The Futures of Causality: Hans Jonas and Gilles Deleuze

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1. Introduction: Determinism and Novelty

One of the meeting-points between the Western scientific tradition and common-sense understandings of physical events lies in the temporal structure of causality. Causality, like time itself, is unidirectional. The past fully determines the content of the present, and therefore the future is only the outcome of what has already occurred, granted the general uniformity of nature. However, there are varieties of physical system where an explanatory gap appears to open up between the past and the future. The assumption that the past of any physical system, at any isolated point in time, constitutes the sufficient reason of its present and future, does not hold for some complex systems that manifest behaviours (e.g. adaptivity) with various degrees of indeterminateness. Complexity, in this sense, tends towards unpredictability rather than the predictability promised by Newtonian and Laplacean conceptions of physical law (Prigogine and Stengers 1997). But the unpredictability it promises is not randomness, but instead the emergence of new and unforeseen forms of order.

In the Newtonian or Laplacean deterministic universe, movement is a property of material bodies through which is 'transmitted' the influence of the past in ways which conform to fixed laws. Change is movement, and is borne by bodies, aggregations of material substance whose attributes vary as their position in space changes over time. In this universe, there is no true novelty. Time is a series of instants or *t*-states, within each of which is re-instantiated the whole set of physical laws that govern the fundamental constituents of material substance. In J. E. McTaggart's terminology (McTaggart 1993), this constitutes the B-series of time, according to which changes can be assigned to specific points in time according to unvarying laws. Change is only the rearrangement of material substance in ways which may vary the properties of individual bodies, but which cannot give rise to anything whose behaviour is not in principle subsumed under the existing laws. In this universe, neither past nor future (McTaggart's A-series of psychological states of memory and anticipation) is truly real.

Since Lamarck and Darwin, and the emergence of modern biology, the meaning of novelty in the universe has however been a central concern of scientific investigation. The theory of evolution by natural selection treats novelty as a real phenomenon, with the laws of natural selection being dependent on the contingent coming into existence of entities which can reproduce and whose offspring are subject to heritable variation. The discovery that such entities have an origin within *historical* time shatters the older world-picture. Instead of one set of fixed laws being operative from the least organised level of matter upward, the changing properties of matter may themselves produce entities whose attributes are organised in ways that are qualitatively different to those of other entities, and which are governed by novel constraints which themselves have a history.

Ontologically speaking it is therefore necessary to understand how novelty, in the shape of new forms of order, can emerge. This shifts the focus of scientific explanation, just as the development of Newtonian mechanics shifted it. In the Newtonian universe, the regularity of nature was explained in a way which radically differed from the Aristotelian cosmology which was intellectually dominant in Europe up to the 16th and early 17th centuries. Whereas the Aristotelian worldview saw rational order within the resemblances between natural phenomena and pure geometrical forms, e.g. in the spherical shape of the earth and the circular orbits of the planets, the new natural philosophy proposed instead that mechanical motion of the basic constituent parts of nature was the basis of natural law. Developments in algebra, leading to innovations in coordinate geometry, allowed geometrical forms to be seen as the products of functions that were taken to represent physical laws. This form of mechanistic explanation replaced the idea that the Ideas of geometrical forms were themselves the eternal final causes of motion (Jonas 1982, pp. 67-68). What the problem of novelty produces is another shift in our understanding of the nature of order, with the mathematical regularities that are taken to typify natural laws being seen as emergent products of processes which must themselves be described. The question then arises as to what constraints these processes themselves operate under and how, if at all, they can be described.

2. Mechanism, Finality and the Future

In order to define these constraints, we might consider two options:

(A) The constraints are somehow given independently of the systems which they constrain, and are therefore eternal limits on the variations that may occur in the properties of different kinds of material entities. This, however, takes us back beyond Newtonianism, to an Aristotelian universe in which deterministic final causes act as teleological attractors for the development of material entities in time. If we return to the assumption that final causes in this sense are real, then any questions concerning the mechanism by which the intelligible forms of material objects are made to inhere in them promise to take us beyond scientific naturalism and on to cosmotheology. Here, the options for development somehow reside outside time as possibilities which are realised within time through a process of selection that limits what can be realised at any one instant (Deleuze 1991, pp. 96-97). The transcendent order of final causes together with past moments understood as a sequence of efficient causal transitions fully determines the present. Hence it is difficult to view the future as anything other than the yet to be worked-out consequences of these two orders of causality. Novelty, in this sense, does not truly exist. We are back once again with McTaggart's B-series, in the sense that the experience of futurity or anticipation is an index of the epistemological limits that derive from our temporalised, finite existence.

