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LIFE AS PROCESS

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The thesis of this paper is that our understanding of life, as reflected in the biological and medical sciences but also in our everyday transactions, has been hampered by an inappropriate metaphysics. The metaphysics that has dominated Western philosophy, and that currently shapes most understanding of life and the life sciences, sees the world as composed of things and their properties. While these things appear to undergo all kinds of changes, it has often been supposed that this amounts to no more than a change in the spatial relations of their unchanging parts.

From antiquity, however, there has been a rival to this view, the process ontology, associated in antiquity with the fragmentary surviving writings of Heraclitus. In the last century it has been especially associated with the work of the British metaphysician and logician, Alfred North Whitehead. For process ontology, what most fundamentally exists is change, or process. What we are tempted to think of as constant things are in reality merely temporary stabilities in this constant flux of change, eddies in the flux of process.

My main claim in this paper will be that a metaphysics of this latter kind is the only kind adequate to making sense of the living world. After explaining in more detail, the differences between these ontological views, I shall illustrate the advantages of a process ontology with reference to the category of organism. Finally I shall explore some further implications of a process ontology for biology and for philosophy.

Keywords: process ontology, organism, metaphysics of science, evolution, inheritance, personal identity, free will

ЖИЗНЬ КАК ПРОЦЕСС

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Тезис автора состоит в том, что наше понимание жизни, отраженное в биологических и медицинских науках, а также в наших повседневных делах, было затруднено неуместной метафизикой. Метафизика, которая доминировала в западной философии и которая сейчас в значительной степени определяет понимание жизни и наук о жизни, видит мир как состоящий из вещей и их свойств. И хотя эти вещи, по-видимому, претерпевают всевозможные изменения, предполагается, что это всего лишь изменение пространственных отношений их неизменных частей. Однако с древности альтернативу этому подходу представляла онтология процесса, связанная с фрагментарно сохранившимися произведениями Гераклита. В прошлом же веке она нашла выражение в работах британского метафизика и логика А. Уайтхеда. С позиции онтологии процесса то, что существует, представляет собой изменение, или процесс. То, что мы склонны считать постоянными вещами, на самом деле является лишь временной стабильностью в извечной череде изменений, вихрями в процессуальном потоке. Автор полагает, что метафизика этого последнего типа является единственно адекватной пониманию живого мира. После более подробного объяснения различий между этими онтологическими перспективами автор анализирует преимущества онтологии процесса применительно к категории организмов. В статье также рассматриваются некоторые дальнейшие следствия онтологии процесса для биологии и философии.

Ключевые слова: процесс, онтология, организм, метафизика науки, эволюция, наследование, персональная идентичность, свободная воля

1. Introduction

The thesis of this paper is that our understanding of life, as reflected in the biological and medical sciences but also in our everyday transactions, has been hampered by an inappropriate metaphysics. The metaphysics that has dominated Western philosophy, and that currently shapes most understanding of life and the life sciences, sees the world as composed of things and their properties. Among those things are a subset of simple things (atoms) – though this aspect of the picture has been greatly complicated by developments in physics since around 1900 – and the familiar macroscopic entities of everyday experience are complex structures of these simple things. These complex things undergo change. That is to say, they have different properties at different times, and such differences amount to a thing undergoing change. Following seventeenth century founders of the Scientific Revolution, such as John Locke and Robert Boyle, these changes are often thought of as grounded in changes in the way the simple things that make up a complex thing are arranged.

From antiquity, however, there has been a rival to this view, more prominent in Eastern philosophical traditions, but a persistent theme also in the West. I refer to process ontology, associated in antiquity with the fragmentary surviving writings of Heraclitus. In the last century it has been especially associated with the work of the British metaphysician and logician, Alfred North Whitehead[1]. For process ontology, what most fundamentally exists is change, or process. What we are tempted to think of as constant things are in reality merely temporary stabilities in this constant flux of change, eddies in the flux of process.

My main claim in this paper will be that a metaphysics of this latter kind is the only kind adequate to making sense of the living world[2].

1 The classic source is [Whitehead, 1957]. A more accessible introduction is [Whitehead, 1961 (1933)].

2 This, and several other themes in this essay, are explored in greater depth in [Nicholson and Dupré, 2018]. See especially the introduction, [Dupré and Nicholson, 2018]. All the essays in this volume are available open access from Oxford University Press.

I shall not say much about the application of the view to the level of the hypothetical simple things of the alternative view. I will just remark that to a casual view contemporary physics looks a great deal more like a theory of processes than a theory of things. As one of the most prominent recent defenders of process metaphysics, the American philosopher Nicholas Rescher [1996, p. 97], put it, echoing the earlier reaction of Whitehead, "the rise of the quantum theory put money in the process philosopher's bank account".

But here I shall stick with biology. After saying a bit more, in the next section, about the difference between processes and things, in section 3 I shall explain several reasons why organisms, a central ontological category in any biological science, are much better seen as a kind of process. In section 4 I shall discuss some biological issues that can be understood differently, and I think better, from this perspective. Finally, and briefly, in section 5 I shall consider some implications for some more traditionally philosophical issues. But first I shall conclude this introductory section with a very brief further word about Whitehead.

