

Species in three and four dimensions

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Abstract There is an interesting parallel between two debates in different domains of contemporary analytic philosophy. One is the endurantism–perdurantism, or three-dimensionalism vs. four-dimensionalism, debate in analytic metaphysics. The other is the debate on the species problem in philosophy of biology. In this paper I attempt to cross-fertilize these debates with the aim of exploiting some of the potential that the two debates have to advance each other. I address two issues. First, I explore what the case of species implies regarding the feasibility of particular positions in the endurantism–perdurantism debate. I argue that the case of species casts doubt on the recent claim that three-dimensionalism and four-dimensionalism are equivalent descriptions of the same underlying reality. Second, and conversely, I examine whether the metaphysical worry about three-dimensionalism and four-dimensionalism can help us to better understand the nature of biological species. I show that analyzing the thesis that species are individuals against the background of the endurantism–perdurantism debate allows us to explicate two different ways in which this thesis can be interpreted.

Keywords Endurantism · Four-dimensionalism · Perdurantism · Species-are-individuals thesis · Species problem · Three-dimensionalism

1 Introduction

An issue of continuing interest in analytic metaphysics is how the persistence of objects is to be understood. How does a given object remain in existence as numerically the same object for an extended period of time, even though its material composition and

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its observable properties may be different at different times? I am the same entity that I was a year ago, notwithstanding that in the mean time most of the cells in my body have been replaced by new ones and there have been some changes in the way I look, in my body mass, in what I believe to be true, in what I prefer and dislike, etc. But exactly *how* am I still the same?

The two main ways of answering questions like the above are endurantism, or three-dimensionalism, and perdurantism, or four-dimensionalism. According to endurantists, the entities that exist in the world are three-dimensional entities that extend in the three spatial dimensions but not in time. Perdurantists, in contrast, conceive of the world as consisting of four-dimensional entities that extend in the three spatial dimensions as well as in the temporal dimension. The endurantism–perdurantism (henceforth: E–P) debate is about which of the two competing camps holds the correct view of the nature of the various entities that exist in the world.

Recently, McCall and Lowe have argued that the E–P debate is metaphysically empty. They wrote:

“(. . .) the 3D and the 4D descriptions of the world are equivalent in the sense of being *intertranslatable without remainder*, and (. . .) there is no ‘fact of the matter’ as to whether we live in a 3D or a 4D world. Instead, one can *freely choose* whether to describe it in 3D or 4D terms. Either way, it’s the same world. The so-called “3D/4D controversy” is a storm in a teacup, and philosophers should not feel obliged to support one side or the other.” (McCall and Lowe 2006: pp. 570–571; emphasis added).

At first glance, this is a plausible position. We have only limited sensory access to the world and we are unable to verify directly whether the things in the world are *really* three-dimensional or four-dimensional entities. It is therefore reasonable to hold a modest view of our knowledge of the world: we are free to describe the world in various ways as long as our descriptions fit the available observations, but we should refrain from making claims about whether the world is ultimately made of three-dimensional or four-dimensional building blocks.

The claim that McCall and Lowe defend is however stronger than this epistemologically modest view. McCall and Lowe do not merely claim that both three-dimensional and four-dimensional descriptions of the world can be useful in different contexts and that we should refrain from making metaphysical claims about what the world is really like. They claim in addition that we are *fully free* to use three-dimensional and four-dimensional descriptions of the same reality alternatively, because these descriptions are *fully intertranslatable* into one another. In any given case, on this view, there is thus no way of deciding between the three-dimensional and the four-dimensional description because both fit the observed facts equally well. As such, it is a minority view in the E–P debate: many participants in the debate hold that empirical observations *can* be used to decide between the two ways of describing reality.¹

In the present paper I shall cast doubt on McCall and Lowe’s strong claim that we are free to choose between three-dimensional and four-dimensional descriptions of reality

¹ For example authors who defend four-dimensionalism on the grounds that it alone is empirically adequate to relativity theory (e.g., Balashov 2000a,b, Hales and Johnson 2003).

because these descriptions are intertranslatable. If McCall and Lowe are correct, their claim should hold up for all the diverse ontologies that are adopted in the various fields of science. I shall test their claim on one case—the case of species in biology—and I shall argue that it does not hold up there. My principal interest is to examine whether the—somewhat outlandish, as many natural scientists and most members of the general public would say—metaphysical worry about three-dimensionalism and four-dimensionalism can help us to better understand the nature of species. However, from my analysis of the case of species also some conclusions can be drawn regarding the feasibility of particular positions in the endurantism–perdurantism debate. This is because there is an interesting parallel between the E–P debate and the debate on the nature of biological species: both are about the nature of objects and in both debates three-dimensionalist and four-dimensionalist ontologies stand in opposition. So far the two debates have led largely separate lives, the E–P debate within the borders of analytic metaphysics and the species debate confined to the domains of philosophy of biology, but there seems to be potential for fruitful cross-fertilization.²

After having introduced the E–P debate in Sect. 2 and the species debate in Sect. 3, I shall explore the potential for cross-fertilizing the two debates in Sect. 4. I shall argue for two main claims. (1) Analyzing the species-are-individuals thesis against the background of the E–P debate allows us to see that the species-are-individuals thesis underdetermines the ontological status of species and to explicate two different ways in which this thesis can be interpreted.³ (2) The case of species casts doubt on McCall and Lowe’s 3D/4D equivalence claim and can be interpreted in favor of what can be called a “mixed ontology.”

