-century theories are paralleled in modern times by emerging notions of the unpredictability of living systems and the irreversibility and indeterminacy of their trajectories. In *Energy Forms*, the book that gave this subchapter its title, Bruce Clarke charts a cultural poetics of the energy concepts in classical thermodynamics and early electromagnetics that not only dominated science but that also influenced the narratives of modernity at large. He mentions William Thomson's paper 'On the Universal Tendency in Nature to the Dissipation of Mechanical Energy' of 1852 as the moment in Anglo-American science when the Galilean-Newtonian 'marriage' of mathematical and dynamic principles produced as its offspring an authoritative discourse about energy as a calculable 'closed-system phenomenon seeking a final state of thermal equilibrium' (2001: 5) that makes system boundaries impermeable. In the secular age, the harmony was no longer orchestrated by God but rather by gravitational laws. Within this framework, life as a whole, social processes as well as cultural developments, could all be approached as problems in mechanical engineering and 'subjected … to the material economies of physical systems' (ibid.). During the same era, however, creative literature not only supported these 'positivist scientisms' (ibid.) but also presented a counterdiscourse to them. It did so precisely by putting centre-stage the tension within classical thermodynamics itself, namely the fact that most energy forms – heat, light, electromagnetism – are not solid but fluid occurrences. Such flows cannot be captured and controlled for a perfect and complete conversion into work within one system (conservation): instead, they are irreversibly dissipated to the outside. The scientific romance 'The Persian King' (1886) by mathematician Charles Howard Hinton provides an example of the allegorical portrayal of the interaction between conservation and dispersal of energies (as analysed by Clarke, 1997). Slowly but surely, the discipline had to learn that dynamic systems oscillate between states of order and chaos, and that energy flux is a crucial aspect of life. This energy flux renders complex systems *open* to each other (while being operationally closed) in order to allow them to enter into couplings that are indispensable for symbiosis and that are conducive, at the same time, to self-organisation and the autopoietic, biophysical and neurodynamic construction of individuality, or what Francisco Varela preferred to call 'interbeing' (reported in Rudrauf et al., 2003).

In order to grasp better the role of such recursive and embodied feedback loops in the emergence of life and the circular operations of internal self-production, it will be necessary not only to follow energy flows as theorised by vitalist thinkers in biology, physics or philosophy, but also to learn about 'natural computationalisms' which link information to matter-energy (Dodig-Crnkovic, 2011 and 2012) -- and which have their own literary and artistic articulations (Clarke & Henderson, 2001). A more inclusive theorisation of what it is to be alive/a life will need to position itself in favour of the cosmopolitical project – a project that connects us human beings energetically to a dynamic, complex and intelligent environment to which we owe our existence and livelihood as individuals and as a species.

Energy Flows: Powering Cosmopolitics

> In a natural universe governed by the laws of energy flow we must understand our true nature and how it is shared with other naturally occurring complex energy systems. - Dorion Sagan, 2009 (blog)

Energy flows are the building blocks of the universe – at least when seen through the scientific theories that followed classical thermodynamics. Energy moves in many channels and often nonlinear directions, and in all dynamic, far-from-equilibrium systems (Schneider & Sagan, see especially 'The River Must Flow: Open Systems' on the website of their book *Into the Cool*). Energy streams engulf us all (listen to 'We Are All Connected' in the Symphony of Science series, a sampling featuring Carl Sagan, Richard Feynman, Neil deGrasse Tyson and Bill Nye). Again, these ideas are not new. They find their discursive ancestors in much earlier times and places, above all in Asia, and also in non-scientific communities: dating back to the 5th century BC, *qi* is a very old expression in Chinese culture for this idea. The sign, appropriately brushed as three wavy lines, is frequently translated as 'energy flow', or that which pertains to any living organism. Literally meaning 'air' or 'breath', it is similar to Hindu *prana*, which is the life 'ener-chi' one can access when practicing yoga. Such Eastern practices meet Western traditions in studies and therapies of life energy processes which draw on energy concepts from the natural sciences as well as the humanities. Finally, *i-no-chi*, the Japanese word for life, means 'energy of breath', as Nakeshi Naganuma explains (2009: 835). In his paper, written from the standpoint of astrobiology, the scientist includes an extract from the Medieval essayist and poet Kamo-no-Chomei (1155-1216), which also testifies to the fluid and constantly changing existence of human and nonhuman life: 'The flowing river never stops and yet the water never stays the same. Foam floats upon the pools, scattering, reforming, never lingering long. So it is with man and all his dwelling places here on earth' (829). This notion is visualised on the same page with the drawing of Vitruvian Man as a vortex, consisting of molecules flowing in and out of the body. As these images suggest, change comes from the movement within a system, which is also expressed in Jane Bennett's definition of *qi,* or *shi* in her spelling, as 'the style, energy, propensity, trajectory, or élan inherent to a specific arrangement of things' (2010: 35). Here again, as already emphasised in the previous section of this book, we are made aware that open systems – including ourselves – owe their agency to the sum of the vital materialities that constitute them.

