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Beyond Horses and Oak Trees

A New Theory of Individuation for Living Entities

> A main cause of philosophical disease – a one sided diet: one nourishes one's thinking with only one kind of example.
>
> Ludwig Wittgenstein

1.1 INTRODUCTION

Past attempts to explain how to individuate living things have failed for two reasons. They have not assimilated a full range of biological examples or they have been misled by the most common examples and thought experiments. In this book, I explore and resolve paradoxes that arise when one applies past notions of individuality to biological examples beyond the conventional range. I also present a new analysis of identity and persistence.

My argument is based on the belief that to answer the philosophical question "What is a living individual?" it is necessary to find a satisfactory solution to the question "What should a population biologist count when she counts organisms?" Both questions seem to have clear answers when we consider stock examples. Under normal circumstances we can count the number of puppies in a litter or tomato plants in a garden. However, the same intuitions that allow us to count puppies and tomato plants with confidence leave us perplexed when we try to count colonial siphonophores like the Portuguese man-of-war. Things get strange when we extend folk notions of individuality beyond folksy uses. We can find cases in which criteria of individuation for living things that we are used to seeing hang together give contradictory answers to the question "Is it an individual?" If we take the word 'individual' to be synonymous with 'particular,' there will not be many questions at the level of the organism and below (though there may be confusion about the nature of species). But traditionally the term 'individual' has been used more broadly, and in this work I explore many of these uses as they

relate to organic organization, genetics, development, and models of natural selection.

The theories of individuation generated by considering only a narrow and conventional range of examples prove inadequate when applied to real living things whose normal modes of existence include complex metamorphoses, regeneration of lost parts, splitting apart and fusing together. A clonal population of the fungus *Armillaria bulbosa* occupies at least fifteen hectares in a Michigan forest. Some mycologists have called it the largest individual living thing on earth. What are the grounds for this claim? Some species of rhizocephalans, a group of parasitic barnacles, have several distinct developmental phases. Is each phase a separate individual or do they collectively compose an individual? Strawberries can reproduce through sexual or clonal reproduction. Is each clone an individual or does the entire set of clones compose an individual? Or are both individuals? Questions like these cannot be answered satisfactorily by a theory that treats the characteristics of a higher animal as the necessary and sufficient conditions of individuality. In fact, cases like these raise the question of whether there are necessary and sufficient conditions for individuality *simpliciter*.

In answering these questions I will address others. What makes a biological entity an individual as opposed to a colony or a component of a larger individual? What criteria should we use to determine that a biological entity – for example, a colony of termites or an asexual organism – is the same colony or organism as one that existed at a previous time? In metaphysical terms, what biological (or other) processes cause substantial change?

In this chapter, I show that past philosophers have failed to explicate the conditions an entity must satisfy to be a living individual. I then explore the reasons for this failure and explain why we should limit ourselves to examples involving real organisms rather than use thought experiments.

1.2 THE MEANING OF 'A LIFE'

Many philosophers assume that it is easy to individuate living things. In this section I present a pair of examples. John Locke claims in the second edition of *An Essay Concerning Human Understanding* that a plant or animal need not be composed of exactly the same particles of matter throughout its existence. A living thing's persistence is not contingent on its particular material constitution. Instead, the continuation of a life preserves the identity of an organism through the flux of material constituents.

> In the state of living Creatures, their Identity depends not on a Mass of the same Particles; but on something else. For in them the variations of great parcels of

> Matter alters not the Identity: an Oak growing from a Plant to a great Tree, and then lopp'd, is still the same Oak: And a Colt; grown up to a Horse, sometimes fat, sometimes lean, is all the while the same Horse: though there may be a manifest change of parts. (Book II.xxvii.3)

The metabolic processes involved in the continuation of a particular entity's life result in a constant change of matter. If the continued identity of a living entity does not depend on its being composed of exactly the same matter throughout its existence, on what does it depend?

Locke thinks that the continuation of *a life* preserves the identity of an organism through the flux of material constituents. A plant, for example, persists through changes in its constitutive matter by continuing the same life.