2 Two theories about the nature of objects

Let me begin by introducing the E–P debate. The explications of endurantism and perdurantism that I provide here must be brief and therefore somewhat sketchy; I shall largely ignore the differences between the various extant versions of the two positions, focusing only on the core ideas of endurantism and perdurantism.⁴

Endurantism and perdurantism are opposing theories about the nature of objects. Specifically, they are metaphysical theories about how objects persist in the world.⁵ To say that an entity persists is to say that numerically the same entity exists for an extended period of time, rather than just existing instantaneously for an infinitesimally small time. Clearly, many objects change over time with respect to their material composition and the properties that they exhibit, while we would still consider them to

² Cf. Mahner (2005: p. 239). On only very few occasions have the two debates been brought into contact: Hull ([1975] 1989), Brogaard (2004), Crane (2004) and Mahner (2005).

³ The species-are-individuals thesis as a claim about the nature of species is widely endorsed by biologists as well as philosophers of biology. While usually talk is about the “species-as-individuals thesis,” I write “species-are-individuals thesis” in order to emphasize that my concern is with the individuality thesis as a metaphysical claim about the nature of species.

⁴ More detailed discussions can be found with Van Inwagen (1990), Sider (1997, 2001), Balashov (2000a,b), McCall and Lowe (2003, 2006), Butterfield (2005), Hughes (2005) and Crisp and Smith (2005).

⁵ The terms “enduring”, “perduring” and “persisting” as used in the E–P debate are due to David Lewis.

remain the same objects. How exactly, then, do those objects remain in existence over extended periods of time as the same objects while still undergoing change?

Endurantists understand persistence by conceiving of the world as consisting of objects that are extended in three (spatial) dimensions and may be present at different points in time. The core idea of endurantism is that at any time at which an entity exists it is present *as a whole*. What exactly it means to say that an entity is wholly present at a particular time or place is subject of discussion and various definitions of “being wholly present at” exist.⁶ For my present purposes a simple conceptualization of “being wholly present at” suffices, according to which for a given entity to be wholly present at any time at which it exists means that *all* the parts of which the entity is made up also exist at that time: “(. . .) to be wholly present at a time means to have all of one’s parts present at that time.” (Miller 2005: p. 110). Three-dimensional entities, then, persist by existing in their entirety at multiple distinct, consecutive times: persistence is being wholly present at consecutive times. Understood as a three-dimensional entity, I am now wholly present in the sense that all the entities (atoms, cells, organs, etc., depending on the level of analysis that is taken) that can be considered to be parts of me are now present. Change, from the three-dimensionalist viewpoint, is to have different properties and/or parts at different times.

Perdurantists, in contrast, understand persistence by seeing the world as being made up of objects that are extended in four dimensions: objects are so-called “space-time worms” that extend in the three spatial dimensions as well as in the temporal dimension.⁷ In the perdurantist’s view, at any particular time at which an entity is present, only one of its temporal parts or stages is present—the entity is thus never *wholly* present. The entity as a whole, the perdurantist holds, is the mereological sum of all of its temporal parts: “(. . .) everyday objects, such as you and me, are space-time worms that persist through time by having temporal parts none of which is identical to the object itself. Objects are aggregates or sums of temporal parts.” (Brogaard 2000: p. 341; see also Miller 2005: p. 96). Four-dimensional entities persist by occupying an extended part of the temporal dimension: persistence is being present in an extended segment of the temporal dimension while having different temporal parts at different times. Understood as a four-dimensional entity, I consist of all the atoms, cells, organs, etc. that at any time of my existence have been or will be a part of any of my different temporal parts, so my material composition as a four-dimensional entity is unchanging. Change, from the four-dimensionalist perspective, obtains when an entity has different consecutive temporal parts that in turn have different properties and/or different compositions.

Endurantism and perdurantism present us with different views about what the objects in the world are like. For the endurantist, only three-dimensional entities such as the ones that we see around us every day are real. For the perdurantist, reality consists of four-dimensional space-time worms notwithstanding that we are used to seeing these four-dimensional entities in a three-dimensional manner; what we observe are the three-dimensional time-slices of four-dimensional entities that are coexistent in

⁶ Crisp and Smith (2005) discuss six definitions of “being wholly present at” and add their own definition.