(B) The constraints are somehow produced *within or alongside* the systems they constrain. In other words, they do not pre-exist them in any sense which implies some kind of hierarchy of the material and intelligible, with intelligible forms being transcendent to matter yet somehow mysteriously imparted to it. Here, novelty truly exists in the sense that an open future is a real dimension of the present. The present cannot be understood without placing the future within it as that which holds it open. To explain the present, we need to understand its past and the genesis of the forms of order which operate within it, but we also need to attempt to grasp in what directions these forms are themselves evolving. The reality of the future does not mean that it is in some sense pre-ordained. Rather, its reality lies in how it holds the present open in a determinable – rather than wholly indeterminate – way. That the future of a system is open does not mean that 'anything can happen', but rather that it should be thought of as a *problem* ("what next?") which the system poses in a way which is unique to that system and its interactions with other systems.

In this essay, I want to examine two attempts to understand what option (B) might mean for explanations of change. Hans Jonas offers an account of, in the main, living systems which presents metabolism as the basis of understanding their irreducible future-orientation, and argues for the necessity of phenomenological description in explaining how living systems operate. Phenomenological description here (implying a standpoint which takes the appearance of the world *to* a particular system as irreducible) is posited as a necessary constraint on mechanistic description, one which promises to unite an observer with the futures that 'inhabit' a particular system. Gilles Deleuze offers a contrasting account of how order emerges within material systems *per se*, including physico-chemical, biological, social and technological forms of organisation. Instead of phenomenological description, he points to *virtual* constraints which operate within material systems, making possible both tendencies towards homeostasis (like the metabolic processes Jonas describes) and tendencies towards metamorphosis. Both homeostasis and metamorphosis are theorised as operating across the widely different timescales of production and reproduction that differentiate types of systems from each other. The virtual attractors that incline matter towards either tendency inhabit the present in a different way to the phenomenological future of which Jonas writes.

While neither author promises a return to the Aristotelian universe of deterministic final causes, both refuse the Newtonian option of assigning to causation the single meaning of efficient causation. Instead, they arguably retain an Aristotelian inspiration insofar as they interpret the category of *aition* (broadly, whatever can be offered as a response to a 'why?' question) as inherently ambiguous, due to the temporal structure of change.

3. Hans Jonas and Immanent Teleology

The schema offered by option A (section 2, above) is a preformationist one in which *teloi* are imagined as somehow given in existence anterior to the existence of individual entities which, after birth, develop in accordance with specific mechanical laws selected and regulated by their individual *telos*. Kant's assessment of teleological judgement in his *Critique of Judgement* is directed against the validity of such a view, which interprets purposes as objective elements which are placed within nature, such that natural processes serve as means to the achievement of external ends. Hans Jonas, in a series of essays which, it has been suggested, constitute an attempt to solve the ambiguities within Kant's third *Critique* concerning the status of teleology (Weber and Varela 2002), has argued that such views of teleology as anterior or *external* to nature reflect a mistaken judgement based on experience. External teleology is, as Kant argued, not an *a priori* principle of experience. It is derived from our actual experience, but from our understanding of human artefacts, where purpose always precedes manufacture, rather than from our experience of living things (Jonas 1982, pp. 117-122). However, Kant considers it legitimate, when confronted with some natural entities, to reflect on the nature of a purpose which is not given to us in order to make sense of our experiences of them (Kant 2005, §80). This kind of purpose is what Jonas characterises as an immanent form of teleology, one which marks a formal distinction between organic and inorganic systems and which requires a phenomenological level of description.

Mechanistic approaches to characterising what marks the difference between living and non-living systems typically proceed by listing the characteristics of the material processes that operate in either case. In this way, the characteristics of the material substrates of these kinds of system and the laws according to which energy is transferred through them are assumed to be formally sufficient to distinguish them. What this leaves out, from Jonas' point of view, is how a living system such as an organism constitutes a centre of experience or a *thing-for-itself*, and how the minimal formal characteristics of such a conception force us to treat a mechanistic explanation of life as an incomplete abstraction.