> That being then one Plant, which has such an Organization of Parts in one coherent Body, partaking of one Common Life, it continues to be the same Plant, as long as it partakes of the same Life, though that Life be communicated to new Particles of Matter vitally united to the living Plant, in a like continued Organization, conformable to that sort of Plants. (Book II.xxvii.4)

Similar conditions of identity are true for animals.

> An Animal is a living organized Body; and consequently, the same Animal, as we have observed, is the same continued Life communicated to different Particles of Matter, as they happen successively to be united to that organiz'd living Body. (Book II.xxvii.8)

For Locke, identity is preserved in the changing of substances by being unified by one continued life. A plant that is spatiotemporally connected by a continuous series of matter changes to an earlier plant of the same kind is identical with that earlier plant just in case there is a common life between them. Similarly, the identity through time of a human being or other animal consists in its participation in a common life.[1]

According to Locke, if bodies existing at different times are connected by a common life that endures through the change of material substance, those distinct bodies compose the same living individual at different times.[2] Curiously, Locke does not explain how to individuate *a life*, though this concept provides the principle of individuation for plants and animals. Perhaps he thinks it too obvious to require an explanation – he is, after all, talking about human beings, horses, and oak trees. Under normal circumstances, a competent observer has no trouble determining whether the horse eating an apple today is the same horse he brushed yesterday. Nor does he doubt that the oak tree struck by lightning last winter is the same oak that he carved his initials in as a child.

Three hundred years after Locke wrote the *Essay*, Peter van Inwagen argues that the only way composite objects can exist is if the parts composing the object are connected through a special kind of causal connection; those parts must constitute *a life*. According to van Inwagen,

> ($\exists y$ the xs compose y) if and only if
>
> the activity of the xs constitutes a life (or there is only one of the xs). . . . I mean the word "life" to denote the individual life of a concrete biological organism. (1990, pp. 82–83)

To phrase the matter in van Inwagen's terms, what is the individual life of a concrete biological organism? He offers some insight into what makes something living rather than nonliving, but does not explain how to decide exactly what constitutes the individual life of an organism. He offers analogies between an organism and a club that is arranged like the metabolism of an organism. He also describes a life as an "unimaginably complex self-maintaining storm of atoms. . . . One might call it a homeodynamic event." These analogies offer some insight into his intentions, but leave many difficult cases unexamined. He asks again,

> But what is a life? What features distinguish lives from other sorts of events? In the last analysis, it is the business of biology to answer this question, just as it is the business of chemistry to answer the questions 'What is a metal?' and 'What is an acid?', or the business of physics to answer the question 'What is matter?' (1990, p. 84)

Despite his intentions, van Inwagen does not provide a solid set of criteria to distinguish living individuals from parts of larger living individuals or groups of living individuals. I agree with van Inwagen that we will not find the answer to the question of what a life is without reference to "the business of biology," but the biological literature on individuality could itself use some philosophical tidying up.

Determining the boundaries of a life is a more difficult task than looking over the normal range of examples may lead one to believe. Locke and van Inwagen are in good philosophical company when they treat the concept of a life as an intuitively clear idea that can be used to explain other, more difficult concepts, such as identity through time or issues of mereology. But they have not provided a comprehensive description of living individuality. Assuming that we could articulate necessary and sufficient conditions for being alive (and no one has), we still do not know whether a particular mass of living tissue is a living being. It may be, but it could also be several living things or a part of a more comprehensive life. These questions are unanswered by Locke,

van Inwagen, and many other philosophers. Why this lacuna? I suspect that both blindspots are, to a large extent, the result of poor examples.

1.3 THE POVERTY OF EXAMPLES

Normal people in normal circumstances can count the number of horses entered in the Kentucky Derby or the number of oaks that flank the driveway. Horses and oak trees are easy to count. They are distinct from their surroundings and other horses or oaks.[3] If we limit our scope to these familiar cases, we can forgive the omission of details as to what is involved in being an individual life. But if we look beyond those cases, we find that our intuitions can lead us to paradoxical judgments of individuality and make us turn a fresh eye to old cases as our basic assumptions about individuality become contingent facts to be explained.

