

- Concepts', in: Meier J. and Wheeler, Q. (Eds.), *Species Concept and Phylogenetic Theory. A Debate*, New York: Columbia University Press, pp. 179–184.
- Montoya, J. M. and Solé, R. V. (2002) 'Small World Patterns in Food Webs', *Journal of Theoretical Biology* 214, pp. 405–412.
- Nathan, M. (2014) 'Molecular Ecosystems', *Biology and Philosophy* 29(1), pp. 101–122.
- Noe, R. and Hammerstein, P. (1994) 'Biological Markets: Supply and Demand Determine the Effect of Partner Choice in Cooperation, Mutualism and Mating', *Behavioral Ecology and Sociobiology* 35(1), pp. 1–11.
- Nowak, M. A., Tarnita, C. E. and Wilson, E. O. (2010) 'Evolution of Eusociality', *Nature* 466, pp. 1057–1062.
- Odling-Smee J., Laland K. and Feldman M. (2003) *Niche Construction. The Neglected Process in Evolution*, Princeton, NJ: Princeton University Press
- Okasha, S. (2006) *Evolution and the Levels of Selection*, New York: Oxford University Press.
- Pepper, J. W. and Herron, M. D. (2008) 'Does Biology Need an Organism Concept?', *Biological Review of the Cambridge Philosophical Society* 83, pp. 621–627.
- Pimm, S. L. (2002) *Food Webs*, Chicago, IL: University of Chicago Press.
- Pradeu, T. (2010) 'What Is an Organism', *History and Philosophy of Life Sciences* 32(2/3), pp. 247–267.
- Queller, D. C. and Strassmann, J. E. (2009) 'Beyond Society: The Evolution of Organismality', *Philosophical Transactions of the Royal Society London B Biological Sciences* 364, pp. 3143–3155.
- Quine, W. V. O. (1948) 'On What There Is', *Review of Metaphysics* 2(5), pp. 21–36.
- Scadden, D. (2006) 'The Stem-cell Niche as an Entity of Action', *Nature* 441(7097), pp. 1075–1079.
- Shorter, J. and Lindquist, S. (2005) 'Prions as Adaptive Conduits of Memory and Inheritance', *Nature Reviews Genetics* 6, pp. 435–450.
- Simon, H. (1980) *The Sciences of the Artificial*, Cambridge, MA: MIT Press.
- Slater, M. and Yudell, Z. (2017) *Metaphysics and the Philosophy of Science*, New York: Oxford University Press.
- Sober, E. and Wilson, D. S. (1998) *Unto Others: The Evolution and Psychology of Unselfish Behavior*, Cambridge, MA: Harvard University Press.
- Strassmann, J. E. and Queller, D. C. (2010) 'The Social Organism: Congresses, Parties, and Committees', *Evolution* 64, pp. 605–616.
- Strawson, P. (1959) *Individuals: An Essay in Descriptive Metaphysics*, London: Methuen.
- Turner, J. S. (2000) *The Extended Organism: The Physiology of Animal-Built Structures*, Cambridge, MA: Harvard University Press.
- Umesono, Y. and Agata, K. (2009) 'Evolution and Regeneration of the Planarian Central Nervous System', *Development, Growth and Differentiation* 51, pp. 185–195.
- van Baalen, M. (2014) 'Adaptation, Conflicting Information, and Stress', *Biological Theory* 9(4), pp. 431–439.
- Walsh, D. M. (2010) 'Not a Sure Thing: Fitness Probability and Causation', *Philosophy of Science* 77, pp. 141–171.
- West, S. A. and Gardner, A. (2013) 'Adaptation and Inclusive Fitness', *Current Biology* 23, pp. R557–R584.
- West, S. A., Griffin, A. S. and Gardner, A. (2008) 'Social Semantics: How Useful has Group Selection Been', *Journal of Evolutionary Biology* 21, pp. 374–385.
- Wilson, J. (1999) *Biological Individuality: The Identity and Persistence of Living Entities*, Cambridge: Cambridge University Press.

## 4 What is the problem of biological individuality?

Eric T. Olson

In Anne Sophie Meincke and John Dupré, eds, *Biological Identity: Perspectives from Metaphysics and the Philosophy of Biology*, Routledge 2021.

### 4.1 Biological individuals

One of the fundamental questions of biology is how to characterise life. We know, for example, that life involves complex structures that are intrinsically unstable and in need of constant renewal. And this renewal comes from within. Life builds and maintains itself: we don't need to take it to the shop for repairs. We know that this building and maintenance is accomplished through metabolism: life takes in materials, imposes a characteristic form on them, then expels them in a less ordered state. We know that life grows and reproduces, making more life of the same sort. This too is not merely a result of external circumstances: fires proliferate as temperature, fuel, and oxygen allow, but life expands according to an internal plan. These and other features distinguish the living from the non-living world.

But knowing what life is raises a second large question: how does it divide into units? Life does not simply occur here and there, like wind or gravity. It comes in ecosystems, species, herds, lineages, generations, organisms, and cells.<sup>1</sup> For there to be life is for there to be living things, just as for there to be movement is for there to be things that move. The jargon calls these units *biological individuals*.

The concept of a biological individual plays a vital role in the life sciences. A mature Portuguese man-of-war looks just like a single large animal, but the way it develops leads most zoologists to consider it a colony of many small ones. This is a claim about how life divides into organisms. The theory of evolution, to take another example, is about the spread of traits or genes through populations – their change in frequency from one generation to the next. And the very idea of a generation involves a distinction between parents and their offspring, and thus a division of life into individuals (Clarke 2010, p. 313, Godfrey-Smith 2015). For that matter, whether a gene becomes more or less frequent depends on how many individuals it occurs in. The number of occurrences within a single organism doesn't count towards its frequency: you don't spread your genes in the evolutionary sense by putting on more cells with those genes, but only by producing more organisms.<sup>2</sup> This implies that biological individuals must be countable (Clarke 2010, p. 313, Godfrey-Smith 2014, p. 67).

Knowing what life is and where it occurs does not tell us what individuals it consists of. We could know which spacetime regions contain life and why, yet have no idea how to distinguish colonies from single organisms, parents from offspring, or reproduction from growth.

The question of how life divides into units is called the *problem of biological individuality*. My interest is not in solving the problem, but in stating it. What exactly is the question that theories of biological individuality are supposed to answer? What would count as a solution to the problem? Actual statements of the problem have been vague and incomplete. What's more, proposed theories of biological individuality are not detailed enough to solve the problem even if they are correct. In many cases they have entirely the wrong form. The root of these troubles, I believe, is that philosophers of biology have not recognised the metaphysical claims presupposed in the discussion. These claims are implicit not only in proposed solutions to the problem, but in the statement of the problem itself. Making these claims explicit will enable us to see better what the problem is and what form a solution to it would need to have.

#### 4.2 Boundary-drawing and its limitations

I will focus on organisms and leave aside other biological individuals. Organisms are the units that develop from a single cell in ontogeny, that fall ill and fight infections, that engage in reproduction, and that occupy the roles in ecological systems (Clarke 2010, p. 313). I take them to be the paradigmatic individuals in biology. But nearly everything I say will apply equally to others.

