

THE MEANING OF ‘LIFE’

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Abstract

Attempts to define life have been uniformly unsuccessful, and this paper argues that no such definition is to be expected. However, it is important that life is not, as is still often assumed, a collection of discrete individual things, but rather a set of deeply intertwined processes. The paper provides three reasons for this view: that living systems are metabolic systems far from thermodynamic equilibrium; that they have characteristic life cycles, often passing through very different states; and that they are typically symbiotic, mutually interdependent with other systems. Recognition of this processual character of life makes clear why an adequate definition of life, a set of necessary and sufficient conditions for being alive, is unlikely to be forthcoming.

Keywords

definition of life • processual • philosophy of life

I suspect, following Wittgenstein, that most interesting concepts cannot be defined, and that life belongs firmly in that category. There may be necessary conditions for being alive that are not sufficient and perhaps sufficient conditions that are not necessary. But I doubt whether there is any set of conditions both necessary and sufficient.

One reason for such doubt is that there is little or no consensus on what entities the definition should encompass. Elephants and oak trees are surely alive, but viruses, plasmids and prions are more questionable. Commonly cited criteria, such as reproduction, metabolism, evolution, thermodynamic non-equilibrium, etc. seem to apply to even the debated cases, but also to many things that would not generally be thought to be alive.

I shall start here with a much more contentious feature of life, as I understand it, processuality. Being a process, I believe, is a necessary but certainly insufficient condition for being alive. Lots of processes – coastal erosion, price inflation, tropical depressions, etc. – are certainly not alive. But all living things are processes. I shall shortly say why I believe this and then why it matters. But first I must explain briefly what I mean by a process.

Process

Processes are to be distinguished from things, or in more technical philosophical terminology, substances. The crucial

characteristic of a process is that it must change to persist. If the coastline or the price level does not change, erosion or inflation are no longer occurring. The case of a living being is less obvious. A sleeping dog may not seem to be changing. But at a level invisible to the naked eye, trillions of chemical events in the dog's body are necessary for its persistence. If nothing were happening, and hence changing, inside the dog it would be a dead dog.

The processes inside a sleeping dog are internal. But another familiar characterisation of living systems is as systems far from thermodynamic equilibrium. What this implies is that the living system must interact with the environment, if only to acquire the energy it needs to maintain this non-equilibrium state. Even asleep, the dog is breathing, taking in oxygen. A process may be maintained either by internal activities (further processes) or external interactions. Although there is no great difficulty in distinguishing the dog from the oxygen it breathes, such interactions may be so intimate as to make the boundaries of a process indeterminate. Think of a storm. It may surely be an individual countable process (how many named storms have we experienced so far this year?), but it would be impossible to say exactly where it began or ended. Everywhere the moving air is interacting with adjacent quantities or flows of air.

I can summarise the principal differences between a thing and a process as follows. A thing is sharp-boundaried,

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autonomous and its default state is stasis; a process is typically dependent on interactions with other entities, has vague or indeterminate boundaries, and is always active. The last contrast is particularly significant for understanding scientific investigation. Scientists tend to assume that if a thing changes, something caused that change but if it stays the same there is nothing to explain. But for a process staying the same in certain significant respects is often exactly what is most in need of explanation. Medical science, for instance, is ideally devoted to maintaining the functional stability of a very complex process.¹

My own view is that there is only process, and that the appearance of stable things is ultimately no more than the existence of temporarily very well-stabilised processes. But for this paper, my concern will be limited to the reasons for, and implications of, seeing life as a process.

One point, implicit so far, needs to be stressed. I am thinking of many, though certainly not all, processes as continuants. This goes against a common tendency in general metaphysics, to contrast continuants with occurrents, and see processes as a category of occurrent. Occurrents, on such a view, have temporal parts whereas continuants, as is often said in reference to personal identity over time, are wholly present at all times during which they exist. I cannot go into this issue here.²

Living systems are processes

Not accidentally, my introduction of process already made several references to living processes. Here I summarise the decisive reasons for thinking of life quite generally as processual.