Whitehead is indisputably the philosopher from the last century most widely associated with process philosophy. Nonetheless, I shall not use his work as a starting point, for several reasons. First, Whitehead's philosophy is notoriously difficult, even obscure. Arguably, the assumption that an interest in process thinking must pass through the study of Whitehead has been a deterrent to many potential process philosophers. Second, Whitehead's philosophy of process is deeply intertwined with his theology and his commitment to a version of panpsychism. Neither of these is a topic that I am much interested in engaging with. But perhaps most important, it is open to question whether Whitehead is, strictly speaking, a process ontologist. The rationale for this rather surprising claim is that Whitehead promotes a kind of atomism (see [Simons, 2018, p. 53]). The atoms in question are what Whitehead calls "actual occasions" or, synonymously, "actual entities". Although these are analysable, they do not appear to be subject to change. So at the base of his philosophy, it appears, are not processes but unchanging atoms.

2. Things and Processes

Things, or substances, have been a central philosophical topic for millennia, and I can hardly attempt a survey of this history here. However, there are certain widely agreed points. Things persist through time; they have (reasonably) sharp boundaries; and they are autonomous: they do not depend on anything else for their existence. The classical atoms, microscopic impenetrable spheres, provide an important paradigm for entities that perfectly realise these conditions. But more familiar everyday items such as tables, chairs, and rocks also appear to fit the bill.

A crucial point is that other things being equal, things stay the same. It is indeed difficult, perhaps impossible, to make sense of change in a world of things. The problem can be seen in terms of Leibniz's law. Informally, this law states that if two things are identical they have all the same properties. They are, after all, the same thing. For a thing to persist is for the thing at one time to be identical to the thing at a later time. But for thing to change is for it to have different properties at different times. Therefore the thing after a change cannot be identical to the thing before that change and, following Leibniz's law, it cannot remain the same thing. Standard solutions to this problem require a distinction between accidental properties that are subject to change, and essential properties the stability of which constitutes the persistence of the organism. All I shall say about this is that a strong consensus in the philosophy of biology rejects any kind of essentialism (e.g., [Hull, 1965; Dupré, 2002]; though see [Devitt, 2008]).

In attempting to understand how things change, recent Western philosophy has hovered between two poles. The four-dimensionalist, or "perdurantist" view, sees objects as composed of (unchanging) temporal parts strung together through time, in so-called space-time worms. On such a view change is at least illusory *sub specie aeternitate*. The alternative three-dimensionalist, or "endurantist" view insists in opposition to the former view that at any moment an object is "wholly present", it does not consist merely of a temporal part of the whole object[3]. But then it needs to be explained how something wholly present at t1 can be the same thing as something wholly present at t2. It is plausible that neither of these positions really takes change seriously (for detailed argument to this effect, see [Meincke, 2018a]).

A process, at any rate, is something for which change is essential. There are many kinds of processes. Some, like erosion or inflation, require something else to which they happen – cliffs or economies. Others just happen. The "it" in the English expression "it is raining" does not refer to any thing that is raining. Here, however, I am concerned with processes that are individuals, and that persist over time. Paradigmatic here are the already mentioned eddies, or vortices. A striking instance is the Great Red Spot on the planet Jupiter. This has persisted for centuries, but its persistence is at every moment dependent on activity, in this case the very rapid winds that circulate around it. Unlike a thing, it cannot persist without change; if the winds ceased the Red Spot would no longer exist.

3 The terms "endurantism" and "perdurantism" were introduced by David Lewis (1986). Representative defenders of each position are [Sider, 2001] and [Lewis, 1986] for perdurantism, and [Lowe, 1998] or [Simons, 1987] for endurantism.

A process ontology, as I conceive it, is one that asserts the primacy of change: everything is in flux, and the appearance of stable entities is ultimately illusory [Dupré and Nicholson, 2018]. So, recalling my earlier remark about Whitehead, an ontology that sees extended processes as built up out of unchanging parts is not, in this sense, a true process ontology. The challenge for a process ontology is to explain the appearance, ultimately the illusion, of stable things.

This last point leads to a crucial consequence of recognising the processual nature of reality. When a thing, or substance undergoes change this calls out for explanation. Indeed explaining why things change is often thought of as the central aim of science. But in a world of process, change is everywhere. Before we can understand why what we identify as the stable things change, we need to understand why they ever stayed the same. Stability is always an explanandum. Perhaps this is obvious in biology. Much biological work aims to explain homeostasis, the stability of properties of the organism, or homeorhesis, C.H. Waddington's (1957) valuable term for the maintenance of an organism on a typical trajectory, as in ontogeny. For several reasons, which I shall discuss further below, the stability or persistence of a living system should hardly be taken for granted. Nonetheless, most obviously in medicine, we do tend to think of stability as a default. Disease, we often assume, always requires some kind of explanation external to the proper nature of the organism. One of the points of recognising the processual character of life is to avoid this kind of error.

3. Organisms

Organisms have often been taken as paradigmatic substances or even things. Aristotle is the philosopher most famous for treating organisms this way, although he is perhaps also the substance philosopher most sensitive to the dynamic nature of organisms. Recalling the characteristics of things listed earlier, organisms persist through time, they have reasonably sharp boundaries, and they do not depend on anything else for their existence. Or so it is often assumed. In fact none of the preceding statements is true without some considerable qualification, and hence, I shall argue, organisms are more accurately understood as processes.