Thinking of the problem of biological individuality as how life divides into organisms suggests that it has to do with boundaries within the regions where life is present: boundaries around organisms or between one organism and another. These boundaries need not be precise – some atoms might be neither definitely parts of me nor definitely not, for example – but there could not be an organism with no boundary at all.

We can ask about organisms' spatial boundaries – their size and location at a given time – as when we ask whether we have a single complex organism or a colony. Or we can ask about their temporal boundaries: when they begin and end. What counts as a generation has to do with the temporal boundary between parent and offspring. Sometimes both questions operate at once: to ask whether a trait has increased in frequency is to ask both about the temporal boundaries between organisms of different generations and about the spatial boundaries between organisms within each generation.

But not all questions of biological individuality are about the location of boundaries. Many animals have symbiotic bacteria in their gut that are needed for healthy digestion and tolerated by their immune system. We can ask whether this makes them parts of the animal (giving it smaller organisms as parts), or whether the gut is simply a habitat for them, so that they

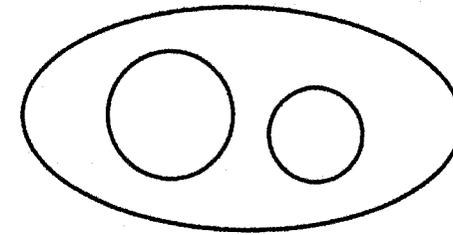


Figure 4.1

and the animal form a colony. This is a question about how life divides into organisms, but it's not about the location of boundaries. Knowing where the boundaries lie – the boundary of each bacterium and the outer boundary of the animal – would not tell us whether the bacteria are parts of the animal. Learning whether they are parts of it would not enable us to draw any further boundary. It would only tell us whether the boundary of each bacterium is also part of the boundary of the animal: whether the bacteria, like grains of sand, exclude the animal from their location.

We can also ask whether my gut bacteria themselves make up or compose an organism – where by definition some things, the *x*s, compose something *y* just if each of the *x*s is a part of *y* and every part of *y* shares a part with one or more of the *x*s.<sup>3</sup> This is analogous to asking whether the members of an ant colony compose a “superorganism” (Wilson and Sober 1989). These too are questions about individuality, but not about where boundaries lie. They are about whether the boundary of each individual insect or bacterium (when they're not touching) is also part of the boundary of a larger organism.

So we could know the location of all the boundaries around organisms without knowing what organisms there are – that is, which things they are boundaries of. Suppose Figure 4.1 shows all the boundaries around organisms. (That it shows just two dimensions is due to my department's limited art budget. Imagine it showing three dimensions of space and one of time.) Suppose life is present throughout the oval region and nowhere else. What would this tell us about what organisms there are?

It would tell us that there are at least two: one whose outer boundary is oval and one located entirely within it. But it would not imply that there are only two. In fact it would not tell us the boundaries or the size of any organism. Given our assumptions, the information in the diagram is consistent with these descriptions:

- There is an organism occupying the whole of the oval region apart from the two round regions, an organism occupying the larger round region,

and an organism occupying the smaller round region: three in all. (By “occupy” I mean “exactly occupy”. A thing occupies a region when its boundaries are the same as the region’s.)

- There is an organism occupying the whole of the oval region including the round regions, and two round organisms. In this case, in contrast with the first, the round organisms are parts of the oval organism.
- There is an organism occupying the whole of the oval region apart from the larger round region, and two round organisms. The smaller round organism but not the larger one is a part of the oval organism.
- As before, only the larger round organism but not the smaller is a part of the oval organism.
- There is an organism occupying the whole of the oval region apart from the round regions and an organism occupying the sum of the round regions that is not a part of the oval organism: two in all. There are no round organisms.
- There is an organism occupying the whole of the oval region and an organism that is a part of it occupying the sum of the round regions.

There will be more possibilities if an organism occupying the sum of the round regions could have round organisms as parts, giving three “levels” of organisms: round, composed of several round ones, and oval. In that case there could be an oval organism, an organism occupying the sum of the round regions, and two round organisms. Any of the smaller organisms may or may not be parts of the oval one.

This shows that knowing the boundaries around organisms barely begins to tell us what organisms there are. The problem of biological individuality is not just about where these boundaries lie, or what determines them, but also about what determines which regions are occupied by an organism. Given that things are located where their parts are, this is more or less equivalent to asking what makes things parts of a single organism.<sup>4</sup>

The situation will be yet more complicated if (as many philosophers believe) two things can occupy the same spacetime region and be made up of the same matter throughout their careers. Jack Wilson takes organisms to come in different kinds: there are, among others, *genetic individuals*, defined in terms of genetic homogeneity and common ancestry, and *functional individuals*, defined in terms of causal integration (1999, pp. 86–99). A genetic and a functional individual can coincide exactly in both space and time (1999, p. 47). But nothing can belong to both kinds, as they entail different modal properties, such as the conditions in which they would continue existing. In that case, even knowing which regions are occupied by organisms would not tell us what organisms there are. There could be any number of them in the diagram.

To simplify matters I will set this possibility aside. That enables us to state the problem of biological individuality as asking what determines which spacetime regions are occupied by organisms.<sup>5</sup> To say that something

determines what regions are occupied by organisms is to say that what regions these are follows from this something together with the “underlying” facts about non-organisms that the discussion takes for granted, such as the distribution of matter and the laws of nature. A theory of biological individuality will be a principle or set of principles answering this question. Given our simplifying assumption, this will also tell us what determines how many organisms there are and what distinguishes one from another.

### 4.3 The problem of psychological individuality

The problem of biological individuality is presumably one problem of individuality among others. There is individuality in other phenomena besides life. Psychology, for example – *mind* in the mass-noun sense – does not simply occur here and there, like wind or gravity. It comes in units. The most important units are individual mental subjects: thinking or conscious beings, *minds* in the count-noun sense. For there to be thought or consciousness is for there to be thinking or conscious beings. So we should expect there to be a question of how mind divides into mental individuals analogous to the question of how life divides into organisms.

And in fact there are puzzles about psychological individuality very like those concerning biological individuality: about what mental individuals there are and what distinguishes one from another. We can know where mind is present without knowing what mental individuals there are. In cases of conjoined twinning, multiple personality, or commissurotomy, for example, we know that there is consciousness, but there is dispute over the number of conscious beings (Puccetti 1973, Olson 2003, 2014, Campbell and McMahan 2010). There is also dispute over the temporal boundaries of mental individuals, manifest in the literature on personal identity over time. There are even views analogous to Wilson’s, saying that distinct mental individuals can occupy the same spacetime region (Baker 2000, p. 103, Hawthorne and McGonigal 2008). The parallels between the two problems will be instructive.

### 4.4 “Defining the biological individual”

I have argued that the problem of biological individuality is the question of what determines the spatiotemporal locations of organisms. An answer will tell us what determines how many there are and what distinguishes one from another. The problem of psychological individuality is analogous.

But philosophers of biology have stated the problem in a very different way. They take it to be what it is to be an organism, as opposed to a non-organism: to “define the biological individual”.<sup>6</sup> By their lights, a theory of biological individuality would be a completion of the formula:

$x$  is an organism *iff*... $x$ ....

(It may need some sort of necessity operator to ensure that it's not true only by accident: even if every organism contains potassium, that's no part of what it is to be an organism and should not appear in the definition.)