There is a strange poverty of real examples in the philosophical literature on identity. In an unscientific survey of the philosophical literature from Aristotle to the present on the individuation of living things, I have found that the choice of examples breaks down into four basic categories: common plants and metazoan animals, people, artifacts, and science fiction fantasies. The majority of living things, which are neither human nor familiar plants or animals, are absent from this list.[4] The poverty of real examples is matched only by the oddity of the thought experiments involving grossly mutated dogs, human beings who split like amoebae, werewolves, and other products of the imagination.

There is nothing wrong with using horses and oak trees as examples. But these familiar examples are dissimilar from most living things; we cannot limit our examples to a pool of familiar organisms. Horses and oak trees are quite different from each other, but they share many attributes we may not notice at first glance:

a. They are clearly demarcated from their surroundings and other organisms of the same kind. This makes them easy to count.
b. They can reproduce sexually.
c. Each develops from a single cell.
d. Each is (at least mostly) genetically homogeneous.
e. Each is multicellular.

If all or most living things had these characteristics, the same principle that worked for horses and oaks would work for other living things.

Most living things do not share all of these features. A horse is a fine example of a mammal. An oak tree is a fine example of a tree. Most living

things, in terms of number of species, number of organisms, or pure biomass, are neither mammals nor trees and do not share properties *a–e*. We ignore the majority of living things if we limit discussion to just these kinds of cases. It is not surprising that our examples would be of this nature. When we think of living things, common, relatively large, and discrete plants and vertebrates are what generally come to mind. It makes sense that our concepts and language have developed around these kinds of living things rather than around colonial invertebrates or giant fungi.

In a five-kingdom taxonomy of life on earth, oaks and horses represent only two kingdoms, the plants and the animals. 'Represent' may be the wrong word. Oaks and horses are only parts of their respective kingdoms, which also contain radically different forms of life. I will discuss these more unusual forms in later chapters, as well as puzzlers from the other kingdoms. How should we count these organisms? Even if we know all the relevant functional and historical facts about the living thing in question, the answer still may not be clear. The suggestion to count individual lives is not much help because that replaces our question with an equally difficult one. Locke's criterion that identity is preserved when there is a common life is little help in deciding these cases because it is not clear what *a life* consists in for that kind of entity. Locke presents an incomplete analysis of what it is to be a persisting individual living thing.

Artifacts have been used as examples at least since Aristotle wrote the *Metaphysics*.[5] Such examples are misleading because of the significant differences between artifacts such as houses, statues, and axes on the one hand, and individual living organisms on the other. A statue of a dog does not, by itself, change its constitutive matter. A dog does. Because of the differences, it is dangerous to attempt to theorize about the identity of living things based on what one believes about the identity of nonliving objects that, if they change their matter at all, do so slowly. Living things are not artifacts. A living thing can change its constitutive matter in a fashion and at a speed that inanimate objects rarely rival.

I turn my attention now to a brief description of a few real cases that are difficult to explain using the commonsense notion of an individual. I will describe aspects of the biology of a colonial siphonophore, a cellular slime mold, and a butterfly. Each presents a unique problem for the commonsense notion of an individual life.

Some colonial invertebrates form colonies that are integrated to the extent that they are functionally indistinguishable from a metazoan individual. The development and behavior of the siphonophores demonstrate the complexity of the problem. A colony of *Nanomia cara*, for example, looks very much like a jellyfish if it is not examined too closely, but it develops by a radically

different method. A scyphozoan jellyfish begins life as a single-celled hydrozoan that develops into a multicellular larva. This larva undergoes a series of divisions and ultimately becomes a multicellular body or polyp. The polyp strobilates to form medusae or adult jellyfish.