Consider first the persistence through time of organisms. Although we do, certainly, track organisms through time, it is not always so simple to say what we are tracking. Consider the familiar life cycle of an insect, through the stages of egg, larva, pupa, and adult. There is no doubt a spatio-temporal continuity between these stages, but what it is it that continues? Recall the familiar puzzles in the literature of personal identity. Following a parable discussed by John Locke, we may be comfortable in principle with the possibility of a prince turning into a cobbler [Locke, 1975 (1694), ch. 27]. The prince remains at least an adult human, if with a rather different social status. But, pace Kafka, could one really turn into an insect? In what sense could that insect possibly be the same thing as the previously existing person. In Kafka's story the answer is provided by continuity of consciousness. But if this seems to makes sense, it is because we are so used to the dualist ontology in which the part of a person that has consciousness is a separate thing from the material, biological part. We imagine the former moving to inhabit a different biological organism or, in Kafka's case, remaining in place while the organism surrounding it transforms drastically. If we take a materialist perspective on the matter, we should not admit such a separation and rather say that a human had ceased to exist and an insect had somehow come into existence at the same time.

But now let's return to real insects, which do indeed undergo metamorphoses from egg to larva to pupa to adult. These are changes little less dramatic than those from human to insect. How can the egg and the adult be the same *thing*? Still less, could they share the same essence?[4] The answer I suggest is that they are not, but that they are stages of the same process. Although humans do not undergo changes as dramatic as those of the insect, the similarity of the human zygote and the adult human is no greater. In fact all organisms have life cycles encompassing more or less fundamental changes of form. The puzzles to which this gives rise if we try to understand these changes as transformations of a persistent thing are immediately dispelled when we realise that the organism is a process, its life cycle. The connections between the stages of a process are merely causal[5]. There is no question of identity in the sense taken to require an appeal to Leibniz's law.

Now consider the idea that organisms are autonomous. Substances, or things, have generally been understood as those entities that can exist by themselves, without requiring the existence of anything else. But as is widely remarked, organisms are systems far from thermodynamic equilibrium, requiring for their persistence a constant intake of matter or energy from their environment[6]. The constancy of form that an organism

4 One might imagine that the genome could serve this essentialist role. I explain the problems with this idea in [Dupré, 2012, ch. 7]

5 Causal connection is not, of course, sufficient to count two arrangements of matter as stages of the same process. In the case of an organism, and to a lesser extent for inanimate processes such as storms or rivers, there is some further kind of integration that is required, a complex condition indeed for the organism. The nature of this integration is a question well beyond the scope of the present paper. The problem has been addressed under the rubric of "organisation" in a body of work by Alvaro Moreno and colleagues. See, e.g., [Moreno and Mossio, 2015; Arnellos, 2018].

6 The significance of this point is explained in much greater detail by [Nicholson, 2018].

exhibits is not something that continues by default, until something happens to disrupt it. It is something that is achieved by the organism's metabolism constantly maintaining its form and resisting entropy by using this intake of energy from the environment; and organisms have to interact with their environments to ensure this intake of energy. The form is maintained by this constant flow of energy in a way parallel to, if vastly more complex than, that in which an eddy is maintained by the flow of water in a stream. It is the manifestation of a massively complex and exquisitely orchestrated set of processes.

There is an equally important reason why we should not think of organisms as autonomous substances. This is that all or almost all multicellular organisms, and perhaps most single celled organisms, are in fact obligately symbiotic (for discussion see, e.g., [Dupré and O'Malley, 2009; Dupré, 2012, ch. 4]). As we have come to realise, we are not, in the sense that has usually been assumed, entirely human. Somewhere between half and 90% of the cells in our bodies are microbes, and a substantial proportion of these are not mere passengers, but serve functions essential to our thriving. A common response to this with which I have much sympathy is to say that the organism is composed not just of the traditionally human cells, the lineage that descended from our initiating zygote, but the symbiotic whole, what has come to be known as a holobiont (e.g., [Gilbert et al., 2012]). So perhaps the organism is, in this sense anyhow, autonomous; it just contains a lot more stuff than has generally been assumed. I don't think this move helps much, because there are a number of other ways in which organisms are fundamentally dependent on other organisms. In our own case, again, despite the attention that has been focused in social and political thought on the individual, we are profoundly and obligatorily social organisms.

But this leads to the third statement with which I introduced the topic of organisms, that an organism is a thing with sharp boundaries. Are obligate symbionts really separate entities, or at some point do the symbiotic partners merge to become a single entity? The answer is clearly that they do sometimes merge, and indeed some, notably the pioneering scientist Lynn Margulis, have believed that this kind of merger is the main driver of major evolutionary change [Margulis and Fester, 1991]. Whether or not this is right, Margulis and others have convinced biologists that many fundamental evolutionary changes have been of this kind. Most famous is the emergence of the eukaryotic cell from some kind of merger – the details of which admittedly remain highly controversial – between two pre-existing prokaryotic cells [Margulis, 1970]. Our own cells, like those of all other multi-celled organisms, contain mitochondria, the essential energy processing units, now known to be descendants of once free-living bacteria. No one wants to deny that mitochondria are parts of complex organisms like ourselves, yet everyone admits that they belong to an evolutionary lineage with a quite distinct origin, which has only gradually merged into that to which we belong [Lang et al., 1999].