This is puzzling. How could an account of what it is to be an organism tell us what determines an organism's spacetime location, or how many there are, or what distinguishes one from another? An account of what it is to be an F does not generally tell us what determines the locations of Fs. Suppose we define "artefact" as "object fashioned by an intelligent being for a purpose". It's hard to see how this, by itself, could tell us anything at all about what determines an artefact's location or how many there are. Yet that doesn't make the definition wrong.

Think of the problem of psychological individuality again. No one expects a definition of "mental individual" to tell us what determines the spatiotemporal locations of mental individuals or how many there are. You and I might agree perfectly about what it is to be a mental individual and about all the underlying facts concerning the distribution of matter and the like, yet disagree wildly about the boundaries of mental individuals and even whether there are any at all.<sup>7</sup> Most disputes about psychological individuality have nothing to do with the definition of anything.

Though philosophers of mind have said rather little about psychological individuality in general, they've written volumes about the special case of people (or "persons"). Most say that to be a person, as opposed to a non-person, is to have certain special mental properties, such as intelligence and self-consciousness. Locke, for instance, famously defined "person" as "a thinking intelligent being that has reason and reflection, and can consider itself as itself, the same thinking thing in different times and places" (1975, p. 335).

It's easy to see that such definitions cannot tell us what determines a person's spatiotemporal location.<sup>8</sup> Suppose Plato's being a person amounts to his being intelligent and self-conscious. That leaves entirely open when he began and ended. His having those properties in his prime is consistent with his beginning at fertilisation, at birth, or when he was first intelligent and self-conscious. Nor does the definition imply that a person comes to an end when he ceases to be intelligent and self-conscious: for all it says, Plato might have continued to exist after his death as a corpse. All we can infer is that he was not then a person. (Unless he was a person essentially; but that does not follow from Lockean definitions.) Or at least this is so if we take " $x$  is a person *iff*  $x$  is intelligent and self-conscious" to mean " $x$  is a person at time  $t$  *iff*  $x$  is intelligent and self-conscious at  $t$ " – as all those who offer such definitions do. Lockean definitions do not even rule out a person's arbitrarily ceasing to exist without any interruption in her intelligence or self-consciousness.<sup>9</sup> They allow that each of us might come to an end right now and be imperceptibly replaced by an exactly similar but numerically different person.

Nor do they tell us anything about people's spatial boundaries. Most of us take Plato to have extended just as far as the surface of his skin. But even if that's right, it doesn't follow from his intelligence and self-consciousness, or from any other proposed definition of "person" or "mental individual". Those who think Plato was smaller – brain-sized, perhaps (Puccetti 1973, Hudson 2007) – or larger – as the "extended self" thesis has it (Clark and Chalmers 1998, p. 18, Olson 2011) – can and usually do accept a Lockean definition of personhood. For that matter, so can those who think that Plato was entirely immaterial and had no spatial location at all.

Lockean definitions of "person" are no more help in thinking about what determines how many people there are at any one time: whether there are one or two in cases of conjoined twinning, for example. They don't tell us what distinguishes one person from another. In this respect they're just like my definition of "artefact". How, then, could it be any different with definitions of "organism"?

Here is another way of expressing my puzzlement. No proposition about the number of organisms follows logically from any proposition about what it is to be an organism together with propositions about non-organisms (a description of the "underlying facts" about the distribution of matter and laws of nature, say). The claim that to be an organism is to be F can tell us nothing about what organisms there are unless we know something about what Fs there are: what material things with biological properties are *candidates*, so to speak, for being organisms. A definition of "organism" cannot solve the problem of biological individuality without a principle about the existence of the candidates to which it is to be applied. And the definition itself cannot provide such a principle.

The point has nothing to do with the details of the definition. It makes no difference, for example, if the definition of "person" can be known a priori, whereas an adequate account of what it is to be an organism must incorporate empirical discoveries. That no proposition of the form "there are  $n$  Gs" follows from any proposition of the form " $x$  is G *iff*  $x$  is F" (together with a description of the underlying facts) is a simple matter of logic.

Why have philosophers of biology not noticed this or been troubled by it? The answer, I think, is that they have simply assumed the existence of the candidates (the Fs). To work out whether a Portuguese man-of-war is a single organism, it may seem that we need only know whether it satisfies the definition of "organism". If it doesn't, it's a colony of smaller polyps. But this presupposes that there *is* something composed of the polyps, which satisfies either the definition of "organism" or the definition of "colony". This is assumed to be one of the "underlying facts" taken for granted in the discussion. But it is a substantive metaphysical claim. Philosophers of biology have assumed a number of claims about the ontology of material things, often without realising it. Given these claims, a definition of "organism" really could be a theory of biological individuality. Yet the claims are

never stated. What's more, they are highly controversial among metaphysicians. And they have important implications about what form a definition of "organism" needs to have in order to count as a theory of biological individuality – implications that have not been recognised. I will show this using some proposed theories of biological individuality.

#### 4.5 A test case: the genetic theory

Let's examine an account of what it is to be an organism and see what would have to be the case for it to be a theory of biological individuality. We need one with enough detail to enable us to see what follows from it. Its plausibility is less important. (It's hard to find an account of biological individuality that is both detailed and plausible. The more detail you add to any theory, the more objectionable consequences you get.) Consider, then, the view that an organism is an entity with a uniform genotype.<sup>10</sup> I take this to mean a thing composed of *cells* with the same genotype. It's not clear what it could mean to speak of the genotype of fluids that are not parts of cells, such as blood plasma. A thing composed of certain entities is a *mereological sum* of those things. So the proposal is that an organism is a sum of cells with the same DNA.

The metaphysician's term "sum", and its synonyms "fusion" and "aggregate" are sometimes understood in different ways, but on the standard definition, "sum of the *x*s" means simply "thing composed of the *x*s" (where, again, the *x*s compose *y* just if each of the *x*s is a part of *y* and every part of *y* shares a part with one or more of the *x*s). This does not imply that a sum of things is *essentially* composed of those things, or rule out a sum's being composed of different things at different times (van Inwagen 2006). Nor does it imply that the mere existence of certain things suffices for there to be a sum of them: that's a substantive metaphysical claim (more on this later). The definition also says nothing about how a sum's parts must relate to one another. For all it says, things might compose a sum only if their parts interact in a special way – the way characteristic of biological life, for instance (van Inwagen 1990a, Section 9). Mereological sums, on the standard definition, are not things of a special kind. Everything is a sum.

I use the technical term "sum" because the ordinary word "collection" is notoriously slippery. "The collection of the *x*s" can mean either the *x*s in the plural or a single thing that the *x*s compose, obscuring this vital distinction. A sum of things is emphatically something distinct from any of those things (except in the degenerate case in which there is only one of them: because everything is a part of itself, everything is a sum of itself).

Do not confuse sums with *sets* in the mathematical sense. There are deep formal differences between sets and sums. The set whose only member is *x* is distinct from *x* itself, but again the sum of *x* is just *x*. And although the sets  $\{x, y\}$ ,  $\{x, \{x, y\}\}$ ,  $\{\{x, y\}, y\}$ , and so on are all different, there is no analogous

distinction among sums. Nor do sums have anything analogous to the null set that is a subset of all sets. No one thinks that organisms are sets.