Unlike earlier vitalisms that ultimately see life sparked off by an outsider, the neo-vitalist materialisms I want to promote with my contribution do not posit any external or extra-material force but rather focus on the vibrant tendencies for inter/intra-actions within human and nonhuman 'things' themselves. For Gilles Deleuze and Félix Guattari, such forces can also be virtual and not even primarily aiming at the (re)production of life. To disconnect life from the heterosexual matrix and the idea of well-organized bodies, Claire Colebrook (2010) draws precisely on their 'passive vitalism' (which in its turn is indebted to Leibniz) to forge a 'queer vitalism'. Within this framework, vitality is a decidely post-anthropocentric feature because it extends beyond the human. Queer vitalism cherishes a potential that is actualised not by individual intention but through encounters in the interest of the common good: every living being contributes in different and specific ways to the flourishing of the whole (79). Focusing on the relation itself means, for Isabelle Stengers (2010), attending to the 'meso' and the material (rather than micro or macro matters separately and exclusively) and, in the process, addressing the milieu/the middle of a composition, i.e., the way something holds together or breaks. To put it differently, it is the configuration of the whole that counts, rather than any particular part of the assemblage, and that escapes the calculus, insofar as the agential sum is more than its active (or passive!) components. Translating this into energy terms, we can make two related claims: (1) energy flows do not belong to the individual alone or to the collective but rather circulate between the micro and macro level, and (2) the total of energy input is never available to the system for its own functioning; there is always an unavailable remainder that should not be seen as waste or loss but as a useful output for the creative evolution of related systems. The latter, in a nutshell, is the most important cosmological and 'mesopolitical' implication of a 'thermodynamics of life' (Schneider & Sagan, 2005), better known as 'open system thermodynamics' and best known as 'nonequilibrium thermodynamics' (or simply NET). This 'new science' concentrates on 'how energy flow works to bring about complex structures, structures that seem to maintain themselves apart from their environment, structures that cycle the fluids, gases, and liquids of which they're made, structures that have a tendency to change and grow.' Combining physics and biology to describe life processes, NET is basically an adaption of the second law of thermodynamics to open systems.

In its classical formulation by Rudolf Clausius in 1865, the first law expressed the observation that systems in isolated spaces merely transform energy, thus producing a quality change (from heat to work mainly) without any quantitative loss; i.e.; the total energy remains constant. Somehow in contradiction to this claim, the second law admitted the impossibility of transforming *all* the energy, which results in certain amounts of energy loss measured by degrees of entropy understood as alternating states of order, disorder, and/or chaos. As heat irreversibly flows from a hot, high-energy entity to a cold, low-energy one, energy is levelled off until a thermal equilibrium is reached, which ultimately leads to the so-called 'heat death'. This is the moment when the temperature of the universe has cooled down to almost absolute zero (about 270° minus). When the thermodynamic 'arrow of time' finds itself in this point, there is no more energy left for anyting to evolve, hence there is no more life (see Schneider's Life as Energy Lecture of 2006). Such apocalypic visions used to (pre)occupy the scientific and literary imagination alike and have affected philosophical, aeshetic as well as social debates – even though the end of the world would only happen in about a thirty million years. Gillian Beer, for example, traces the discursive overlappings with regard to ‘the death of the sun’ between mythography, linguistics, physics and biology in the Victorian imagination and public debates in the 1860s and 1870s (1996: 219-241; see also the novels discussed by Clarke, 2001). These myths, grounded in the second law of thermodynamics, continued well into the twentieth century, despite the new atomic physics and Albert Einstein's theory of relativity. Also today entropy is still being (ab)used as an analogy or metaphor in ecological economics, as the critique of the field's discourse by Geoffrey P.