And there is spectrum of cases from such complete merger to quite transitory association. Consider for instance the endosymbionts of most arthropods, such as Wolbachia, or Buchnera in aphids, that are transmitted vertically through maternal cells, and which have long since lost many of the genes essential to survival, passing metabolic functions to the host organism. Despite this obligate relationship evolutionary interests of the partners appear to diverge in some cases. Some Wolbachia, for instance, can affect the sex-ratio of their hosts, for example, and sometimes do so in ways that promote the evolutionary interest of their particular strain of Wolbachia rather than that of their current hosts [O'Neill et al., 1999]. Does this show that they are not yet to be counted parts of the host organism, even though the two are fully interdependent and in many cases neither could survive without the other?

Or consider, finally, the enormously successful leafcutter ants of the genera *Atta* and *Acromyrmex*. Inside the vast colonies of these organisms lie the fungus gardens, in which the leaves collected by the ants are converted into a form that the ants can eat. The fungi associated with some ant species have evolved to become fully dependent on the ants, and no longer produce spores. As well as an elaborate internal division of labour with non-reproductive workers specialised for tasks such as foraging, guarding the colony, taking care of the nurseries, the fungus gardens, and the waste disposal chambers, numerous microbial species play more or less vital roles in the colony. The processing of the leaves require microbial partners as well as the fungus; an internal symbiont in the ants produces an antibiotic that protects the fungus food from a dangerous fungal pathogen; and the ants like many other arthropods harbour *Wolbachia* [Van Borm et al., 2001]. Given the crucial role of sex determination in the life cycle of an ant colony, perhaps it is these genetically reduced endosymbionts that are really running the whole show.

What all this shows is at least that the notion of the organism as autonomous is a hopeless one. The spectrum of dependencies from essential endosymbionts through social division of labour to fortuitous ecological interaction demonstrates that for organisms to survive requires a multitude of interactions, some so fundamental to the way of life of the organism that there is no simple way of deciding whether they are mutualistic symbionts or parts of the same living being. The failure of autonomy, in short, makes it highly questionable whether the organism has clear, objective boundaries.

All of this looks very different when we abandon the embedding of our concept of organism (and indeed of biological systems generally) in the traditional substance centred metaphysics and accept an ontology of process. Seen as a process, an organism is a stable pattern in an intricately orchestrated array of processes at many levels of organisation. Internally, these are chemical, metabolic processes within cells, and larger scale actions of, and interactions between, organs and other systems. Externally, there are interactions with a host of other organisms and abiotic features of the environment. Crucially, as has been stressed by recent accounts of niche construction, these interactions are bidirectional: organisms shape their environments in ways that promote the stability of the organism [Odling-Smee et al., 2003]. Equally crucially, the organism is part of a much longer process, the lineage. The lineage also persists through a host of interactions with living and non-living parts of the environment, and through the reproductive capacities of its constituent organisms. The lineage is stabilised by natural selection, and for many lineages including our own the maintenance within the lineage of a population of conspecifics is essential for the survival of the individual[7]. The flow of life is sustained by a hierarchy of organised and interconnected systems from the molecule to the lineage and the ecosystem.

The fact that the stabilisation of an organism involves external as well as internal factors immediately implies that it is not autonomous in the sense generally associated with a substance ontology. Moreover, as I have tried to demonstrate, the complexity and intimacy of many symbiotic relations makes it difficult or impossible to specify the exact limits of the organism. If we draw analogies not from rocks or tables, but rather from partially stable processes such as eddies and flames, this should also be unsurprising. There is surely no precise point at which the eddy ends and the rest of the river begins. Similarly which side of the bacterial film on the surface of my skin is my outer surface is not a question that requires further scientific research, but a conceptual decision that should depend in the end on the purposes for which the decision is being made. Evolutionary studies, for example, may prefer a concept of the organism that includes only symbionts vertically transmitted from parent to offspring, whereas a physiological concept might include any symbiont that was essential, or even just useful, for the survival of the organism.

The recognition that living processes are stabilised both internally and externally, from below and from above, is the key to a proper general account of life. Living systems are hierarchies of processes at a range of spatial and temporal scales. Their persistence comes from this embedding and its explanation requires both the more traditional explanation in terms of parts familiar in reductionist science, but also the constraints imposed by their position in a larger whole. To take just one example almost at random, the animal heart depends on an intricate array of cells of various kinds and their chemically mediated interactions. But as we all know from constant exhortations to exercise more, it depends also on the behaviour of the whole in which it is embedded. Put less whimsically, a heart can only survive embedded in a body with the capacity via various other systems – respiratory, circulatory, etc. – to provide it with oxygen and other inputs needed to maintain its structure and function. A similar

7 For a discussion of the interaction of lineage and organism processes, see [Dupré, 2017].

story could be told for cells, or for molecular structures such as the genome, for which the multiple processes of maintenance and repair have been well-documented.

Returning to the questions about autonomy and organismal boundaries, I conclude that these are handled much better by a process ontology than a traditional ontology of substances. It might still be thought that the apparent persistence of organisms through time would call rather for a substance ontology. But I have already discussed the problems for traditional substance ontology posed by the developmental trajectories that organisms undergo, and the massive differences in properties between the stages of some developmental cycles. Again, a process ontology disposes simply of this problem. Different stages of a process qualify as belonging to the same continuing process by virtue of the causal connections between them, not the properties, still less essential properties, that they share. To take a non-biological example, a tropical depression can become a hurricane and then decay into a large area of low pressure while unproblematically remaining the same meteorological process.