Whereas the mistaken attribution of external, objective purposes to nature derives from our understanding of human artefacts, Jonas observes that our attribution of a hidden end to a living system is based on our experience of ourselves as living bodies, with an urge to continue existing (Jonas 1982, pp. 21-25). Self-knowledge derives from the character of this embodied being, rather than being attendant upon achieving a Husserlian transcendental reduction to pure consciousness. Further, our experience of striving to continue existing within a world full of affordances and resistances gives us the basis for our understanding of causality and change – a proposition which reflects Kant's argument in his *Opus Postumum* that the *a priori* categories of experience are grounded in bodily experience (Weber and Varela 2002, pp. 109-110). That this experience has a particular temporal structure is crucially important, and a theme to which we shall return.

To reason, as Jonas does, that biology has to be based on a phenomenologically-informed set of principles, rather than solely on the methodical search for mathematical regularities in observable data, should not be understood as an attribution of human selfhood to non-human organisms. The analogy between our life experienced as *conatus*, or an overwhelming and consuming concern to persist in one's identity (Jonas 1984, pp. 72-73), and the formal character of life *per se* is much more minimal. From this analogy, Jonas argues in the essays collected as *The Phenomenon of Life* (1966) that the fundamental distinction between living and non-living material systems is that the organism has the character of what Roman Ingarden has elsewhere described as a "relatively autonomous system" (Ingarden 1970). It maintains a dialectical relationship with its environment, actively distinguishing itself from it whilst at the same time managing and sustaining a set of dynamic relationships with it. To put it another way, the organism seeks to maintain its overall functional unity throughout an ongoing exchange of matter and energy with the environment (Jonas 1982, pp. 75-76). By contrast, the non-living system is defined as a collection of indifferent material substrates through which energy is simply transmitted, a system without the phenomenological quality of for-ness or intentionality in the general Brentanian sense. However, this distinction does not imply that the for-ness of an organism is cognitive. Cognition, as we shall see, is interpreted by Jonas as a higher-order manifestation of *conatus*.

The organism cannot therefore be reduced to a bundle of processes of change which simply manifest the varying attributes of an *essentially* unchanging material substrate. On the contrary, everything here is process, out of which stable structures are built. From individual bacterial cells on up, life builds membranes around itself, separating self and other, and thus forming a *cellular* identity (Varela 1997, p. 75) that supports basic metabolic functions. This minimal level of identity differs from the identity of a physical system in three ways: firstly, the identity of each part of a physical system is merely a case of simple spatial self-coincidence, whereas the identity of any specifiable part of a living system (e.g. my liver) cannot be conceived of except in its active and mutually-sustaining relationships with the rest of the system of which it is part. Secondly, the overall unity of the system itself in space and time is only phenomenal or for another, i.e., merely the way another perceives it (i.e. is contributed by another's interest in *this* particular piece of the cosmos), whereas the overall spatial and temporal unity of the living system exists for itself, through being an object of its interest and concern. Thirdly, the only purpose that can be attributed to a non-living system (as Kant and Jonas both agree) is an external one contributed by another (for human artefacts, the inventor or manufacturer; for natural entities, a supernatural being), whereas the teleology of the organism derives immanently from its own existence: it is self-valuing. Its self-production and autonomy is its own immanent purpose, and this shapes (and is shaped by) its form, the dynamic organisation of parts which generates for it its own unique forms of activity within the world (Jonas 1982, pp. 79-81).

Jonas describes this formal character of the organism's relationship with its environment as one of 'needful freedom' (Jonas 1982, p. 80). Crucially, the more individuated and relatively autonomous the organism, and the more autonomy it has by virtue of its behavioural repertoire, then the more intimately it is involved with its environment, the more the world around it is an object of its concern, and the more sensitive it must be to signals from its environment if it is to survive (Jonas 1982, p. 84). The more capacity for independence the organism possesses, the more insecure its existence, and so it uses more energy in finessing its responses to perturbations intruding from outside it. Although it has more degrees of freedom than the plant, the animal pays for the advantages of motility with increased vulnerability, both in terms of scarcity of food sources and need to husband some resources for dealing with the threat of predators.

As a self-valuing entity, the organism also locates values in the world around it. Jonas' contention here is that the organism does not just encounter the environment, it experiences it. That is, the organism's self-concern and its characteristic ways of pursuing its immanent purpose provide a context for its actions, which allow it to interpret significant traits within the world around it and to formulate timely responses. Jonas is evidently close here to von Uexkull's concept of *Umwelt*, the singular world of the individual that differs from the *Außenwelt* or environment of a non-living system insofar as it is structured not only by physical causal regularities but also by processes of semiosis (Kull 1999, p. 390).