First, as I have already noted, living systems are systems far from thermodynamic equilibrium, maintained in that state by all kinds of activities, or processes. An organism, for example, is hardly autonomous, as it depends on continued intake of energy for its persistence, and certainly is not stable by default. A totally stable dog, one in which nothing is going on, is a deep-frozen dead dog.

Second, organisms have life cycles. It is of their nature that they undergo a series of changes over time, together producing a characteristic sequence of states. Some of these are both familiar and dramatic in the changes they involve. Think of the sequence of egg, caterpillar, pupa, butterfly, or egg, tadpole, frog, for instance. Few would deny that such sequences can, despite their differences, constitute the same organism. I noted in the last section that we generally assume that a thing, other things being equal, stays the same. How much change is consistent with the continued existence of a thing? If I take my computer apart and reconstruct the parts into an abstract sculpture, I no longer have a computer. But we do not think the same way about the reconstruction of a caterpillar into a butterfly.

The explanation of this difference is that things and processes have quite different criteria of persistence. The traditional criteria for things – dating back to Aristotle – has been an essential property, the property or set of properties necessary and sufficient for the existence of a thing; a thing persists precisely for as long as it maintains its essential property.³ Here it doesn't matter whether, as has been traditional, the essential property is thought to be stipulated or, following Kripke(9) and Putnam(10), discovered; nor whether there is strictly a necessary and sufficient condition, or something looser, like a cluster of properties, some vaguely defined set of which suffices for persistence.

No version of such a condition plausibly counts the development of an egg into a butterfly as a case of persistence through change. Process theorists have considered processes to depend for their continuity on causal connection between temporal stages of a process.⁴ This criterion makes some decisions as to when a process has ended, divided or merged very difficult to make unambiguously. But this I take to be a feature not a bug; much as we might like it to, nature does not give us precise answers to such questions.

Finally, the idea of the autonomy of a thing can be shown even more directly to be untenable for an organism. This is because of the extremely widespread phenomenon of symbiosis. Symbiosis covers a wide range of relationships between organisms. They may be mutualistic, beneficial or

¹ For much more detailed discussion of this contrast see, e.g., Dupré and Nicholson (1); Dupré (2).

² For general discussion of the continuant/occurrent distinction, see Simons (3); Stout (4) argues for the legitimacy of the category of continuant processes; Steward (5) disagrees. Meincke (6) argues that a proper account of persistence requires a process ontological framework. For a range of discussions of identity from both traditional metaphysics and the philosophy of biology, see Meincke and Dupré (7).

³ For general criticism of the attempt to apply essentialist thinking to biology see, e.g., Dupré (8).

⁴ I do not mean here to reify the temporal stages, as if these were atoms that make up processes. A temporal stage here is just any time period during which the process is going on. For various purposes we do make conceptual divisions within processes, for example stages such as child, adolescent, adult in human lives. No one supposes that these represent the discovery of precise boundaries in nature.

essential for both partners, commensal, benefitting one with no effect on the other, or parasitic, benefitting one at a cost to the other.⁵ Of particular interest are mutualistic relations essential to both parties, for example in lichens, which are partnerships between a fungus and a photosynthetic microbe, in many cases obligatory for both partners.

The great majority of organisms enter into symbiotic relationships. Multicellular organisms generally have vast numbers of associated microbes many of which are essential to the overall functioning of the system. In the human case it has been shown that microbial partners play important roles in processes including digestion, the immune system, development, and perhaps even cognition. Plants are typically deeply interconnected with consortia of bacteria and fungi in the roots and on the leaves. These include fungal mycelia that pass from the interior of the root to the surrounding soil, and that may connect through mycelial networks to other plants with which they exchange nutrients.