I must acknowledge in passing that there is a certain amount of philosophical debate whether it even makes sense to consider a process as a continuant, something that persists over time while perhaps undergoing change (see, e.g., [Wiggins, 2016]). It is argued, for instance, that a process just is the set of its temporal parts; it cannot, therefore, persist by acquiring new temporal parts. I won't try to address these arguments here, remarking only that as a matter of common sense there are processes that last over considerable periods of time – the Red Spot on Jupiter, for instance, is a storm that has existed at least for several centuries, for example, and it has got smaller over time, hence changing – and if organisms are ontologically similar to storms rather than rocks there are vast numbers of processes undergoing persistence and, apparently, change. Metaphysics should make sense of these primitive observations rather than talk itself into denying them.

A further advantage of the process perspective appears when we recall that the facts to be explained about the identity of organisms are not nearly as simple as is still sometimes assumed. Consider the case of vegetative reproduction in plants, of which a classic example in the philosophical literature is the quaking aspen *Populus tremuloides* [Bouchard, 2008]. A grove of these trees is typically formed from the growth of suckers from roots, so that the whole grove is actually the result of a continuous process of vegetative growth. Does that mean that the grove is just one organism? Or might we argue that from the point of view of other, interacting organisms each tree is an individual? And what should we say when the root connecting the tree to its originating plant is severed? Do we have reproduction by dissection?

Within a process ontology we should take a comfortably pluralistic attitude to these questions. The development of the grove of trees is a process within the broader lineage process of the Aspen species, but so are the processes that constitute individual trees. Just as a battle might be variously dissected in various ways into distinct skirmishes or engagements; or a river might be divided into temporarily separated streams or tributaries; so a flow of living material may be variously divided into individual organisms. Whereas a substance ontology has intractable problems dealing even with the basic biological phenomenon of cell division – when does one cell become two? – in a process ontology we have merely a flow of life that can be divided into individuals to suit our purposes.

4. Implications for Biology

Although many practicing biologists may find it somewhat alien to worry about metaphysical questions, these cannot in the end be avoided. As the twentieth century biologist and philosopher J.H. Woodger nicely expressed it, "physiologists who suppose themselves to be above metaphysics are only a very little above it – being up to the neck in it" [Woodger, 1929, p. 246]. Metaphysics can be ignored but not escaped. The explicit recognition of the processual nature of living systems has profound implications across a wide range of biological issues. I shall here briefly mention several of the most important such issues.

4.1. Evolution

Organisms develop but they do not, of course, evolve. What evolves are populations, or species. What are these higher level entities? Or are they mere abstractions, devices for describing distributions and frequencies of genuine entities such as organisms or even genes? In accordance with the dominant evolutionary or cladistic accounts of species, Michael Ghiselin and David Hull have convinced many philosophers and biologists that species are individuals, branches of the tree of life [Ghiselin, 1974; Hull, 1976]. This has engendered a good deal of debate on such topics as whether individuals can be as spatially discontinuous as a typical species. There has also been more recent concern that the tree of life is not as robust as was once assumed. Growing awareness of lateral gene transfer, sometimes across great phylogenetic distances, makes the tree look more like a web or a net.

Problems of these kinds can be quickly dissolved by the realisation that species, or more generally lineages, are not individual things, but individual processes [Dupré, 2017]. As we have seen, processes should not be assumed to have sharp boundaries, and the principle of inclusion in an individual process is not continuity of properties, notoriously difficult to distinguish in an evolving lineage, but the right kind of causal connection.

Seeing the lineage as a process points to an evolutionary role that is easily overlooked from more traditional perspectives. This is its role in top-down stabilisation of individual organisms. In the first place this is a satisfying way of understanding the role of stabilising selection. Though this is not a causal influence on individual organisms, it is a central part of the explanation of how actual organisms exist with the exquisite adaptations that enable them to survive (remain stable) at all. A condition of the existence of an organism at all is that it belongs to a lineage that is itself stable. Such stability depends in ways that have been very widely discussed on natural selection, but also on the existence of causal connections between successive constituents of the lineage, organisms. This brings us to a topic that deserves a separate section, inheritance.

4.2. Inheritance

Lineages maintain themselves by reproduction, and a notorious fact about this process is that like produces like. Clearly this is a condition on, first, the continuation of a lineage as a coherent identifiable process and, second, on its sustainability, since organisms have an integrated suite of adaptations, properties that enable them to survive and, in turn, reproduce. The capacity to transmit properties from parent to offspring is what is referred to as inheritance. Recent neo-Darwinism has attributed this capacity almost exclusively to the transmission of DNA, in its cruder versions with DNA divided into genes with the ability to transmit particular properties. Nowadays it is generally recognised that this kind of partition makes little sense. There are few one-to-one relations between stretches of DNA and properties, and what there are tend to be relatively insignificant or deleterious. Small variations in DNA and consequences that these have on the phenotype may be important for evolutionary theory, but they have minor importance for the broader understanding of inheritance.