A further, *temporal* distinction between non-living and living systems can therefore be drawn. For Jonas, from the point of view of the scientific observer, the physical system is fully determined by a set of timeless regularities, and is therefore effectively complete at each and every instant in which its state is observed. From moment to moment, it is simply a rearrangement of its basic constituents which is choreographed by exceptionless laws. But the organism, viewed as an immanent purpose and therefore as self-valuing, is determined as essentially *in*complete. The environment of an organism is a world because it signals to the organism concerning states which have been or might be. Whereas the physical system is, from the scientist's point of view, simply present in each instant or *t*-state, the world in which the organism lives features traits to which it is sensitive, and which evoke memory and anticipation. Further, these traits are not just singularly significant because of the organism's apparatus for gleaning data about its environment, but gain their significance from the way in which the various metabolic processes of the organism function. These processes, and the dynamic identity they manifest over time, relate the organism to the regularities that inhere in the environment in a particular way, such that some of these regularities are important for it and others not so. As Varela puts it, the identity of the organism constitutes for it a "surplus of signification" (1997, p. 79), placing it outside its environment and granting it not just a cellular identity which closes it off from it surroundings, but a more or less primitive *cognitive* identity, a position from which the world is evaluated. The organism's identity in the present is constituted by references forward and backward in time, and so it never fully coincides with itself. In this way, Jonas suggests it is not possible to conceive of the difference between non-living and living systems without treating some experience of pastness and futurity as ontologically constitutive of what it is to be a living system.

Jonas' analysis of organism thereforevsubverts McTaggart's distinction between the subjective or psychological A-series of time and the physical or objective B-series. An ontologically constitutive sense of past and future are interpreted as existential correlates of certain forms of material organisation. This must be contrasted with pastness and futurity understood as psychological phenomena somehow supervening on a sophisticated central nervous system (A-series), or pastness and futurity as unreal dimensions of an essentially timeless physical reality (B-series). The existential interpretation of organic temporality here is offered as a necessary condition of any explanation of the difference between non-living and living systems. Time, for the organism, is what brings forth the world for it within the horizons of its self-interest, and defines for it its own cognitive identity.

In relation to its own identity in time, the potential futures of the organism therefore constitute a determinate, constitutive lack in relation to which its activity in the present is shaped. The organism seeks in the world what it needs in order to persist, and finds it through the promises embodied in the world by traces of pasts and impending futures. Scents or sonar echoes indicate the impending satisfaction of hunger, the softness of earth underfoot promises a burrow in which to sleep, and the movement of wind and light opens up spaces in which pent-up energy can be expended in running and chasing. The present behaviour of the organism cannot therefore be understood without interpreting the characteristic ways in which it anticipates its own future states and those of its world.

The behaviour of organisms is therefore always modulated to some lesser or greater degree by the need to adapt to a world which is full of potential shocks. To be adaptive in this sense, the organism must be capable of anticipating tendencies of change within its own states as well as outside it, and then of altering its behaviour so that its internal condition remains within a range of viability – as in, for example, the way in which most reptiles move from sun to shade to regulate body temperature. To persist in its being, the organism must stay in motion, must maintain the coherence of a delicately choreographed ensemble of temporal dynamisms. It has to organise its own time (behaviour) and space (territory) in a way that provides for the various needful dimensions of its existence. With higher organisms, their capacity for more sophisticated evaluations of possible futures enables them to recursively redefine what is to count as a viable state in response to unpredictable situations where previously viable states prove to be nonviable (Di Paolo 2005, pp. 439-440).

The futures of organisms therefore have a particular character. They are neither entirely indeterminate nor pre-determined. Nor are they fully actualised. However, they exist within the present in the sense that they are real "in practice" (Arnoldi 2004, pp. 3-5), that is, as indexes of projected tendencies which then recursively shape the ongoing behaviour of the organism. Interpreting these futures is, as Varela writes in relation to the bacterium's feeding behaviour, crucial to understanding living systems. For Jonas, then, the futures available to an organism by virtue of its form and its interactions with its environment constitute its freedom whilst at the same time having to fit in with its characteristic patterns of behaviour. The capacity for anticipation is a necessary formal property of a living creature which makes novelty (in the shape of new behaviours) possible in higher animals. But Jonas' phenomenological explanation of the formal characteristics of organic life leaves untouched the question of how constraints governing the forms of living creatures themselves emerge. He begins from the unity of the phenotype: the relation between the individual organism and its genotype, and with it, the need for an account of the constraints which govern the more fundamental processes of natural selection and embryogenesis that give rise to the individual organism in its specificity, are not addressed. Jonas' account of the role of the real, practical future within the lived unity of the organism is not enough on its own to do away with option (A), the return to a deterministic, finalist universe, as the possibility of the general forms of living entities being somehow ontologically preformed is not entirely ruled out within his ontology.