The significance of these observations is that the assumption that organisms have approximately clear boundaries turns out to be unsupportable. Is the lichen one organism, as it appears at least to superficial inspection, or one fungus and a vast number of photosynthetic bacterial or algal cells? The only sensible answer, I think, is that this depends on the context in which the question is asked. From an evolutionary perspective one might want to look at the distinct lineages of the symbiotic partners; from a physiological perspective one might be interested rather in how the whole system works. The bottom line is that living systems are typically deeply intertwined in changing relations as they develop over time. Distinguishing thing-like entities, stable over particular time periods, within this entangled flow, is possible and may serve many purposes. But it cannot be seen as the discovery of objective things that make up the living world.

Can life be defined?

The standard picture of a definition of life is of the provision of a set of properties such that if they are found in a particular thing then that thing is alive. Reproduction, metabolism, growth, and evolutionary origin are some of the common candidates for such properties. But the diversity of living things even on our own planet, the diversity of states that instances of life on our planet may pass through in a single life, and the fact that

⁵ These relations may also be different at different times. To avoid simplistic dichotomies between good symbiotic relations and bad ones, Maureen O'Malley and I [Ref. (11)] have proposed using the term "collaborative" to cover the range of symbiotic relations.

an important point of defining life is to decide what criteria we would use to decide whether some novel entity, perhaps from a distant planet, was alive, all suggest that a definition will need to be very abstract. Unfortunately, this abstraction is also liable to make it rather unilluminating.

To illustrate this point, consider the proposal by Sara Imari Walker that a thing is alive if it has an assembly index >15 .⁶ An assembly index, roughly, is the number of steps it takes to assemble an object from smaller constituents. If there is a significant number of similar things that take a lot of assembling it is exceedingly improbable that they all came about by chance; indeed, by far the most plausible explanation of large numbers of complex objects is that a lineage has evolved with the resources necessary to assemble them. Lineages, in fact, are the continuant processes that evolve and that generate organisms.

The problem, as just mentioned, is that these observations are far too abstract to give us much insight into the distinctive characteristics of life. To see this, note that just as you surely have an assembly index >15 , so does your smart phone. As William Paley famously argued, it is likely that complex artefacts are reliable signs not only of life but of intelligent life. But we don't want just to know that some complex entity shows us that there is life somewhere, but whether that complex entity is a living thing. In the case of smart phones or Paley's found watch, the answer is surely no. We might, I suppose, just stipulate that a complex object that had come into being by natural selection rather than by the application of intelligence was alive. But, first, I take creationism to be false not nonsense; and second, this still does nothing to tell us what differences there might be between the entities resulting from these very different kinds of causes. And this, surely, is what we want to know. If we find complex objects on a distant planet, we might like to know whether we had found the remains of the inhabitants or one of their refuse tips.

These remarks point to a quite general difficulty with defining life. Living things are enormously diverse and only ambiguously differentiated from the complex flow of living activity. They could not form a natural kind with some property or set of properties shared by all and only their members. What life on Earth has in common is its origination from a single though massively divergent evolutionary process that explains the complexity not only of living systems but of the complex objects they have produced. Even if only one species has produced objects with an assembly number >15 , it has produced an appalling number of them.

⁶ Walker (12). I discuss this proposal in more detail in Dupré (13).

It could be – and here is a virtue of Walker's approach – that the kind of process that produces complex entities can arise only from an evolutionary process similar in important respects to that which occurred on Earth. Perhaps – though I am skeptical – evolutionary processes of this kind do form a natural kind. But still, a common factor in terms of causal origin often provides a fairly useless account of a kind. Think again of the diversity of things that originate as human manufactures, from sculptures to films, and from television sets to tubes of toothpaste. And surely evolution as we know it has been a more powerful originator of diversity even than human creativity.