The claim, then, is that an organism is a sum of cells (that is, a thing composed of cells) with the same genotype. Presumably the cells must also have a common ancestry with that genotype: if, by sheer coincidence, some cells in another galaxy were genetically identical to mine, no one would say that all these cells together composed an organism, scattered across millions of light-years. I will ignore worries about how the ancestry requirement should be specified, or what it is for cells to have the same genotype (Dupré 2014, p. 10). Call this the *genetic theory* of biological individuality.

Almost no one thinks it's a *good* theory. It has the absurd implication that red blood cells, having no DNA, can never be parts of an organism. Nor can atoms that are not parts of cells. And although multicellular organisms commonly contain cells with mutant genes, the genetic theory implies that such cells are never parts of them, but are themselves organisms. There are many further objections (see e.g., Santelices 1999, p. 152). But even the critics of the genetic theory usually take it to be a genuine theory of biological individuality. It has the right form. It answers the questions that the problem of biological individuality consists in, even if it answers them wrongly. (Compare: "Ten" is an answer to the question, "How many English home counties are there?", though a wrong one; "Bananas" is not an answer at all.)

To see what follows from the genetic theory, we need a more precise statement of it. It is usually put in a loose and informal way, and this has discouraged questions about exactly how it would solve the problem of biological individuality. For example, it's no good saying

*x* is an organism *iff* *x* is composed of cells with the same genotype and the right ancestry.

Everyone takes the genetic theory to imply that what we call asexual reproduction is not really reproduction at all, but growth: when an amoeba splits, it does not produce two organisms, but merely comes to be composed of two detached parts (Wilson 1999, pp. 87f., Godfrey-Smith 2014, p. 69). Yet this does not follow from the statement just given. If anything, the statement implies that the two free-swimming fission products are themselves organisms, as each is a sum of cells with the same genotype and the right ancestry. (Remember that everything is a sum of itself.) So the splitting must increase the number of organisms. It also counts my left thumb as an organism, composed as it is of cells with the same genotype and the right ancestry – an implication that no one would attribute to the genetic theory.

Not just any sum of cells with the right genotype and ancestry should count as an organism, but only one that is *maximal* – that is, not a part of any larger such sum. But although this is an improvement, it too lacks the implications ascribed to the genetic theory. It may seem to imply that the

cells resulting from amoebic fission are not organisms, as they're not maximal sums of homogeneous cells, but parts of a larger such sum composed of the two cells. But this is so only on the assumption that there *is* something composed of those cells. Otherwise each cell will itself be a maximal sum of homogeneous cells and thus an organism. Likewise, the account rules out my thumb's being an organism only given that there is something composed of its cells together with my other cells. And nothing in the genetic theory implies either of these claims about composition. Call this the *composition problem*.

Let me say a brief word on this point. It is no tautology that whenever there are two things – even two things of the right sort arranged in the right way – there is a third thing that they compose: a sum of them. No principle of logic can take us from the proposition that there are two cells, for example, however arranged, to the proposition that there is a thing that is not a cell, but has two cells as parts. That requires a claim about when smaller things compose something bigger. And such claims are a subject of metaphysical debate.

You may wonder how anyone could accept that there is an oxygen atom and two hydrogen atoms attached to it by covalent bonds, yet deny that there is a water molecule. Isn't a water molecule by definition an oxygen atom and two hydrogen atoms so attached? But a molecule is not some atoms attached in a certain way. It's something that is not an atom, but rather *made up of* atoms.<sup>11</sup> To say that there is a crowd of people may be only a loose way of saying that there are people crowded together, but to say that there is a molecule is not just a loose way of saying that there are atoms appropriately attached. And the same goes for organisms: a dog is not some cells related in a canine way, but something that is not a cell. A dog is (according to the genetic theory) a thing composed of cells, and cells are not composed of cells. At any rate this is presupposed, as we saw earlier, in the claim that questions of biological individuality are questions about which entities satisfy the definition of "organism". Such a definition says what it is for *a thing* to be an organism. It takes the form "*x* is an organism *iff*...*x*...", where "*x*" is a singular variable. Only a thing composed of many cells can satisfy it (unless it is a unicellular organism). The cells themselves cannot. Definitions alone cannot bridge the gap from atoms to molecules, or from cells to multicellular organisms.

I will return to the composition problem in the next section. But there is another reason why the genetic theory as stated lacks the right implications. Suppose the two products of an episode of amoebic fission do compose something, and the theory counts that thing as an organism. Still, nothing in the theory implies that that organism is the original parent. For all it says, fission may destroy the parent and create a new organism composed of the two resulting cells. Although this would not increase the number of organisms, it would create a new generation and thus count as reproduction and not growth. No one would take that to be compatible with the genetic theory.

More generally, the theory says nothing about what determines an organism's temporal extent. It allows an organism to cease to exist arbitrarily without any genetic change, and be instantly replaced with a new and numerically different organism.

Nor does it rule out an organism's surviving a genetic change. It tells us only what cells an organism must have at any given time. Or at least this is so if it's understood as saying what it is for something to be an organism at a time (just as Lockean definitions say what it is for something to be a person at a time):

*x* is an organism at *t* *iff* *x* is composed, at *t*, of cells with the same genotype and the right ancestry, and *x* is not a part, at *t*, of any larger such entity.

This says at most that an organism must be composed of homogeneous cells at each time when it exists.

In fact it says even less: only that an organism must be composed of homogeneous cells at each time *when it is an organism*. It doesn't rule out a thing's being an organism at one time and a non-organism at another, just as Lockean definitions don't rule out a thing's being a person at one time and a non-person at another. It allows an organism to become composed of heterogeneous cells, if this happens when it's no longer an organism. (Unless an organism must be an organism essentially. But that doesn't follow from the genetic theory.) The genetic theory as stated does not say what determines the spatiotemporal region an organism occupies, or where one leaves off and another begins, for the same reason that Lockean definitions don't say this about people.

The genetic theory is clearly intended to avoid these shortcomings by specifying what cells an organism is composed of not merely at a given time, but without temporal qualification. It should define an organism as a maximal sum of homogeneous cells that exist at *any* time. And it should say not what it is to be an organism at a time, but what it is to be an organism *simpliciter*. It should look like this:

*x* is an organism *iff* *x* is composed of cells with the same genotype and the right ancestry – whatever their spacetime location – and *x* is not a part of any larger such entity.

Qualifications such as "at a time" don't come into it. This rules out a thing's being an organism at one time and a non-organism at another (though not a thing's being an organism in some possible worlds and not in others).

This looks more like the right sort of thing. It seems to imply, as the genetic theory should, that no new organism comes into being when an amoeba divides; rather, the original amoeba continues to exist in divided form.

The parent cell and its daughters, having the same genotype and the right ancestry, must all be parts of a single organism that persists through the division. Most of the things we ordinarily call amoebas – individual free-swimming cells – are not organisms, but parts of a larger organism composed of many cells scattered across space and time. Or at least this is so on the assumption that all amoebic cells with the same genotype compose something – that is, assuming an appropriate solution to the composition problem.