5. Gilles Deleuze and the Quasi-Causality of the Virtual

The questions which remain largely unaddressed by Jonas' account of the role played by futurity in shaping the behaviour of organisms constitute a major theme within the philosophy of Gilles Deleuze. Deleuze's work, both on his own and with Félix Guattari, is devoted to elaborating a fully consistent (B)-type account of nature, one in which being is explicitly presented as the result of becoming, and substance as an effect of process. What constrains and shapes process is conceived of as being produced within matter itself. The purpose of ontology, then, is to show how individual entities congeal out of self-organising matter. Nothing about the particular constitution of individual entities is assumed to be given independently of the material processes that produce them. Deleuze's philosophy is therefore an out and out attack on the idea of essences, and with it, that of pre-existing final causes, one which seeks to show that the specification of a thing is the process from which it emerges, whether the thing in question is a chemical element, an organism, a species, a social institution or a technology (De Landa 2004, p. 10)[1]. In order to explain how material processes congeal into determinate products, Deleuze distinguishes between *actual* causal processes and the *virtual* or "quasi-causal" elements which lend spatio-temporal form to them.

In this ontology, the world is a nested set of complex systems, the majority of which

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[1] My discussion here takes much of its impetus from the realist reconstructions of Deleuze's thought provided by Manuel Delanda (Delanda 2004), and Mark Bonta and John Protevi (Bonta and Protevi 2004).

are, like an organism, not at equilibrium. They are both spatially and temporally open: spatially, because they are related in various ways to other co-existing systems, allowing energy to transit through them, and temporally, because their non-equilibrium condition implies that they are radically incomplete. These two modes of openness necessitate the imposition of formal constraints on any ontological explanation of how order is produced. It is because systems are open that ontology has to do without any concept of substance, be it an intelligible essence which teleologically guides the emergence of an individual's form, or a material substrate which sustains mechanical causation. Within this world, Jonas' account of organic life will appear as a rather parochial attempt to account for the maintenance of form without being able to explain its wider embeddedness in a dynamic material reality.

From the point of view of the organism, the spatially and temporally open processes of morphogenesis in which it is located stretch out below and above it at different spatial and temporal scales. It is both affected by these (insofar as they constrain its form) and affects them (insofar as its actions can constrain these processes). These can be presented in a historical order: firstly the production of inorganic and organic chemical compounds within stars and in the Earth's ecosphere, the eventual evolutionary emergence of its genotype, the reproductive process which resulted in its own existence, and finally the ecosystem it inhabits together with other individuals. Through the behavioural routines which relate it to its environment, the organism can potentially affect its genotype and its ecosystem in various ways (through, for example, forming along with others of its species symbiotic relationships with other organisms). For Deleuze, all these morphogenetic processes, from the emergence of inorganic order through the adoption by organisms of new behavioural routines to the influence of interactions between species on evolution can all be explained through the interaction of two distinct modal aspects of reality, the *actual* and the *virtual*.

The actual is the material, causal order as such, which is characterised by two features. Firstly, as well as actual entities possessing extensive qualities such as length and weight, they are also characterised by intensive qualities through which order is created, maintained and transformed. These qualities (such as temperature or pressure) are ones which cannot be divided (unlike extensive qualities, such as length, which can) without the nature of the system they characterise changing in nature (Deleuze and Guattari 1988, pp. 31-33). For example, by heating a container of water the temperature of the water is divided across the container. With this division, however, comes a qualitative change of state in the body of water itself – it moves from temperature equilibrium to being far from equilibrium, and at a certain point its molecules enter a new ordered state, forming convection cells (De Landa 2004, p. 25). Non-linear systems that are far from equilibrium can enter into heterogeneous relationships with other systems through exchanges of energy (kinetic, potential, chemical etc.) that mark points at which they *couple* with each other (Bonta and Protevi 2004, pp. 15-16; Deleuze 1994, p. 117). Examples of these relationships (or *assemblages*) might include an animal walking on a flat surface, in which the ground, gravity and the animal's capacity to maintain its gait through "controlled falling", a process of balancing the rotating motions of limbs against each other to stop the animal from hitting the ground (Massumi 1998) produce a new system. Symbiotic evolution provides another instance, as in the case of deep-sea tubeworms which are infected during their larval stage by bacteria which then metabolise nutrients for the worms. In coupling, what occurs is a gradual enmeshing of independent processes within one parallel process, in which the individual systems composing it gain new capacities.