So far I have suggested that there is little more to say in defining life than that it is some subset of the highly complex entities that have come into being through long evolving lineages. Before returning briefly to the glaring question of which subset, let me say a little about the concept of a lineage. Lineages, I maintain, are a vital category of living process⁽¹⁴⁾. They are continuant processes, indeed processes that have lasted billions of years. The process that resulted in the present existence of humans, or any other currently extant species, can be traced backwards at least as far as LUCA, the last universal common ancestor, and in principle much further. This lineage consists of a sequence of species, though this point needs to be handled carefully as we should not assume that there will be clear boundaries between species. As with many divisions between stages of a process, for example those between children and adolescents or adolescents and adults in the human life cycle, the beginnings and ends of species are more or less conventionally determined. They do point to the almost indefinite change that can occur within a lineage. Note, finally, that biological lineages are much less isolated than we once thought. Not only is hybridisation common, but viral and similar vectors can mediate genetic transfers between distantly related lineages.

Could we define life simply as evolving lineages which, through processes such as natural selection, are generating complexity? Once again, this is more or less correct, but unhelpful. It is more or less correct in that as far as we know structural complexity of the kind found in living systems has only come about through such lineages. It is unhelpful, however, because it does not tell us anything about the character of the complex entities we think of as living.

This matters because it is certainly not a necessary truth that all evolved complex structures are living. One could certainly

argue that termite mounds or birds' nests were evolved structures, though perhaps they can be eliminated from the category of living on the grounds of insufficient structural complexity.⁷ But as already mentioned, this will not eliminate the products of human construction.

And this finally matters because this is where the actual questions we might want to answer based on a definition of life arise. Are viruses alive? This remains a heated debate among virologists and philosophers. Can we tell when, if ever, our computers or robots should be counted as living? And whether or not there is anything that matters about those questions, surely it is something that we would want to ask of some evolved entity we encountered on a distant planet. Once again, a very general account of causal origin is unlikely to distinguish a set of products with interesting properties in common.

Why do we want to distinguish the living? Perhaps it will be thought that this would have been the right question to start with. But I think the answer becomes easier to discern after some reflection on what might be involved in answering it. At any rate, I hope it is now possible to see the attraction of my own view, that there is no good answer to the question. Why should we care whether viruses are alive? We know a lot about what they are like and what they do? What would it add to this to know whether they are alive? Similarly, with aliens we might encounter. Of course, there are lots of hard questions we might want to ask. Are they conscious, intelligent, sentient, and so on. But having answered all such questions to our satisfaction, would we also want to ask whether they were alive? I cannot imagine why. And though some of these qualities may be sufficient for life, none is necessary.

Let me add finally that of course none of this implies that we should not be interested in exploring in more or less general ways what life is like. At the very general end, Maureen O'Malley and I [Ref. (11)] once argued that life occurs at the intersection of lineage and metabolism, where members of many lineages engage in shared or overlapping metabolic processes. This was, among other things, a way of articulating the importance of accumulating insights into the prevalence of symbiosis, and of stressing the interactive, relational and processual nature of both lineages and organisms. But this was certainly not intended as a definition. Not every organism

⁷ Alternatively, they might even be seen as parts of organisms or in the termite case superorganisms, in something like the sense of Richard Dawkins's (15) extended phenotypes.

on earth is symbiotic (there are planktonic bacteria in the ocean that seem not to be) and it would hardly be a matter of importance in how we viewed an alien species that they turned out to have emerged from an isolated lineage.

So I end where I began, with the conclusion that life, like most interesting concepts, is not definable. There are nevertheless lots of things that we can say about it, some at a very high level of generality. The philosophy of life, of which my argument that life is a processual not substantial is an example, is an important topic. But it is unlikely to give us a definition. Perhaps it will, nonetheless, help us to adjudicate the boundary disputes that such a definition might have been intended to solve: are viruses, prions, robots, highly alien aliens, and so on, alive? For the viruses and prions, though I confess to having spent some effort on such disputes, I am currently inclined to doubt whether it matters. For the robots and aliens, on the other hand, we will be more likely to want to ask more focused questions: are they conscious, sentient, moral, intelligent, and suchlike. None of these is equivalent to being alive, but perhaps if we answer them that last question won't bother us very much.

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