A colonial siphonophore also begins as a zygote. The zygote divides and forms a larva. The larva's ectoderm thickens and buds off zooids. The process is called astogeny and it is quite different from the development of the true scyphozoan jellyfish. The zooids remain attached together rather than becoming detached. New zooids are budded off from one of the two growth zones located at the end of the nectophore region.

Each colony is composed of a variety of zooids that closely resemble the parts of a normal jellyfish. The top of the colony is a gas-filled float. Below the float are the nectophores that move the colony by pumping water. Their action is coordinated. Other zooids called palpons and gastrozooids ingest prey and distribute the nutrients to other colony members. Sexual medusoids propagate new colonies by forming and fertilizing gametes.

The colony can swim and feed like a single organism. Despite its functional integration, clear vestiges of its colonial nature can be found. Each nectophore has an independent nervous system, but these are coordinated through the nerve tracts connecting the nectophores. The gastrozooids and palpons all pump at the same time (E. O. Wilson 1975).

Both the true jellyfish and the siphonophores have essentially the same functional structure despite their different developmental histories.

> Other higher animal lines originated from the mesoderm, without passing through a colonial stage. The end result is essentially the same: both kinds of organisms escaped from the limitations of the diploblastic (two-layered) body plan and were free to invent large masses of complicated organ systems. But the evolutionary pathways they followed were fundamentally different. (E. O. Wilson 1975, p. 386)

Is a siphonophore colony an individual or is each zooid an individual? Our commonsense notion of individuality does not decide this case, nor does the suggestion to look for the individual life.

The commonsense notion of an organism does not give a clear account of the transition between a caterpillar and a butterfly. A caterpillar develops from a zygote into a complicated multicellular body. Before metamorphosis, it surrounds itself with a cocoon. Inside the cocoon, the caterpillar body breaks down and the dissolved body is used to fuel the growth of the imaginal discs. These discs are small groups of undifferentiated cells that are encapsulated during caterpillar development and play no role in the functioning of the caterpillar's body. When exposed to the right hormone, they grow into the

parts of the adult butterfly body and replace the juvenile body. The butterfly is genetically identical with the caterpillar but it is the result of a distinct developmental process fed by the larval body. I am not sure that the commonsense notion of an individual can give us a clear answer as to whether we have one life or two here. Some organisms have life cycles with several developmental sequences as radical as that dividing the caterpillar and the butterfly. To further confuse the issue, there are many degrees of metamorphosis and some stages are composed of more than one organism.

Blackberry plants reproduce both by sexual means resulting in seeds and also through vegetative growth. Some stands of blackberries are hundreds of years old and trace their origin back to a single sexually produced seed. The seed grows into a plant, which sends out runners. Some of the runners and roots remain connected underground and others have become detached. What should we count when we count blackberry plants? The descendants of the initial zygote, the genetically identical descendants of the zygote, or all the contiguous parts of the blackberry plants? Similar problems arise for counting some species of fern, quaking aspen, bamboo, and some fungi.

At one point in the life cycle of certain species of cellular slime molds, a number of independent, ameobalike single cells aggregate together into a grex. The grex is a cylindrical mass of these cells that behaves much like a slug. It has a front and back, responds as a unit to light, and can move as a cohesive body. The cells that compose a grex are not always genetically identical or even related. They begin their lives as free-living single-cell organisms. The grex has some properties of an individual and behaves very much like one. The commonsense notion of individuality does not enable us to determine whether or not it is an individual. These cases break down the connection between the set of properties characteristic of those organisms we feel most comfortable calling individuals using our commonsense notion of individuality.

I will not begin by specifying a set of necessary and sufficient conditions for being an individual living thing. Instead, I will enumerate the characteristics held in common by paradigmatic individuals. I approach the issue this way because I believe that we have developed a rough-and-ready concept of biological individuality as a conceptual tool to help us deal with our practical affairs. There may not even be a complete definition of 'living individual' but we think we know one when we see it. This concept may not prove to be as useful if we try to use it in a philosophical or scientific context. The original concept was not formulated to deal with these apparently paradoxical cases. I want to offer a useful extension of our practice. This extension is not implicit in the rules set by the concept as it currently exists in common language or by the practices based on those implicit rules. The result will not

look like the commonsense concept that I take as a starting point. I offer this list of properties and make no decisions now about which, if any, of them are essential for individuality. I approach the general question through a variety of concrete living entities, those we consider individuals and those that we do not. It may well turn out that there is no set of properties shared by every entity we call an individual.