Secondly, actual systems possess their own temporalities. The processes that compose them manifest periodic oscillations which, for Deleuze, characterise the individual "living presents" of the system. This actual time, which can be counted and measured, he refers to by the Stoic designation of *Chronos*, a time which can always be understood in terms of a set of nested periods of different sizes (from the period of an atomic oscillator through the circadian rhythms of an organism to the orbit of a planet) (Deleuze 1990, p. 162).

The actual world therefore consists of a continuous individuation of systems operating at different spatial and temporal scales, which are largely defined by their intensive properties (the specific ways in which energy flows through them). This process largely consists of the coupling of entities through their capacities for exchanging energy. Processes of coupling are a kind of mutual entrainment of different components which possess their own intrinsic temporalities. Deleuze describes embryogenesis in these terms, as a process of assembly driven by the differences between rates of change in the bio-chemical components of an egg (Deleuze 1994; Deleuze and Guattari 1988, p. 48). These processes are not determined by final causes which in some sense pre-exist the emergence of specific forms, and dictate the properties which these forms must possess. Rather, they emerge from within actual, empirical interactions between components of systems and systems themselves. In this sense, they are novel relational properties which appear, from the point of view of the actual entity, to emerge through chance – like the property of the earth of being a surface on which animals can walk.

For Jonas, as we saw, novelty as the capacity of an organism for behavioural flexibility depended on its defining constitutive lack. The possible futures of an organism constitute a determinate gap within its present, a hesitation between needs and their satisfaction which he calls needful freedom. In other words, the *necessary* conditions of its continuing existence (which are given through its defining genotype – i.e. what is necessary for one species of plant may not be for another, and what is necessary for a carnivore is not for a herbivore, etc.) provoke its freedom and shape the range of potential futures it hesitates between. Deleuze, however, suggests that novelty is produced more generally through the conjunction of non-linear processes, and is not confined to living entities whose activities are defined by their *conatus*. But these processes are not entirely random. Just as Jonas' organism is a nexus of necessity and freedom, in which regularities are subject to flexible adaptation, so Deleuze's concept of the combination of heterogeneous actual systems implies a form of regularity that flexibly constrains the potential development of these systems. This form of regularity is not, however, comparable with the linear form of regularity which typically constrains the behaviour of systems studied by classical mechanics.[2] Instead, it characterises the *virtual*, which Deleuze posits as immanent within the actual yet irreducible to it.

The virtual consists of "multiplicities" (Deleuze 1991, p. 39, 1994, p. 182), a concept which Deleuze intends as a replacement for both the deterministic concept of final

[2] On the preference of classical mechanics for linear physical systems, see Stewart (1989).

causes *and* the concept of mechanistic laws which ensure that matter is rearranged from moment to moment in essentially predictable ways. As such, it is the virtual which embodies the specific reality of the future within all actual processes. Multiplicities are defined by *singularities*, features of the state space of a given actual system which map out its long-term tendencies. They are the attractors which define the potential sets of trajectories which describe changes in the intensive properties of the system. For example, a highly significant singularity within the enlarged system of the ambulatory animal, gravity and ground is the animal's centre of gravity (Massumi 1998). The centre of gravity is an attractor that governs the stretches and rotations through which the animals limbs move it forward and keep its body from lurching too far from equilibrium. If we imagine a state-space diagram describing changes in muscular tension and relaxation, with one dimension for each of the various muscles involved in walking, then the centre of gravity serves as a coordinating point for the trajectories which describe changes of state within the animal's muscular system. Importantly, this singular point does not itself represent a possible state for the system, as the trajectories of its components can only *approach* it asymptotically (De Landa 2004, p. 34). The reality of the singularities is the internal structure they give to state space (Deleuze 1994, pp. 208-209). They "preside over the genesis" (Deleuze 1990, p. 54) of the individual trajectories which describe the actual behaviour of the system. The structures they define can be realised in any number of different physical systems, as in Manuel Delanda's example of the single point attractor which governs both the formation of soap bubbles and crystal growth (De Landa 2004, p. 15).

Deleuze therefore understands the actual behaviour of a system's components, together with their intrinsic temporalities, as governed by virtual singularities. Whether the object under consideration is the metabolism of an organism or the rates of population change within an ecosystem, the phenomena are constrained by elements which are non-actual, yet real. Singularities do not just produce periodic regularities that define the "living present" of a system, however. They also govern how it can re-order itself, either internally or in combination with other systems.