Hammond & Adrian B. Winnett makes clear (2009: 1196-1225). To demystify entropy, the authors suggest we should carry out analyses of exergy (the actually available and usable energy) alongside entropy analyses, because 'exergy is a more easily understood thermodynamic property than is entropy to represent irreversibilities in complex systems' (1220). NET certainly seconds such critical endeavours by focusing on the question of how energy flows organize and sustain complex systems (Sagan & Whiteside, 2004: 174).

While not opposed to the second thermodynamic law in general, NET rephrases it to argue against its universal applicability. There is steady production of entropy but its increase or a state of its relative stability only defines the situation of closed systems, such as a watch and other purely mechanical and more solid systems that do not interact and exchange any energy (as heat or work) or matter with their outside environment. Entropy should therefore not be seen to be the major component of the second law when it comes to processes of systems that are open to energy and/or material flows, such as trees, for example, through the transpiration of gases from air or human beings through the intake or digestion of nutrients. These living systems maintain their form not only by continuous energy dispersal but also by dissipating gradients (i.e. measurable differences of all sorts, including not only thermal, biological or chemical differences but also economic, social or cultural ones). Open systems depend on external fluxes because they need gradients which they experience as disorder but which they then, as dissipative structures, reduce in order to organize themselves in a coherent, orderly manner and in order to maintain that (self-

)organization in a locally reduced entropy state -- a state which, however, can never be exactly predicted. For the proponents of this reformulated second law of thermodynamics, ambient gradient reduction is the origin as well as the purpose of life (Schneider & Kay, 1994: 25-48), with life's 'purpose' understood not in the humanist sense of conscious intentionality but, in posthumanist terms, as its function and prebiotic physiology, immaterial propensity or, to refer to Deleuze and Guattari once more, its virtual vitality. The openness of such complex systems thus also leaves the future wide open and subject to contingencies of all kinds. In short, NET offers a non-deterministic theory of evolution as an emergent process marked by the (re)cycling of energy flows between inside and outside, system and environment.

When the (his)story of life is understood not just as competition or survival of the fittest but also, if not primarily, as dependent on interaction and cooperation, then it should perhaps come as no surprise that cybernetics helped to explain the control mechanisms of diverse life-forms as concerted 'global regulation of environmental variables' (Sagan & Whiteside, 2004: 179), similar to the 'unconscious' information processing of computers, insofar as cybernetic mechanisms, 'amplify or attenuate trends automatically' (ibid.) through positive and negative feedbacks. Such optimization or normalization of energy flows, as Eric J. Chaisson suggests, 'might well act as the motor of evolution broadly conceived, thereby affecting all of physical, biological, and cultural evolution' (2005: 27). Widening the discursive frame of energy by focusing on inter/intra-active connections and co-evolution rather than primarily on substances also allows for a more dynamic and complex flow between disciplines, theories and concepts that are often seen as being in opposition: the natural sciences and the humanities, cybernetics and deconstruction, information and materiality, physis and semiosis.

Energy Matters: Entangling Physis and Semiosis

Matter and meaning are not separate elements. They are inextricably fused together, and no event, no matter how energetic, can tear them asunder ... most evidently perhaps ... when the smallest parts of matter are found to be capable of exploding deeply entrenched ideas and large cities. - Karen Barad, 2007

Just as a nomadic concept conserves some of the memories of its voyages across disciplinary territories, so are these territories marked by the imprint of its connotations in foreign lands. Mid-nineteenth century prototypes of what is now the science of physics appropriated contemporary literary and philosophical meanings of the term not just to enrich their discourse with appealing metaphors but also to find 'terms that named new conceptions of natural objects and processes' (Clarke 2001: 2). And these new understandings then again influenced the way artistic production and reception was understood. The scientific notion that energy matters such as light and heat are essentially vibratory, for example, became so prominent over the course of the nineteenth century that artists and writers of the first half of the twentieth century also began to transform their practice and to develop a modern aesthetics with which to grasp the unseen forces that connected the interior self to the exterior environment. I am thinking here in particular of

Virginia Woolf's *The Waves* (see Beer 1996: 295-318). Similarly, the form-generating potential or living force inherent in any matter made Paul Klee draw an analogy to the form-generating power of the line; it also provided visual form to chemist Wilhelm Ostwald's theory of energetics, according to which 'energy is the only real substance in nature' or, to put it the other way round, 'matter was simply a manifestation of energy rather than the weight and mass traditionally designated as matter' (1993: 311). Philosopher Henry Bergson, the 'life philosopher' *par excellence*, added a further analogy, namely that between the dynamic concept of physical reality as energy flows and the mind as 'mind-energy' (1920), thus replacing the more static definition of mind as awareness or consciousness.