The gene transmission theory of inheritance is a classically thing-centred story. How does one thing, the parent, influence the character of another thing, the offspring? By passing a large collection of little things, genes, to it. In a processual view we might rather start with the recognition of the lineage and the organism as part of a hierarchy of processes mutually stabilising one another, as indicated by the general view of living systems I sketched earlier. In this context it is easy to see that a much broader view of inheritance is needed. Social and cultural processes, behavioural imitation of parents by offspring and the vital shaping of the relevant environment by conspecifics in the process perhaps never better described than in Darwin's (1881) treatise on earthworms, but more generally theorised today as niche construction, all function as means of passing traits from generation to generation. I should also mention one further process the importance of which has become increasingly clear in recent science, epigenetics[8].

It is likely objected that while these various processes of inheritance may be important in describing the ontogeny of an organism, they lack the special properties, notably longevity, required for evolution by natural selection, and are thus of much less biological interest. Here, I think, we have a particularly striking instance of thing-centred thinking. Serious evolutionary change, in a thing centred view, must involve the production of new and stable things, namely genes. Even, as memorably argued by Richard Dawkins in his classic book, *The Selfish Gene* (1976), immortal things. But a lineage, like any process, is constantly susceptible to change. Much of this change is random and unpredictable, but processes that persist over long periods of time – and lineages are spectacularly durable processes – do so by having resources to change in response to changing external conditions. Learning, changing the environment, modifying social structures, and so on, are all good ways of so responding. Perhaps the most crucial property of successful lineages, again a topic of much recent discussion, is evolvability, a property that should encompass all of these possible modes of change. The complaint that only genetic change has the permanence required for evolutionary change, immortality even, is particularly commonly heard in response to suggestions that epigenetics might be an important evolutionary process. But a process changes all the time, and changes that might in principle be reversed in a relatively short time, may nonetheless be stabilised indefinitely. Again, I can only see this yearning for permanence as a distorted expression of the quest for the intrinsically unchanging substance.

Process thinking also has important consequences for medicine. I shall mention just two important examples. In the early years of the germ theory of disease it was supposed that microbes are intrinsically bad things, always liable to do us harm. This is a view still sometimes represented in advertisements for cleaning products. Now we realise that all life is fundamentally dependent on microbial system and activities, and the view of microbes as inherently bad is indefensible. It is easily replaced by a categorisation of microbes into the good, the bad, and the indifferent. But this is also indefensible. The same microbe will support some systems in some contexts and harm others in the same or different contexts. Many of the bacteria that are essential for the functioning of our gut will cause catastrophic illness when they find their way into other parts of our bodies. We cannot think of microbes and their hosts as things with merely intrinsic properties. What matters is the way they interact within a great variety of complex processes[9].

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8 For detailed discussion of the various dimensions recognised in "extended inheritance" views of evolution, see [Jablonka and Lamb, 2005].

9 For further discussion see [Méthot and Alizon, 2014].

My second example is cancer. If the body is a thing that stays the same until something comes along to change it, we will suppose that every cancer has an identifiable cause, the intervention that disrupted the default state of health. From a process perspective, we might better start by considering the exquisitely accurate system of interacting processes that regulate the precise balance between cell division, differentiation and death, constrained both by the interactions of entities within the cell, and by the placement of the cell within particular larger tissues and other structures. Failure of this mutual adjustment results in the multiple disorders classified as cancers. The question we should ask first is why we ever *don't* get cancer. From this point of view it is wholly unsurprising that the causes of cancer are distributed across the genetic, epigenetic, cellular, tissue and environmental levels [Dupré and Bertolaso, 2018].

5. Philosophical Implications

I shall conclude with some very brief remarks about some more philosophical topics greatly affected by the shift to a process ontology. In particular I shall consider some implications of the fact that humans, as organisms, are themselves processes.

The most obvious topic on which a processual ontology should bear with respect to the human is that of personal identity, the major question that has engaged problems about the persistence of an entity over time[10]. Central to this debate have been imagined scenarios in which the mental and physical continuity of a person have come apart, updated to modern post-dualist philosophy with imagined brain transplants. The first point to note is that the replacement of mind-body dualism with brain-body dualism makes little sense in a process ontology. The brain is essential for the proper functioning of the human organism in ways ranging from brain stem control of a range of physiological processes to controlling the behaviour necessary for continued functioning. Here I assume without argument a version of the contemporary so-called "animalist" perspective, according to which a human person is some part of the life history of a human animal.

But second, if a human is a process, the continuity of which is determined by causal connections between its temporal stages, then there is no special requirement of common properties between those stages. This may be disquieting to those who think of personal identity in a more robust way as requiring some kind of mental coherence over time for the persistence of a person. My own view is that we should accept this

10 More detailed process-centred accounts of personal identity can be found in [Dupré, 2014] and [Meincke, 2018b].

conclusion: I don't think there is a great deal in common between myself now and myself 50 years ago beyond causal continuity. Of course personal identity over time may well be a necessary assumption for the organisation of society and institutions ranging from the repayment of debts to the infliction of criminal punishment. But these can be sufficiently justified for purely practical, social reasons. Identity, in the strict sense in which it is often taken, is a fiction. I hasten to add that here I am not attempting to offer compelling arguments for such a view, but merely pointing out that the issue will look quite different in a processualist context.