This is possible because, Deleuze argues, the virtual is already completely differentiated *qua* structure, although it is never expressed within the actual all at once. It is comprised of diverse sets of singularities which are related to each other by a progressive "adjunction" of differences (Deleuze 1994, p. 187). These sets are effectively nested within each other, and through their relationship to each other define different potential phases of a system. At certain critical points of intensity of energy transfer through a system (as when the temperature of the water in a vessel increases or the biochemical concentrations within an egg fluctuate), it reaches a condition in which it shifts phase, receiving a shock which re-orders its state space around a new set of attractors (De Landa 2004, pp. 19-20). At these "bifurcation points", the system (depending on the nature of its internal complexity and/or external relationships) may be faced with a "choice" between sets of singularities. While the bifurcation point is *necessarily* critical for the system in the sense that it represents a trajectory which is so far away from an attractor that it cannot return to it, which set of attractors the system is nudged towards is a matter of chance, that is, of the kind of external shock which is being experienced by the system (Prigogine and Stengers 1985, p. 177). The "phases" of a system, if recurrent, will also express a recurrent sequence of sets of attractors. For example, heating a vessel of water eventually shifts the system from homogeneity (equal temperature throughout) to a less symmetrical but more ordered state, where convection currents flow. At this critical point, the single point attractor that governed the homogeneous system is replaced by periodic attractors. Further heating produces turbulence, at which point the system shifts again, the periodic attractors being replaced by chaotic singularities. (Prigogine and Stengers 1985, pp. 142-144, 167-148). Living systems, as we noted above, are governed by their own internal temporalities, which taken the form of periodic oscillations at different scales. Being therefore far from equilibrium, they tend to be governed by multiple nested sets of periodic attractors. For example, when a horse moves from walk to trot to gallop, the state space which describes the relaxation and contraction of its muscles is shifted between different periodic singularities as the rhythm of its movements speeds up and slows down (Deleuze and Guattari 1988, p. 483).

The virtual is therefore operative within the actual in two senses, and is in neither case reducible to it. First, it constrains what it can do, and in this sense represents the "destiny" of the actual (Deleuze 1990, p. 169). That an actual system has a destiny does not mean, however, that it is subject to a deterministic necessity of the kind posited in classical mechanics (Deleuze 1990, p. 170).

> Destiny never consists in step-by-step deterministic relations between presents which succeed one another according to the order of a represented time. Rather, it implies between successive presents non-localisable connections, actions at a distance, systems of replay, resonance and echoes, objective chances, signs, signals and roles which transcend spatial locations and temporal successions. (Deleuze 1994, p. 83)

"Non-localisable connections" which govern the long-term tendencies of a system are ones which need to be described in terms other than those (such as the familiar billiard-ball metaphor) appropriate to mechanical causation. Crucial here is the point that, being non-localisable, they are not part of any present moment in which actual systems take on some specific spatio-temporal configuration – as noted above, singularities are never actualised. Instead of having causal efficacy in the way that changes in intensive properties do, the virtual plays a *quasi-causal* role (Deleuze 1990, p. 169). It defines the long-term regularities which are expressed, in divergent ways, in the genesis of individual entities, without playing the role of a cause which determines exactly what happens from instant to instant.

The second way in which the virtual is operative within the actual is in the way it holds it open, allowing chance and novelty to enter. Just as the potential futures which Jonas ascribes to the living organism shape the constitutive lack which drives it onward, the virtual offers alternative routes which actual systems can take. For Deleuze, however, the virtual is not a manifestation of lack or absence. It is itself fully determinate, without being actual. He likens this condition of the virtual to the determinateness of a vector field in relation to a state space (Deleuze 1994, p. 177). A state space specifies (or in Deleuze's terms, expresses) its singularities through the trajectories within it, which represent "integral curves", i.e. solutions to non-linear differential equations. The vector field, by contrast, is the set of instantaneous rates of change, obtained mathematically through differentiation, which define the shape and tendencies of trajectories and therefore also locate the singularities of a particular multiplicity or virtual structure. This field lacks nothing; its reality consists in its being a fully-determinate product of continuous, differential relations. As such, virtual multiplicities represent Deleuze's transformation of the structuralist concept of differential structure.[3]