#### 4.6 Temporal parts and material plenitude

So construed, the genetic theory implies that organisms have their parts without temporal qualification. But that's rather puzzling. Do I not have different parts at different times? Few of the cells that made me up in 1970 are parts of me now, and the atoms that composed me then are now scattered to the four corners of the earth. If I have my parts without temporal qualification, these cells and atoms must somehow be both parts of me and not parts of me. How could that be? How, if parthood is timeless, can things *change* their parts?

Metaphysicians usually answer by appealing to *temporal* parts. A temporal part of something is a part of it that takes up “all of that thing” whenever the part exists. Socrates's nose is a part of him, but not a temporal part, as it doesn't take up all of him while it exists. It's too small, spatially speaking. His adolescent portion, if we may so speak, would be a temporal part. His temporal parts are exactly like him when they exist. They eat and drink and ask awkward questions. They differ from him only in their shorter temporal extent.

Friends of temporal parts say that talk of temporary or temporally qualified parthood is a loose manner of speaking (Sider 2001, p. 57). For an atom to be a part of me now is for its current temporal part to be a part, without temporal qualification, of my current temporal part. More generally:

$x$  is a part of  $y$  at  $t$  iff the temporal part of  $x$  located at  $t$  (exactly located then) is a part of the temporal part of  $y$  located at  $t$ .

Strictly speaking, then, I'm not composed of atoms – no atom is a part of me without temporal qualification – but of temporal parts of atoms (roughly those located entirely within my spatiotemporal boundaries). And on the genetic theory I am also composed of temporal parts of cells. If we call a temporal part that exists for only an instant (or if there are no instants, a very brief period) a “stage”, the genetic theory should say that an organism is a maximal sum of cell-stages with the same genotype and the right ancestry.

This implies that organisms, atoms, cells, and presumably all persisting things are composed of temporal parts. Or better, of *arbitrary* temporal parts. For every period when I exist, long or short, there is a temporal part

of me located then and only then. This follows from the principle about temporary parthood just given: because atoms can be parts of me for any period, both they and I must have temporal parts of any length.

That all persisting things are composed of temporal parts (and that things have their parts without temporal qualification) is highly contentious.<sup>12</sup> The genetic theory presupposes a second contentious metaphysical claim as well, namely *unrestricted composition*. This is the view that for any things whatever, there is something composed of them: a sum.<sup>13</sup> If some entities did not compose anything, there would be no guarantee that all the cells (or cell-stages) of a given genotype composed anything, or even any apparent reason to suppose it. Think of all the amoebic cells (or cell-stages), scattered across space and time, with the same genotype as the one on this microscope slide, and the right ancestry. What reason could there be to suppose that there is a vast, disconnected material thing composed of those cells, other than the thought that *any* things, whatever their nature or arrangement, must compose something?

But unless those cells do compose something, they cannot compose an organism, even according to the genetic theory. If there is no sum of them at all, there is none that can satisfy the definition of “organism”. The theory would *allow* that any amoebic cells (or cell-stages) with the right genotype and ancestry that are not parts of any larger sum of such cells compose an organism. But it would also allow that some such cells compose organisms and others don't. It would even allow that none of them do (except in the trivial sense that each composes itself), and that each individual cell is itself an organism. The theory says, in effect, that anything such cells compose is an organism. But it doesn't say whether they do compose anything.

No one discussing the genetic theory considers these possibilities. Both its advocates and its critics assume that the cells (or cell-stages) in question compose something. Their disagreement is about whether that thing is an organism or a non-organism. Debates over biological individuality are about classification: about assigning individuals to sorts. That follows from their statement of the problem as asking for a definition of “organism”. Questions about what individuals there are – about which homogeneous cells or cell-stages compose anything, for example – do not arise. This can only be because the debate presupposes a “generous” account of composition: one implying that any entities that anyone might take to compose an organism or other biological individual compose something or other. And the only such account that has ever been proposed is unrestricted composition.

Assuming unrestricted composition thus avoids the composition problem. It rules out the possibility that the two cells resulting from an amoeba's division are each maximal sums of homogeneous cells and thus organisms themselves. And it rules out my left thumb's being an organism. It does so by implying that each of these entities is a part of a larger sum of homogeneous cells.

The temporal-parts ontology and the doctrine of unrestricted composition are nearly always held together.<sup>14</sup> Their conjunction implies that every matter-filled spacetime region is occupied by a material thing.<sup>15</sup> As Quine once put it, a physical object “comprises simply the content, however heterogeneous, of some portion of space-time, however disconnected and gerrymandered”.<sup>16</sup> Call this the *principle of material plenitude*.

#### 4.7 The functional-integration theory

I have argued that both friends and enemies of the genetic theory presuppose important metaphysical claims: that biological individuals are composed of temporal parts and that any cell-stages whatever compose something. The debate is about which sums of cell-stages are organisms and which are not, never about whether the sums exist in the first place. The only systematic principle that would secure these claims, or at least the only one that anyone has ever actually proposed, is the principle of plenitude. All parties to the debate take it for granted.

In a way this is not surprising. As we saw earlier, no claim about what it is to be an organism (together with propositions about atoms, cells, and the like) can entail a claim about what organisms there are or how many. To reach a conclusion about what organisms there are from the premise that all and only organisms are F, we need to know what Fs there are. We need an account of the “candidates” to which the definition can be applied. The principle of plenitude supplies this. But any such account will be independent of a definition of “organism”. It follows that no definition can be a theory of biological individuality by itself, but at best in conjunction with a metaphysical principle about what material things there are. Or, to put it differently, a definition can be such a theory only if some such metaphysical principle is presupposed.

The point has nothing to do with the genetic theory in particular, but is a simple matter of logic. Consider the more appealing view that an organism is a sort of “functionally integrated whole” (e.g., Sober 1993, pp. 150–153, Wilson 1999, p. 89, Pradeu 2010, p. 252). What makes things parts of the same organism is not any sort of similarity, but something to do with their causal interrelations: metabolic and immune activities, for instance.

Suppose we could specify these activities at the level of atoms. (Specifying them at the level of cells would be easier, but a definition of “organism” based on such a specification would imply that organisms are composed of cells and cannot include extracellular fluids.) Then we could say that an organism is a sum of atoms, each of which interacts in this way with every other – or better, any two of which either interact in this way or stand to each other in a chain of such interactions. Call such atoms *I-related*. An organism would then be a sum of I-related atoms. Or rather a maximal such sum: one that is not a part of any larger one. Otherwise my left thumb would count as an organism.

(That is presumably why organisms are called integrated *wholes*.) Call this the *functional-integration theory* of biological individuality.

Does it tell us what determines which spatiotemporal regions are occupied by organisms? Take the spatial case first. Suppose my symbiotic gut bacteria are I-related to my animal cells because my immune system interacts with both in the same way.<sup>17</sup> More precisely, the atoms composing these bacteria and the rest of my atoms are I-related. Does the proposal imply that those atoms compose an organism? Well, only if they compose something at all. Otherwise they will not compose a maximal sum of I-related atoms, even though they are all I-related to each other and not to any other atoms – maximally I-related, we might say. If instead my “animal” atoms that are not parts of my gut bacteria compose something, *it* will be a maximal sum of I-related atoms, even though those atoms are not maximally I-related. In that case the functional-integration theory will imply that this smaller entity is an organism and there is none composed of it together with my gut bacteria. There will be no such organism because there is no such entity at all.