I shall touch even more briefly on the topic of freedom of the will. The determinism that sets up much of the dialectic on this topic is entirely the product of a thing ontology that sees all causal capacity as originating from the lawlike behaviour of the simple things that compose the universe. Order within a process ontology is far more limited, and emerges only when an array of constraints and processes creates a more or less orderly structure. Humans, from this point of view, are uniquely dense concentrations of causal capacity. I think there is much to be said for the widely endorsed compatibilist argument, in so far as that human action and hence freedom must be and is compatible with whatever proves to be the causal structure of the world. The problem is with the determinism that many philosophers for some reason take to be licensed by the progress of science. Humans, I propose, are causally powerful entities (processes) that provide the originating causes of multiple changes to their (thoroughly indeterministic) world. As I have argued for some time, we are exceptional not for the randomness of our behaviour, but for its capacity to impose order. Given this conclusion, concerns about whether I could, when I act, have done otherwise may seem less pressing (see further [Dupré, 2013; 2001, ch. 7]).

Finally, I naturally deny that humans are strongly autonomous. We are massively social organisms, uniquely dependent on an extraordinarily complex division of labour without even worrying about our ecological and symbiotic relations to a host of other organisms. A process ontology should help to undermine the radical individualism that underlies a great deal of Western social and political thought for the last two centuries or so, and is expressed in scientific approaches such as neoclassical economics or, with a biological twist, evolutionary psychology [Dupré, 2001]. Happily, this insight undermines the conclusion of both these hyper-individualist scientific programmes, that humans are ultimately selfish and nasty. Given our place in a hierarchy of interconnected processes including many – from social groups and families to evolutionary lineages – of which we are merely contributing parts, there is no reason to suppose that cooperative behaviour is inherently problematic. This is not, of course, to deny that it is possible to provide social arrangements that will foster selfishness and nastiness.

6. Conclusions

In this paper I have tried to show, first, that notwithstanding a great deal of philosophical history, a process ontology is far more plausible than the dominant thing or substance centred alternative. At the very least, a process ontology makes much better sense of living systems. I have then tried to show that beyond the phenomena that initially make a processualist perspective so attractive, there are multiple implications of this metaphysical shift, both for the biological sciences, and for philosophy more broadly. In the last case, I have not tried to make detailed or watertight arguments, merely to show that the metaphysical assumptions have potentially significant consequences. My hope here is less to convince, than to encourage further exploration of a vital philosophical perspective that has been inexcusably neglected in many parts of the philosophical world.

References / Список литературы

Arnellos, 2018 – Arnellos, A. "From Organizations of Processes to Organisms and Other Biological Individuals", in: Nicholson, D.J. & Dupré, J.: *Everything Flows: Towards a Processual Philosophy of Biology*. Oxford: Oxford University Press, 2018, pp. 199–221.

Bouchard, 2008 – Bouchard, F. "Causal Processes, Fitness, and the Differential Persistence of Lineages", *Philosophy of Science*, 2008, vol. 75 (5), pp. 560–570.

Darwin, 1881 – Darwin, C. *The Formation of Vegetable Mould, through the Action of Worms, with Observations on their Habits*. New York: D. Appleton, 1881.

Dawkins, 1976 – Dawkins, R. *The Selfish Gene*. Oxford: Oxford University Press, 1976, 544 pp.

Devitt, 2008 – Devitt, M. "Resurrecting Biological Essentialism", *Philosophy of Science*, 2008, vol. 75 (3), pp. 344–382.

Dupré, 2001 – Dupré, J. *Human Nature and the Limits of Science*. Oxford: Oxford University Press, 2018, 201 pp.

Dupré, 2012 – Dupré, J. *Processes of Life: Essays in the Philosophy of Biology*. Oxford: Oxford University Press, 2012, 362 pp.

Dupré, 2013 – Dupré, J. "How Much of the Free Will Problem Does (the Right Kind of) Indeterminism Solve?", *Philosophical Inquiries*, 2013, vol. 1 (1), pp. 79–92.

Dupré, 2014 – Dupré, J. "Animalism and the Persistence of Human Organisms", *The Southern Journal of Philosophy*, 2014, vol. 52, Spindel Supplement, September, pp. 6–23.

Dupré, 2017 – Dupré, J. "The Metaphysics of Evolution", *Interface Focus*. Published online, August 18, 2017. [http://rsfs.royalsocietypublishing.org/content/7/5/20160148/, accessed on 19.09.2019]

Dupré and Bertolaso, 2018 – Dupré, J. and Bertolaso, M. "A Processual Perspective on Cancer", in: Nicholson, D.J. and Dupré, J. *Everything Flows: Towards a Processual Philosophy of Biology*. Oxford: Oxford University Press, 2018, pp. 321–336.

Dupré and Nicholson, 2018 – Dupré, J. and Nicholson, D.J. "A Manifesto for a Processual Philosophy of Biology", in: Nicholson, D.J. and Dupré, J. *Everything Flows: Towards a Processual Philosophy of Biology*. Oxford: Oxford University Press, 2018, pp. 3–48.

Dupré and O'Malley, 2009 – Dupré, J. and O'Malley, M. "Varieties of Living Things: Life at the Intersection of Lineage and Metabolism", *Philosophy and Theory in Biology* 1: e003. Reprinted in Dupré (2012), ch. 12.

Ghiselin, 1974 – Ghiselin, M.T. "A Radical Solution to the Species Problem", *Systematic Biology*, 1974, vol. 23 (4), pp. 536–544.