One might perhaps object that my use of the term 'energy' outside the domain of physics has been purely metaphorical or, worse, accuse me of holding on to the paradigm of social and cultural constructionism I have critiqued here (Rossini 2006) and elsewhere. Indeed, I have largely spoken in terms that the scientists at CERN clearly distanced themselves from at the press conference of July 4, 2012 – on Higgsdependence Day. They did not offer an answer when a journalist asked them about their preferred metaphor (knowing that they hated the popular expression 'God's particle') for the Higgs boson. Speaking for all of them, director Rolf Heuer summarised: 'the podium is metaphorless'. Instead, they repeated that they had found 'something'; i.e., only a *signal* that would drive their research for the next 50 years towards the final explanation of the universe and that, whatever it is, this new particle 'embodies the substance to all these other particles that exist' (50:00-51:53). While mainly drawing attention to the physical aspects of the boson (if it is a boson), one spokesperson on the panel also emphasised that 'these particles are not isolated, they talk to each other' (47:55-47:58) and that only a very small part of the full story has been told now. That this 'something' is but a nanoelement in a gigantic picture is demonstrated by the probability of 5 sigma – this is, a 1:3'000'000 certainty that the discovery was not a random fluctuation but the Higgs boson of the standard model – which seems highly fictitious to me but which indexes a reality within CERN's experimental systems. Even if this 'it' is not the predicted boson, the approximately 4000 physicists carrying out the ATLAS and CMS experiments can claim that they discovered a new particle with a mass of 125 to 126 gigaelectrovolts, which is about 133 times more than the weight of a proton. The experiments show that physical properties are a matter of measurement, which in turn is contingent upon measurement devices or massive apparatuses such as the Large Hadron Collider that allowed the acceleration of the protons in order to produce such a deep impact for 'something' consistent with the hypothesized Higgs element to appear in the first place. I owe this statement about 'objective' measurement and its condition to Isabelle Stengers, who contrasts the conversion-of-energy paradigm as a 'way of seeing' (beginning with Leibniz and continuing well into the 19th century with the post-Kantian naturalists) to the conservation law of energy as the measurement of mechanical work; i.e., 'something' that, thanks to Joule's calculation system, could be used to quantify conversion and hence put what was circulating as an 'aesthetic idea' without having one single author/ity into the realm of author/ized science (2010: 192-193).

What begins after the experimental phase is the meaning-making process and the analysis of the communication that happens when matter 'speaks'. In other words, the material cannot be grasped outside the semiotic. Conversely, meaning not only possesses a materiality that manifests itself as the trace of difference but also has real, material consequences. Similarly, information is never disembodied but rather context-dependent; it is produced by at least two interacting bodies, none of which have a self-contained existence. Hence my endavour with this book to bring back matter into constructionist theory as it interacts with the linguistic and informational, which is a move that is similar to Foucault's interweaving of material practice and discourse but that above all remains indebted to the insights of new materialism. Its representatives are mainly feminists (some of whom I quoted before) who, for decades now, as scientists or cultural analysts (or both) have enlisted paradigms from physics, biology, neurology and other fields of the natural sciences to argue their case. With a background in theoretical physics and teaching cultural studies of science, Karen Barad, for example, fuses being and knowledge on the basis of Niels Bohr's materialist understanding of concepts in order to forge what she calls an 'onto-epistem-ology' and, like Stengers, to point to the inextricability of measurement, appartus and description (2007: 109). With regard to the CERN experiments, one would have to ask with Bohr: What do you *mean* by a 'boson' or 'particle' in general? And the answer would be that the Higgs boson has no pregiven existence, substance, position or movement prior to the measurement or discourse: 'Particles aren't inherently bounded and propertied entities running in the void. Mattering is about the (contingent and temporary) becoming-determinate (and becoming in-determinate) of matter and meaning, without fixity, without closure' (Barad 2010: 253). Mattering or the agency of matter, we may add, is brought about by theory. This tenet is the core element of Barad's 'agential realism', which conceptualises agency without an intentional (human) subject acting upon a passive (nonhuman) object in a one-way causal relation or linerar temporality. It follows from there that, rather than speak of the Higgs boson as a '(some)thing', the experimental physicists should regard it as a phenomenon and, to draw on Barad's vocabulary once more, to 'get real' and think of reality as 'things-in-phenomena'; i.e., as co-constituted by 'intra-actions' between discursive and material agents (2007: 140). The Higgs boson is there but not *simply* there (there is no there there, as Gertrude Stein poetically intuited); it is nevertheless an empirical thing they can interact with, producing both a theory and a living phenomenon.