Although I am reluctant to consider them as necessary and sufficient conditions, there are a group of properties that most of the organisms we consider to be paradigmatic individuals share. The relevant characteristics held by the higher plants and animals are:

i. spatial and temporal continuity,
ii. spatial and temporal boundedness,
iii. composed of heterogeneous causally related parts,
iv. development from a single cell to a multicellular body,
v. subject to impaired function if some of its parts are removed or damaged,
vi. ability to reproduce sexually, and
vii. genetic homogeneity.

These properties are, to a greater or lesser extent, common to a horse, a termite mound, an oak tree, a stand of bamboo, a slime mold plasmodium, a lichen, and a eukaryotic cell. Does this make them each individuals? Can we coherently extend our concept of individuality to all of them? These properties may come as a group, but that is not always the case. This is part of the problem in specifying exactly what is and is not an individual. Some entities have only some of these properties. Also, these properties can be held to different degrees even though the judgment of individuality is generally recognized as an all-or-nothing decision.

The commonsense notion of individuality is just that, a commonsense notion. We often think of a lichen as an individual thing. The lichen is composed of algae and fungus combined in symbiosis. This does not imply that biologists must accept the lichen as an individual or that commonsense folk ontology must accept other symbiotic unions as individuals. Even if it makes sense to begin with our folk ontology, our analysis of individuality may lead us far from where we began.

1.4 IMAGINARY EXAMPLES AND CONCEPTUAL ANALYSIS

Thought experiments and imaginary examples have a venerable history in philosophy.[6] Constructing thought experiments and puzzling over them is fun

and difficult to resist. Unfortunately, they often mislead us and it is unclear what they contribute to philosophy.

> [P]eople think that they can conceive of a centaur, and in a very superficial way, they can, but too many questions remain unanswered, and no means exist for answering them. How many pairs of lungs does a centaur have, how many hearts? How are the circulatory and pulmonary systems of these creatures connected? What happens to food that has been digested in the human half of the centaur? Does it empty into the stomach of the horse half? Of course, we are not supposed to ask such questions of mythical creatures. (Hull 1989, p. 312)

I use very few thought experiments in this work. Instead, I rely on real examples. For the project I have in mind, thought experiments and imaginary examples more often confuse than clarify.

I am primarily interested in devising a system of individuation for living things capable of explaining unusual real cases as well as more common real ones. My goal is to construct a theory that can best accommodate the diversity of organisms and other living entities, not to derive the necessary and sufficient conditions for being a living individual in any possible world. Merely imagined possibilities are not particularly relevant to this project. I limit my examples to real living things for reasons that I explain below. This choice affects my arguments. It determines the kind of counterexamples that I need to consider, which will, in turn, affect the structure and scope of my arguments. Imaginary, though logically possible, examples do not provide direct evidence against a position on individuation that has been tailored to fit this world.

The abundance of real counterexamples that create tension in our commonsense conceptual boundaries renders imaginary examples inconsequential. The examples may not always be obvious, but they are plentiful, and unlike thought experiments, real examples come complete with the relevant background conditions either known or discoverable. Given the choice between a real example and an imaginary one, we should choose the real one.

The usefulness of a thought experiment depends on a correspondence between imagination and possibility, a relation subject to at least two common sorts of failure. We can apparently imagine an impossible state of affairs without recognizing its impossibility. And we may be unable to imagine something that turns out to be possible.

It is debatable what role thought experiments and imaginary examples should play in revising our concepts. We hope that our concepts help us to think about the world in a useful way. If a concept is inadequate to deal with an imaginary but possible example, that is a poor reason to reject it. Unless