No one would take the functional-integration theory to have this consequence. Everyone assumes that maximally I-related atoms compose a maximal sum of I-related atoms, which the theory classifies as an organism. But for this to be the case, such atoms must compose something. What could ensure this? The most obvious answer is, again, that any atoms whatever compose something, no matter what their nature or arrangement. Those discussing biological individuality simply don’t worry about when atoms or other small things compose something. This insouciance is appropriate only on the assumption of unrestricted composition (or some other “generous” ontology of material things).

Does the theory tell us what determines organisms’ temporal extent? Not if it says only what it is for something to be an organism at a given time – that something is an organism at a time just if it is composed, at that time, of atoms that are then I-related and it is not then a part of any larger such sum. That would allow that an organism might arbitrarily cease to exist without any interruption of its metabolic or immune activity and be replaced with a new organism. Or it might continue after all such activity stops and cannot be restarted: the theory would imply only that it was not an organism then. It might carry on after its death as a former organism, just as graduates become ex-students.

Like the genetic theory, the functional-integration theory is clearly meant to tell us not which parts an organism is composed of at a given time, but which it is composed of *simpliciter*: that an organism is a maximal sum of I-related entities that exist at any time. As we saw in discussing the genetic theory, this implies that organisms are not composed of atoms, but of temporal parts of atoms. So the functional-integration theory too presupposes that atoms and other persisting objects have temporal parts – arbitrary

temporal parts in fact, as an atom can be a part of an organism for any period. Combining this with unrestricted composition yields the principle of material plenitude.

Similar remarks will apply to any theory of biological individuality that takes the form of a definition. It cannot do its job without a generous ontology of material things.

#### 4.8 What a definition needs to say

Philosophers of biology never argue for the principle of plenitude or any other account of what material things there are. They rarely even mention the point.<sup>18</sup> For the most part they appear unaware that their discussions of individuality presuppose such a principle. My purpose is not to criticise them for this or to argue against the principle, but only to show that this is an unavoidable feature of any theory of biological individuality taking the form of a definition.

This matters because the principle of plenitude (or any other generous ontology) implies that not just any definition of “organism” can be a theory of biological individuality, right or wrong, but only one having a special form. The definition must say what determines an organism’s spatiotemporal boundaries. This is because a theory of biological individuality needs to say what distinguishes a colony from a single complex organism, copies of a gene in one organism from copies in many organisms, and members of different generations. It needs to say what determines how many organisms there are and what distinguishes one from another. And the principle of plenitude makes this task more difficult by providing an awkward surplus of things with biological properties – of candidates, so to speak, for being organisms.<sup>19</sup> It implies that my office contains a vast number of entities made up entirely of living matter: me; my left thumb; my northern half; sums of a human being and certain dust mites, and of arbitrary portions of man and mite; my current stage; the thing composed of my stages located up to now and yours located thereafter; and so on. No one would take more than a trivial proportion of these things to be biological individuals of any sort. A theory of biological individuality will have to tell us what determines which ones they are – what distinguishes the organisms from the arbitrary pieces of ontological rubbish. To do that, it needs to say what determines the spatiotemporal boundaries of organisms.<sup>20</sup>

I have never seen a definition that does this. Accounts in terms of reproductive capacities, for instance (Clarke 2010, p. 317), or in terms of autonomy and self-sufficiency (Santelices 1999, pp. 152f., Boden 2008), do not say what determines organisms’ boundaries, and thus, given plenitude, which of the many things with biological properties count as organisms. Accounts in terms of the nature of the life cycle, such as the “bottleneck” view characterising an organism as what develops from a single cell (Wilson 1999, pp. 99–101, Clarke 2010, pp. 317f., Dawkins 2016, pp. 334–341), may tell us

when an organism begins, but say little about its other boundaries. These proposals may contribute towards a theory of biological individuality, but they cannot be theories of biological individuality by themselves. They simply have the wrong form.

Even the genetic theory falls short. My best formulation in Section 4.5 implies that any homogeneous cells (or cell-stages) with the right ancestry are parts of a single organism. It follows that if a bramble scratches off some of my skin, I don’t lose any cells. The detached cells remain parts of me. I merely become disconnected. If a violent accident destroys all my cells but one, I still exist (as I am located where my parts are). Almost no one takes the theory to have these consequences. (Wilson is again an exception: 1999, pp. 87f.) As normally understood, it requires an organism’s cells to stand in a special causal relation in addition to their having the right genotype and ancestry – one that does not hold between the cells currently within my skin and those that have been detached. Genetic theories have not specified this relation.

Functional-integration theories seem explicitly designed to solve this problem: they’re all about the causal relations among an organism’s parts. But existing proposals of this kind fall short. Thomas Pradeu’s version, for example, says only that what determines an organism’s temporal extent is “the spatiotemporal continuity of the interactions between components of the being involved” (2012, p. 249). That sounds right, but what follows from it? Spatiotemporal continuity comes in infinite varieties. When an amoeba divides, there is plenty of spatiotemporal continuity between the interactions of the parent’s atoms and those of the atoms composing each daughter cell. But is it the right sort? Does the theory imply that the original amoeba survives the split? If so, are both daughters identical to it (contrary to the transitivity and symmetry of identity, which are theorems of standard logic)? Or does the original become composed of the two daughter cells? If it doesn’t survive, where is the spatiotemporal discontinuity? Without further detail, there’s no saying. Wilson’s account says more (1999, pp. 89–99), but still leaves many questions unanswered.

#### 4.9 Individuality without definitions

I have argued that no definition of “organism” can be a theory of biological individuality on its own, but only in conjunction with a substantive claim about the ontology of material things providing the candidates to which the definition is applied. This claim is rarely stated: it is a hidden assumption that those engaged in debates over biological individuality are often unaware of. And it requires a definition far more detailed than any of those actually proposed.

Let me make one more point. Philosophers of biology give the impression that a theory of biological individuality must take the form of a definition, or at least include one. It needs to complete the formula

(x)x is an organism iff...x....

This is not so. It's possible to say what determines the spatiotemporal locations of organisms without defining "organism". And it can be done without presupposing any metaphysical claim about the existence of the candidates – the values of "x" in the formula. Rather than asking what it is for something to be an organism as opposed to a non-organism, we can ask instead under what circumstances *there is* an organism as opposed to there not being one. Or better, we can ask when things compose an organism. (All philosophers of biology that I know of agree that organisms have parts: they're not mereological simples.) We can try to complete the formula

(ys)( $\exists x$ )x is an organism and the ys compose x iff...the ys....

How are the two formulas different? Well, because the variable "x" occurs on the right-hand side of the first formula, its blanks need to be filled with a condition on organism-candidates – complex material things with biological properties. If we complete it with "x is a maximal sum of I-related atoms", for example, we presuppose that there *are* such sums – that maximally I-related atoms always compose something. Otherwise the theory will tell us nothing about what determines how many organisms there are. It will not imply that there are any organisms at all, even given the "underlying facts" about the distribution of matter and so on mentioned in Section 4.2 – including those about which atoms are maximally I-related. It will not do what a theory of biological individuality is supposed to do. That's why a definition of "organism" needs to be combined with a claim about the ontology of material things, such as the principle of material plenitude (the one most discussions of biological individuality appear to presuppose).