Other allies are researchers from the fields of biosemiotics and cybersemiotics. As Wendy Wheeler has already contributed an excellent volume on biosemiotics to the LiviBL series and a recent special issue, edited by Søren Brier, of the open-access journal *Entropy* was dedicated to cybersemiotics, I only very briefly refer to those aspects which underline the imperative to approach the topic of energy from an interdisciplinary perspective as a living force involved in material interaction, intra-action and 'sign action' (semiosis) with all kinds of other agents. Biosemiotics starts from the premise that all living systems are meaningful systems with the capacity to write, read and interpret signs, understood largely as codes for establishing cooperative relations. As the name already indicates: life and semiosis are co-existing. Indeed, as Günther Witzany's paper makes clear, bio-communication of bacteria lies at the evolutionary root of cellular life (2008: 44-54). This is why we need a critical ecology that is not only framed in thermodynamic terms but that also takes the capacity of interpreting and communicating of human and nonhuman systems into account. One precursor of such a theory is Gregory Bateson who must be credited, as Clarke reminds us, not only for 'a significant relay of cybernetic discourse from the natural to the social sciences' but especially for revisiting the orthodoxy that information is distinct from matter (2010: 165). While Bateson was sharing the Saussurean postulate that something is this because it is *not* that when he famously defined information as 'a difference which makes a difference' (1972: 453), biosemioticians prefer to draw on the semiotics of C.S. Peirce because it is more useful for developing a theory of signification that avoids the intentional fallacy and that can be better interlocked with the concept of autopoesis (see section 'Energy Forms' above). When life itself is seen as differential, then we need not hang on to the negativity or meaninglessness associated with difference by Ferdinand de Saussure, for whom there are no positive terms in language, or by Freudian or Lacanian psychoanalysis. Becoming something rather than being this or (not) that is the game of the living. Rather than perceiving and thinking in black and white, we should be aware of the shades of grey and all the colours of the rainbow. Life consists of vibrant energy matter that cannot really be seen, classified or controlled. Shifting to becoming, communication, and differentiation also means focusing on processes and forms rather than substances (as is the case with the conservation law of energy in classical thermodynamics) in order to witness the interplay of body and mind in sign-mediated interaction for cognition and decision as well as meaning-making of human and nohuman organisms alike.

As I have summarized in the section 'Energy Forms' above, nonlinear dynamic systems are open to external signs such as energy gradients and manage to dissipate those differences, producing order from chaos. This action requires semantic capacity and a certain degree of 'freedom'. To counter the entropic view of thermodynamics as it was applied to information in the cybernetic discourse of the 1940s, Bateson introduced the notion of 'bioentropy' to name these processes. Peter Harries-Jones explains that, unlike other ecologists of his time, Bateson refused to define the organisational power of ecosystems exclusively in terms of their physical properties of biomass and energy converted into work. Instead, his observation was that 'metabolisms rates were different in kind from physical flux. Organisms had the ability to regulate their chemical activities or compensate for changes that result in an imbalance to their activities of reproduction, growth and movement' (2010: 2672). Living organisms, in other words, are not machines.

The story of energy connections I have begun to tell with this book seeks to induce a greater attentiveness on the part of human beings to the active power of things-in-phenomena and to the concomitant complex inter- and intra-actions between various living systems that together assemble our world -- and on which humanity depends for survival. In the process, I argue against a mechanistic and hence deterministic view of matter as predictable, as something to be fully controlled or 'hunted down', as a CERN spokesperson phrased it at the press conference. By the same token, also the present analysis is but a travelling sub(p)article in the ongoing energetic and mutually energizing relations we can forge between disciplines and cosmopolitan actors. In this adventure, energy matters as a nomadic concept for turning the humanities into the posthumanities, in ways that will make them more responsive to the challenges of our times.

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