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Viruses as living processes

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A R T I C L E I N F O

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The view that life is composed of distinct entities with well-defined boundaries has been undermined in recent years by the realisation of the near omnipresence of symbiosis. What had seemed to be intrinsically stable entities have turned out to be systems stabilised only by the interactions between a complex set of underlying processes (Dupré, 2012). This has not only presented severe problems for our traditional understanding of biological individuality but has also led some to claim that we need to switch to a process ontology to be able adequately to understand biological systems. A large group of biological entities, however, has been excluded from these discussions, namely viruses. Viruses are usually portrayed as stable and distinct individuals that do not fit the more integrated and collaborative picture of nature implied by symbiosis. In this paper we will contest this view. We will first discuss recent findings in virology that show that viruses can be 'nice' and collaborate with their hosts, meaning that they form part of integrated biological systems and processes. We further offer various reasons why viruses should be seen as processes rather than things, or substances. Based on these two claims we will argue that, far from serving as a counterexample to it, viruses actually enable a deeper understanding of the fundamentally interconnected and collaborative nature of nature. We conclude with some reflections on the debate as to whether viruses should be seen as living, and argue that there are good reasons for an affirmative answer to this question.

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1. Introduction

It is still often assumed that life is composed of discrete, genetically homogeneous, organisms, either single cells or the descendants of a single originating cell in the case of multicellular organisms. This assumption accords well with the orthodox metaphysical thesis that the world is composed of things, or substances. These things are typically thought of as fairly stable entities, and as bearers of properties. Although these properties can change, some subset of them must persist if the entity itself is to persist. Things are thought of as having reasonably clear boundaries, and their important properties, the properties that determine their continued existence, as being intrinsic, i.e. as being grounded on features that lie entirely within those boundaries.

Realisation of the near omnipresence of symbiosis, however, is one factor that has presented severe problems for this background position (Dupré, 2012; chap. 7, 11). Widespread symbiosis threatens the clarity of boundaries between organisms, and even the uniqueness of these boundaries. This paper starts from a position articulated in Dupré and O'Malley (2009): the typical living system consists of interconnected and collaborating segments of many genetically distinct lineages. Humans, for instance, comprise, as well as the lineage of 'human' cells derived from an original zygote, numerous lineages of symbiotic bacteria, archaea, and fungi. These vary in the extent to which they are mutualistic, commensalistic or parasitic; often the same organism can play different such roles at different times (Méthot & Alizon, 2014). The boundaries of the organism, which may or may not be taken to include some or all of these symbionts, may be to some extent indeterminate. The realisation of the integrated nature and blurred boundaries of organisms has led to claims that traditional (substance-based) metaphysical accounts of individuality should be replaced with a

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process ontology, as the only 'philosophy of organism' that can make sense of the biological phenomena as we now know them (see for instance (Henning, 2013)).

Whilst the adoption of a process ontology might be thought of merely as an epistemological strategy our claim here is an ontological one: biological systems *are* processes.[1] It is not just that biological things are complexly interrelated with other biological things. These relations are necessary for the persistence of the biological system. Whereas persistence is the default state of a thing, the persistence, or stability, of a process requires explanation; it is actively maintained. The stabilisation of multicellular organisms, in particular, has been found to depend not only on internal processes, but also on the interactions between its symbiotic constituents, which leads us to argue that all or most of these should be seen as parts of the overall process that constitutes the organism. The organism, thus broadly construed, can then be seen as a stable eddy in the flow of interconnected biological processes (see also (Dupré, 2012; chap. 4, 5)).

The aim of this paper is to explore the role of viruses in relation to this general processual view of life. Viruses have usually been seen as distinct individuals that are entirely competitive among themselves, and entirely harmful to anything else unlucky enough to be affected by them. Given this understanding it is not clear how viruses could fit into the more integrated and interdependent picture of life that we have just sketched. They are rather seen as distinct entities that follow their own intrinsic (and pathogenic) agenda.

We want to challenge this view on two counts: first we will claim that viruses should be understood very much in the same way as other lineages in the flow of living systems. As we will discuss in Sections 2–4, recent research in virology shows that there are also 'nice' viruses. Often, as is very familiar, the intersection of viral processes with organisms is destabilising and pathogenic. But viruses also make important contributions to the stability, or health, of the hosts they intersect with. Symbiotic systems therefore may include viruses as well as plants, animals and microbes (this point is elaborated by Pradeu (2016), a paper highly complementary to ours).