The second formula, by contrast, does not presuppose any metaphysical claim about the existence of the candidates. The variable occurring on the right-hand side, "the ys", ranges not over candidates for being organisms, but over candidates for being their parts: atoms, cells, or the like. Filling in the blanks will specify what nature and arrangement such things need to have in order to compose an organism – as opposed to composing either a non-organism or nothing at all. (By "their nature" I mean their intrinsic properties and by "their arrangement" I mean the spatiotemporal and causal relations they bear to one another and perhaps to their surroundings.) Given that things are located where their parts are (and that composition is defined in terms of parthood), it will tell us what determines which spatiotemporal regions are occupied by organisms.<sup>21</sup>

We might call this an "existential" statement of the problem of biological individuality, and a solution to it an existential theory – as opposed to the "definitional" statement or theory usual in the philosophy of biology. The definitional statement presupposes the existence of organism-candidates and says that an organism is one having the right features. The existential statement presupposes only the existence of smaller things such as atoms,

and says that an organism exists just when those smaller things have the right features.

It's a trivial exercise to derive a definition of "organism" from an existential theory: an organism will be anything composed of entities satisfying the condition got by filling in the blanks in the second formula – atoms related in the right way, as it may be. But such a definition is no part of the theory, and is not needed in order to say what determines the parts of an organism and thus what region one occupies. An existential theory of biological individuality requires no definition of "organism". (Of course, we'll need to know what the word "organism" means in order to understand the theory, just as we need to understand the other words occurring in it. But understanding a word is not the same as knowing its definition.) So we can think of the problem of biological individuality not as what makes something an organism as opposed to a non-organism, but rather as what has to be the case for there *to be* an organism – or more specifically, what nature and arrangement atoms or other things need to have in order to compose one.

If composition is timeless and something is or is not an organism without temporal qualification, such an account will also tell us what determines organisms' temporal boundaries – though as we saw in Section 4.6, that requires persisting things to be composed of temporal parts. Otherwise it will need a separate clause covering persistence – a completion of the formula:

If x is an organism at t and y exists at t\*, then x=y iff...x...t...y...t\*....

The existential statement of the problem is not quite equivalent to the one I gave in Section 4.2: what determines which spacetime regions are occupied by organisms. Knowing what determines which things compose an organism and what it takes for one to persist will tell us what determines its spacetime location. But not vice versa: knowing an organism's location will not tell us what composes it. It won't tell us whether the neutrinos now passing through me are among my parts, for instance. That said, the difference is unimportant. We are unlikely to know the answer to the original question, about organisms' locations, without knowing the answer to the new one, about their parts. We could find out what determines which region an organism occupies by discovering what it takes for things to compose one. It's hard to see how we could discover it in any other way.

In any event, the existential statement of the problem has an important advantage over the definitional statement: it does not presuppose the principle of plenitude or any other controversial metaphysical claim. It requires no independent list of candidates to which the definition can be applied, and makes no tacit assumptions about when atoms or other entities make up larger things. It has no hidden metaphysical commitments. Of course, it will be uninteresting unless there are atoms or other entities whose nature

and arrangement are responsible for the existence of organisms. But this commitment is evident on the surface. Nor is it much disputed.

The existential statement also has the advantage of not presupposing, as the definitional statement does (Section 4.5), that an organism must be an organism throughout its existence. This does not imply the opposite – that something could be an organism at one time and a non-organism at another. That's left open, as it should be.

The definitional statement, by contrast, has no evident advantage over the existential statement. I don't know how much practical difference it would make to discussions of biological individuality if the problem were formulated existentially rather than definitionally. Maybe all parties are happy with the metaphysical presuppositions of the definitional statement – though I doubt it. And adopting the existential statement would remind us that theories of biological individuality need to specify what determines the spatiotemporal boundaries of organisms. By obscuring this fact, the definitional statement makes the problem appear easier than it is. And it's surely better for contentious metaphysical claims to be recognised and open for discussion than tacitly presupposed by the terms of the debate.

### Acknowledgements

I am grateful to Arthur Carlyle, Ellen Clarke, John Dupré, Charles Jansen, Anne Sophie Meincke, Will Morgan, and Karsten Witt for generous comments on earlier versions.

### Notes

- 1 See Dupré and O'Malley (2012) for more examples.
- 2 Bouchard (2008) argues that there are exceptions.
- 3 Most definitions also require the *x*s not to overlap, but we can ignore this. The word "compose" is sometimes used in other, more tendentious ways. I will use it exclusively in the way defined here.
- 4 Godfrey-Smith says the problem is "what collects the parts...of a system into a living individual" (2015, p. 85; see also Sober 1993, pp. 149–153). I will return to the relation between a thing's parts and its location in Section 4.9.
- 5 If an organism can have imprecise boundaries, they may be vague regions, which certain areas are neither definitely parts nor definitely not parts of.
- 6 Clarke (2013, p. 414). See also Santelices (1999), Wilson (1999, p. 1), Pradeu (2010, p. 248), Pradeu (2012, pp. 227, 244), Godfrey-Smith (2014, pp. 66–80), Wilson and Barker (2017, section 2). Clarke says explicitly that the problem is not about organisms' spatiotemporal boundaries (2013, pp. 414f. fn.).
- 7 On the view that there are no mental individuals, see van Inwagen (1990, pp. 72f.), Merricks (2001, chapter 5), Olson (2007, chapter 8).
- 8 Do not confuse Lockean definitions of "person" with Lockean theories of personal identity over time. These theories do say what determines a person's temporal boundaries: it has to do with psychological continuity. But they don't follow from Lockean definitions of "person".
- 9 Shoemaker (1999) disagrees, but his view is unique in this respect.

- 10 This seems to be the thought behind the view that there are "clonal organisms" composed of parts that look like organisms themselves: individual aphids or aspen trees, for example (Janzen 1977, Bouchard 2008, p. 563). But advocates of this view rarely commit themselves to an explicit principle of individuality.
- 11 Van Inwagen (1990a, §§2, 9, 10, 1994); see also the references in note 13.
- 12 See e.g., Thomson (1983), Lewis (1986, pp. 202–204), van Inwagen (1990b), Sider (2001). Some use the language of temporal parts in a less contentious way (e.g., Shoemaker 1984, pp. 74f.). By a "stage" of an organism they mean only a temporal part of its history, which they take to be distinct from the organism. My statement of the genetic theory requires organisms themselves to have temporal parts.
- 13 Advocates include Lewis (1986, pp. 212f.), Sider (2001, pp. 120–139), and Hudson (2007, pp. 223–228); critics include van Inwagen (1990a – the classic discussion of theories of composition) and Merricks (2001).
- 14 Without temporal parts, unrestricted composition rules out a thing's having different parts at different times (van Inwagen 1990a, p. 78, Olson 2007, p. 230). And much of the theoretical work the temporal-parts ontology is designed for requires unrestricted composition (Sider 2001, pp. 120–139).
- 15 Or every "occupiable" region (van Inwagen 1981, pp. 135f., fn. 3). It may be metaphysically impossible for a material thing to occupy a region of fewer than three spatial dimensions, for example.
- 16 Quine (1960, p. 171). Like Quine, I don't mean anything special by "object" or "thing". I use them as completely general count nouns. "*x* is a thing" is equivalent to " $(\exists y)y=x$ ". Everything is, by definition, a thing.
- 17 Pradeu (2010, pp. 259f.), Dupré and O'Malley (2012, p. 224); see Pradeu (2012, p. 248) for further references.
- 18 Wilson is a commendable exception: "all earthly life or any span of it", he says, "can rightly be considered a particular" (1999, p. 61). This seems to mean that any part of the spacetime region where life is present is occupied by a material thing. But even he does not think the claim needs any defence.
- 19 This may be what Hull means when he speaks of "the welter of individuals that clutter our conceptual landscapes" (1992, p. 183).
- 20 It needn't be completely precise. Material plenitude implies that many beings differ from me only trivially, by a few atoms or milliseconds. That's not the problem here. We can count these things as if they were one (Lewis 1993). It's such things as my thumb and my first half that the theory needs to classify as non-organisms.
- 21 This is van Inwagen's approach (1990a, §§2, 9).