A key problem for structuralist theory is the temporal status of structure and its relation to the history of actual systems. This is solved by Deleuze through the application of the theory of singularities. As noted above, the relations singularities establish with the actual world are non-localisable: they are not actualised within the material world. This gives them a unique temporal status: the temporality of virtual structures is different from that of actual systems, which is composed of living presents. To virtual time Deleuze gives the name *Aion*, borrowed, like Chronos, from Stoicism. Rather than being composed of more or less extended presents, which draw into them pasts and futures, Aion is an instantaneous form of temporality without presence, in which change has always already happened *and* is about to happen. For example, a singular point which marks a phase transition, such as that between ice melting and water freezing does not occupy a moment within a living present and therefore mark a definite state, but rather marks the indeterminacy between actual states, embodying whatever divergent directions of becoming can be taken by the actual system *at the same time* (Deleuze 1990, p. 80).

All the nested sets of virtual multiplicities which describe the potential destinies of actual systems are thought of as coexisting within Aion, and are actualised within the intensive processes through which actual systems maintain themselves and evolve. When systems suffer shocks and thereby communicate through flows of energy with other systems, if these perturbations shift the trajectories occupied by the system enough, then it will "select" from the virtual a new destiny. The future of a system is therefore essentially unpredictable insofar as it is open to its environment. As non-linear systems are the prevalent form of organisation in nature, this unpredictability is not therefore limited to organic systems. Depending on conditions, such as the capacities which create compatibilities between systems (like the tubeworm and its symbiotic bacteria), unforeseen transformations can occur at any point. The identity of a system is defined by the intrinsic destinies which constrain its actual development in time, but these destinies also define potentials for sudden and unforeseen shifts which destabilize the identities of things and force upon them sometimes violent metamorphoses (Turetzky 1998, p. 227). The future, for Deleuze, can therefore possess a "pure" form, that of "events in play", a kind of groundlessness (Lampert 2006, p. 55), in which the conjunction of actual and virtual marks a transition between destinies too quick to notice. This future is qualitatively distinct from the future of a living present, which is always located somewhere further along the trajectory which a system traces around its periodic attractors. While this "ordinary" future is largely a function of extrapolation, the "singular" future never is, as it transforms and redistributes the intrinsic temporalities of systems (Turetzky 1998, p. 229). In this way, what counts as a present changes dynamically with the becoming of systems, undermining McTaggart's B-series concept of a timeless set of temporal relationships between events.

6. Conclusion

[3] On the relation between Deleuze's concept of difference and that utilised by structuralism, see e.g. May (1993).

The problem with which we began, to understand how novel forms of order can emerge within the world, is answered by Jonas and Deleuze in divergent ways. For Jonas, the organism is a centre of indeterminacy, but this "gap" within it always has a more or less definite shape. This derives from the degree of complexity inherent in its needs and the ways these could be met. Its capacities for adaptivity and behavioural variation in general are shaped primarily by its genotype, which yields its modes of sensory access to its environment, its needs, and with these the formation of its characteristic *Umwelt* (in von Uexkull's terminology). The futures of the organism are shaped by the behavioural routines made available to it by its genetic inheritance and its modes of interaction with the world. For organisms with higher degrees of internal complexity, more scope for behavioural variation is available, in line with the greater complexity of their needs. A range of possible futures becomes real "in practice" for organic life insofar as it inserts a determinate lack into the living present from moment to moment.

For Deleuze, by contrast, the indeterminacy of the future is not a by-product of *conatus*, that is, of the form of an individual entity. Rather, it is produced by the ontological difference within matter between virtuality and actuality. The complexity of the virtual ensures that transitions between different phases of order within actual systems are both constrained and unpredictable. The chance interactions between actual systems can lead to all manner of transformations, even within otherwise stable entities. But the openness of the future does not mean that it is empty. Just as Jonas sees the range of futures an organism produces for itself as possessing a more or less determinate shape, the operation of selection performed by actual interactions upon the virtual reconstitutes the destiny of a system in ways which, from the point of view of the actual world, are entirely unforeseen yet, from the point of view of the virtual, are entirely determinate. For both Jonas and Deleuze, the future possesses a certain determining efficacy which is neither rigidly necessary nor merely possible. Both thinkers therefore argue that the formal constraints which govern our accounts of change need to be reinterpreted in order to understand novelty. For Jonas, this implies the necessity of acknowledging the body as a source of interpretive knowledge about complex systems. For Deleuze, it requires that we rigorously expunge essentialism from our ontologies. In either case, Aristotle's ambiguous category of *aition* is invoked in the readmission of futurity as a necessary dimension of understanding change in the present.

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