Gilbert et.al., 2012 – Gilbert, S.F., Sapp, J. and Tauber, A.I. "A Symbiotic View of Life: We Have Never Been Individuals", *Quarterly Review of Biology,* 2012, vol. 87, pp. 325–341.

Hull, 1965 – Hull, D.L. "The Effect of Essentialism on Taxonomy – Two Thousand Years of Stasis (I)", *The British Journal for the Philosophy of Science*, 1965, vol. 15 (60), pp. 314–326.

Hull, 1976 – Hull, D.L. "Are Species Really Individuals?", *Systematic Zoology*, 976, vol. 25 (2), pp. 174–191.

Jablonka and Lamb, 2005 – Jablonka, E. and Lamb, M.J. *Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life*. Cambridge, MA.: MIT Press, 2005, 480 pp.

Lang et al., 1999 – Lang, B.F., Gray, M.W. and Burger, G. "Mitochondrial Genome Evolution and the Origin of Eukaryotes", *Annual Review of Genetics*, 1999, vol. 33 (1), pp. 351–397.

Lewis, 1986 – Lewis, D.K. *On the Plurality of Worlds*. Oxford: Blackwell, 1986, 286 pp.

Locke, 1975 (1694) – Locke, J., P.H. Nidditch (ed.). *An Essay Concerning Human Understanding*. Oxford: Oxford University Press, 1975 [1694].

Lowe, 1998 – Lowe, E.J. *The Possibility of Metaphysics*. Oxford: Oxford University Press, 1998, 288 pp.

Margulis and Fester, 1991 – Margulis, L. and Fester, R. (eds.). *Symbiosis as a Source of Evolutionary Innovation: Speciation and Morphogenesis*. Cambridge, MA: MIT Press, 1991, 470 pp.

Margulis, 1970 – Margulis, L. *Origin of Eukaryotic Cells*. New Haven, CT: Yale University Press, 1970, 349 pp.

Meincke, 2018a – Meincke, A.S. "The Disappearance of Change: Towards a Process Account of Persistence", *International Journal of Philosophical Studies*, 2018, vol. 27 (1), pp. 12–30. DOI: 10.1080/09672559.2018.1548634.

Meincke, 2018b – Meincke, A.S. "Persons as Biological Processes. A Bio-Processual Way-Out of the Personal Identity Dilemma", in: Nicholson, D.J. and Dupré, J. *Everything Flows: Towards a Processual Philosophy of Biology*. Oxford: Oxford University Press, 2018, pp. 357–378.

Méthot and Alizon, 2014 – Méthot, P.O. and Alizon, S. "What is a Pathogen? Toward a Process View of Host-Parasite Interactions", *Virulence*, 2014, vol. 5 (8), pp. 775–785.

Moreno and Mossio, 2012 – Moreno, A. and Mossio, M. *Biological Autonomy: A Philosophical and Theoretical Enquiry*. New York, NY: Springer, 2015, 221 pp.

Nicholson and Dupré, 2018– Nicholson, D.J. and Dupré, J. *Everything Flows: Towards a Processual Philosophy of Biology*. Oxford: Oxford University Press, 2018, 416 pp.

Odling-Smee et al., 2003 – Odling-Smee, F.J., Laland, K.N. and Feldman, M.W. *Niche Construction: the Neglected Process in Evolution*. Princeton: Princeton University Press, 2003, 488 pp.

O'Neill et.al., 1997 – O'Neill, S.L., Hoffmann, A.A. and Werren, J.H. (eds.). *Influential Passengers: Inherited Microorganisms and Arthropod Reproduction.* Oxford: Oxford University Press, 1997, 232 pp.

Rescher, 1996 – Rescher, N. *Process Metaphysics: An Introduction to Process Philosophy*. Albany, NY: SUNY Press, 1996, 224 pp.

Sider, 2001 – Sider, T. *Four-Dimensionalism*. Oxford: Oxford University Press, 2001, 288 pp.

Simons, 1987 – Simons, P. *Parts: A Study in Ontology*. Oxford: Oxford University Press, 1987, 408 pp.

Simons, 2018 – Simons, P. "Processes and Precipitates", in: Nicholson, D.J. and Dupré, J. *Everything Flows: Towards a Processual Philosophy of Biology*. Oxford: Oxford University Press, 2018, pp. 49–60.

Van Borm, Wenseleers, Billen and Boomsma, 2001 – Van Borm, S., Wenseleers, T., Billen, J., & Boomsma, J.J. "*Wolbachia* in Leafcutter Ants: A Widespread Symbiont that may Induce Male Killing or Incompatible Matings", *Journal of Evolutionary Biology*, 2001, vol. 14 (5), pp. 805–814.

Waddington, 1957 – Waddington, C.H. *The Strategy of the Genes*. London: Allen, 1957, 274 pp.

Whitehead, 1961 (1933) – Whitehead, A.N. *Adventures of Ideas*. New York, NY: The Free Press, 1961 (1933), 320 pp.

Whitehead, Sherburne, 1957 – Whitehead, A.N. and Sherburne, D.W. *Process and Reality*. New York, NY: Macmillan, 1957.

Wiggins, 2016 – Wiggins, D. "Activity, Process, Continuant, Substance, Organism", *Philosophy*, 2016, vol. 91 (2), pp. 269–280.

Woodger, 1929 – Woodger, J.H. *Biological Principles*. London, UK: Kegan Paul, Trench, Trubner, 1929, xii + 498 pp.