### References

- Baker, L. R. (2000) *Persons and Bodies*, Cambridge: Cambridge University Press.
- Boden, M. (2008) 'Autonomy: What Is It?', *BioSystems* 91, pp. 305–308.
- Bouchard, F. (2008) 'Causal Processes, Fitness, and the Differential Persistence of Lineages', *Philosophy of Science* 75, pp. 560–570.
- Campbell, T. and McMahan, J. (2010) 'Animalism and the Varieties of Conjoined Twinning', *Theoretical Medicine and Bioethics* 31, pp. 285–301.
- Clarke, A. and Chalmers, D. (1998) 'The Extended Mind', *Analysis* 58, pp. 7–19.
- Clarke, E. (2010) 'The Problem of Biological Individuality', *Biological Theory* 5, pp. 312–325.
- Clarke, E. (2013) 'The Multiple Realizability of Biological Individuals', *Journal of Philosophy* 110, pp. 413–435.

- Dawkins, R. (2016) *The Selfish Gene, 40th Anniversary Edition*, Oxford: Oxford University Press.
- Dupré, J. and O'Malley, M. (2012) 'Varieties of Living Things. Life at the Intersection of Lineage and Metabolism', in: Dupré, J. (Ed.), *Processes of Life: Essays in the Philosophy of Biology*, Oxford: Oxford University Press, pp. 206–229.
- Dupré, J. (2014) 'Animalism and the Persistence of Human Organisms', *Southern Journal of Philosophy* 52, Spindel Supplement, pp. 6–23.
- Godfrey-Smith, P. (2014) *Philosophy of Biology*, Princeton, NJ: Princeton University Press.
- Godfrey-Smith, P. (2015) 'Individuality and Life Cycles', in: Guay, A. and Pradeu, T. (Eds.), *Individuals Across the Sciences*, Oxford: Oxford University Press, pp. 85–102.
- Hawthorne, J. and McGonigal, A. (2008) 'The Many Minds Account of Vagueness', *Philosophical Studies* 138, pp. 435–440.
- Hudson, H. (2007) 'I am Not an Animal', in: van Inwagen, P. and Zimmerman, D. (Eds.), *Persons: Human and Divine*, Oxford: Oxford University Press, pp. 216–236.
- Hull, D. (1992) 'Individual', in: Keller, E. F. and Lloyd, E. A. (Eds.), *Keywords in Evolutionary Biology*, Cambridge, MA: Harvard University Press, pp. 181–187.
- Janzen, D. (1977) 'What Are Dandelions and Aphids?', *The American Naturalist* 111, pp. 586–589.
- Lewis, D. (1986) *On the Plurality of Worlds*, Oxford: Blackwell.
- Lewis, D. (1993) 'Many, but Almost One', in: Campbell, K., Bacon, J. and Reinhardt, L. (Eds.), *Ontology, Causality, and Mind*, Cambridge: Cambridge University Press, pp. 23–38.
- Locke, J. (1975) *An Essay Concerning Human Understanding*, 2nd ed., Oxford: Oxford University Press. (Original work 1694).
- Merricks, T. (2001) *Objects and Persons*, Oxford: Oxford University Press.
- Olson, E. T. (2003) 'Was Jekyll Hyde?', *Philosophy and Phenomenological Research* 66, pp. 328–348.
- Olson, E. T. (2007) *What Are We? A Study in Personal Ontology*, New York: Oxford University Press.
- Olson, E. T. (2011) 'The Extended Self', *Minds and Machines* 21, pp. 481–495.
- Olson, E. T. (2014) 'The Metaphysical Implications of Conjoined Twinning', *Southern Journal of Philosophy* 52, Spindel Supplement, pp. 24–40.
- Pradeu, T. (2010) 'What is an Organism? An Immunological Answer', *History and Philosophy of the Life Sciences* 32, pp. 247–268.
- Pradeu, T. (2012) *The Limits of the Self: Immunology and Biological Identity*, Oxford: Oxford University Press.
- Puccetti, R. (1973) 'Brain Bisection and Personal Identity', *British Journal for the Philosophy of Science* 24, pp. 339–355.
- Quine, W. V. O. (1960) *Word and Object*, Cambridge, MA: MIT Press.
- Santelices, B. (1999) 'How Many Kinds of Individual Are There?', *Trends in Ecology and Evolution* 14, pp. 152–155.
- Shoemaker, S. (1984) 'Personal Identity: A Materialist's Account', in: Shoemaker, S. and Swinburne, R. (Eds.), *Personal Identity*, Oxford: Blackwell.
- Shoemaker, S. (1999) 'Self, Body, and Coincidence', *Aristotelian Society Supplementary Volume* 73, pp. 287–306.
- Sider, T. (2001) *Four-Dimensionalism: An Ontology of Persistence and Time*, Oxford: Oxford University Press.

- Sober, E. (1993) *Philosophy of Biology*, Boulder, CO: Westview.
- Thomson, J. J. (1983) 'Parthood and Identity Across Time', *Journal of Philosophy* 80, pp. 201–220.
- Van Inwagen, P. (1981) 'The Doctrine of Arbitrary Undetached Parts', *Pacific Philosophical Quarterly* 62, pp. 123–137.
- Van Inwagen, P. (1990a) *Material Beings*, Ithaca, NY: Cornell University Press.
- Van Inwagen, P. (1990b) 'Four-Dimensional Objects', *Noûs* 24, pp. 245–255.
- Van Inwagen, P. (1994) 'Composition as Identity', in Tomberlin, J. (Ed.), *Philosophical Perspectives* 8, *Logic and Language*, Atascadero, CA: Ridgeview, pp. 207–220.
- Van Inwagen, P. (2006) 'Can Mereological Sums Change Their Parts?', *Journal of Philosophy* 103, pp. 614–630.
- Wilson, D. S. and Sober, E. (1989) 'Reviving the Superorganism', *Journal of Theoretical Biology* 136, pp. 337–356.
- Wilson, J. (1999) *Biological Individuality: The Identity and Persistence of Living Entities*, Cambridge: Cambridge University Press.
- Wilson, R. A. and Barker, M. (2017) 'The Biological Notion of Individual', in: Zalta, E. (Ed.), *The Stanford Encyclopedia of Philosophy* (Spring 2017 Edition), <https://plato.stanford.edu/archives/spr2017/entries/biology-individual/>.