Second we will argue that viruses have to be seen as processes. Viruses pass through an intricate and specific sequence of states or activities that must be seen as an ongoing and repeated series of cycles (Sections 5–8). Specific stages of the cycle might have significant stability (for instance the virion stage), but this stability is temporary, and the fact that there are (perhaps very many) such temporarily stable entities can only be understood by reference to their role in the larger process that *is* the virus. This processual nature of viruses will be elaborated in more detail in the second half of the paper.

Bringing both the processual nature of viruses and their intermittent 'niceness' to the fore will show that viruses are not counterexamples to the integrated and dynamic picture of biological systems advocated here and elsewhere (Dupré, 2012). Indeed, the example of viruses serves to reinforce (and further inform) a processual view of biological systems. Viruses, or so we will claim, are vital and omnipresent constituents of the larger flow of interconnected processes that make up biological systems.

2. The microbiome and its benefits

Not long ago, it was standard to think of a multicellular organism as a lineage of differentiated cells, originating from a founder cell, typically a fertilised egg. Microbes, especially bacteria, were generally thought of as potential enemies, poised to invade and attack the multicellular system. It gradually became clear, however, that multicellular organisms are typically populated by vast numbers of microbial residents and that these often do little harm. Perhaps they are just passengers, taking advantage of a warm and well-resourced niche. But it was also clear that in exploiting these resources some bacteria also provide some benefit. In the case of animals like cows, which rely on digesting such recalcitrant molecules as cellulose, it was long known that this was only possible with the help of resident bacteria, and here can be seen the beginnings of a shift in perception of microbes from dangerous threat to necessary symbiont.

More recently, it has become clear that microbial symbionts do far more than just these often essential contributions to digestion. They are involved in the modulation of development, and play a central role in the development and homeostasis of the immune system (Chu & Mazmanian, 2013; Round & Mazmanian, 2009; Spasova & Surh, 2014). They have even been found to connect to the central nervous system (Bravo et al., 2012). In plants, hugely complex systems of bacteria and fungi modulate the interface between the plant's roots and the surrounding soil (Philippot, Raaijmakers, Lemanceau, & van der Putten, 2013). These insights have contributed to a major philosophical reconsideration of the concept of the biological individual, with some researchers arguing that multicellular organisms are typically massively symbiotic individuals or, as they are sometimes known, *holobionts* (the concept of holobiont is discussed in Mindell, 1992; Rohwer, Seguritan, Azam, & Knowlton, 2002; Rosenberg, Koren, Reshef, Efrony, & Zilber-Rosenberg, 2007).[2] The human microbiome, according to some, consists not of passengers, but of parts of an integrated individual.

Importantly, according to this integrated view of the biological individual, the organism itself in its stable state turns out to be a product of a myriad of interactions between host and microbes. The body then is not just the passive and pre-existing vessel that can host a bacterium; it is shaped and maintained by the interaction with its 'guests'.

The human body, however, is not only populated by bacteria, archaea and fungi but also by viruses. It is difficult to provide a good estimate of the number of virus particles within the human body, but as techniques have developed for finding them, results have been more or less consistent with the analogical inference from simpler systems studied that there are about ten times as many virus particles as cells (Brüssow & Hendrix, 2002). This might immediately raise a question how, if viruses are as uniformly nasty as the standard view supposes, we manage to stay alive at all.

3. Viral collaborators?

As pointed out at the beginning of this paper, there is evidence that the resident community of viruses provides services to biological systems; possibly even such vital services that we should consider them, like many bacteria, to be integral parts of complex symbiotic biological organisms.

Apart from the very obvious fact that they frequently fail to kill us, there is a general reason for supposing that the vast numbers of viruses or virus-like particles found in the human body are an integral part of the system rather than a reservoir of predators, generally kept sufficiently under control to allow the system to function. This is that the composition and size of the virome seem to be remarkably stable (see Section 5 for a more detailed discussion of the term 'virome'). If viruses were primarily hostile, then we would expect their numbers to oscillate in the way analysed in the

[1] For more on the distinction between epistemological and ontological processism see (Rescher, 1996).

[2] More general philosophical discussion is provided in (Dupré & O'Malley, 2009; Bouchard & Huneman, 2013; Pradeu & Carosella, 2006).