⁷ Within perdurantism there are different views about what the basic ontological elements of the world are; see for example McCall and Lowe (2003: pp. 115–116).

time with us (with our own three-dimensional time-slices, that is). At present, the two opposing camps are well-staffed and several varieties of three-dimensionalism and four-dimensionalism are defended in the literature. On the three-dimensionalist side we find, for example, [Van Inwagen \(1990\)](#); advocates of four-dimensionalism include [Sider \(1997, 2001\)](#), [Brogaard \(2000, 2004\)](#) and [Hales and Johnson \(2003\)](#).⁸

As far as common sense is concerned, endurantism is the more plausible of the two views. After all, what we see around us in everyday life and understand ourselves as talking about are not four-dimensional objects but three-dimensional objects that can be present at different times and places. In addition, under the perdurantist view the reference of object names takes a non-intuitive form. The perdurantist interprets names of individual objects as referring to four-dimensional space-time worms that cannot be seen or interacted with (we can only see and interact with some of their three-dimensional parts). What we are actually doing when referring to objects, from the perdurantist perspective, is talking about four-dimensional entities and attributing to them the properties of having particular time-slices that in turn have particular properties (see [Van Inwagen 1990](#): p. 245ff. for further discussion; as [Van Inwagen](#) points out, an alternative way of formulating the E–P issue is to ask what the names of objects that we use refer to). The three-dimensionalist's statement that some time ago my mass was m can be understood in a straightforward manner as saying just that some time ago my mass was m . In contrast, the four-dimensionalist's statement that some time ago my mass was m has to be interpreted as actually meaning that I, as a space-time worm, have a temporal part at time t that is attributed the property of having mass m . Four-dimensionalism thus seems unnecessarily complicated, less fitting than three-dimensionalism to our intuitions about what the world is like and about how we talk about the world, and hence the less attractive option. Considerations of particular scientific theories (particularly relativity theory), however, are often taken to favor four-dimensionalism over three-dimensionalism (e.g., [Balashov 2000a,b](#), [Hales and Johnson 2003](#)). “Perdurantism,” [Hales and Johnson \(2003](#): p. 524) for example write, “fits beautifully with our current scientific understanding of the world.”

At present, the two opponents seem to stand in an irresolvable deadlock. Neither of the two camps has yet been able to decide the debate once and for all in its favor, although there seems to be a slight tendency in the direction of four-dimensionalism at the moment because of four-dimensionalism's fit to the scientific picture of the world. I shall have more to say on the reasons for this deadlock in Sect. 4.

3 Two theories about the nature of species

The volume of philosophical and biological literature on the species problem is immense. My discussion here will be brief; recent overviews of the debate are given in [Stamos \(2003\)](#) and [Reydon \(2005\)](#).

One main dichotomy in the species debate is between the view that species are classes and the so-called species-are-individuals thesis, that is, the view that species

⁸ For more of the players on the various teams, see [Sider \(2001](#): p. 3), [McCall and Lowe \(2003](#): pp. 115–116) and [Butterfield \(2005](#): p. 237).

are concrete objects in the same way that organisms, chairs and firms are concrete objects. The discussion is about the ontological status of species. The ontological difference between the two positions can be clarified by considering the relation between organisms and the species to which they belong. On the class view this is a relation of membership, while on the individuals view organisms are parts of their species in the same way as my cells are parts of me. While the view that species are classes (or even natural kinds) has been the traditional understanding of the nature of species from (very roughly) Aristotle to (very roughly) Darwin, the species-are-individuals thesis has become the dominant position since it was introduced in the 1960s–1970s by Ghiselin (1966, 1974) and propagated by Hull in many papers ([1975] 1989, 1976, 1977, 1978, 1980, 1983, 1987).⁹ The reasons for suggesting that species are individuals rather than classes were related to various problems that the classes/kinds view of species was facing. Species have since Darwin been understood as things that evolve, no laws of nature about any species have so far been found and essentialism regarding species was found to be mistaken—all issues that make sense if species are individuals but are problematic under a class view of species. At present, most biologists and philosophers of biology understand species to be individuals of some sort.

This consensus notwithstanding, the species-are-individuals thesis has failed to resolve the species debate once and for all. In particular, there is profound disagreement whether species are to be conceived as synchronic (that is, three-dimensional, as I shall argue) or diachronic (four-dimensional) entities. Much has been said and written in support of both positions and, as is the case in the E–P debate, both camps are well-staffed. In the case of species, the camps largely coincide with two distinct yet intimately connected fields of work in biology, evolutionary biology and systematic biology. These fields have different explanatory interests; consequently, the notion of species plays different theoretical roles and different ontologies of species are found to be adequate by researchers in the different fields.¹⁰

Systematic biology is concerned with the *products* of the evolutionary process. The aim of systematic biology as it is practiced today—whether in the form of strict phylogenetic systematics or the more flexible evolutionary systematics sensu Mayr—is to reconstruct the evolutionary history of life on Earth and to construct a classificatory system for the whole of biodiversity on the basis of this reconstructed historical pattern. Species are featured in systematic biology as the principal building blocks of the reconstructed history of life and the classificatory system that is built on it (Futuyma, 2005: p. 355). Correspondingly, most (though not all) schools in biosystematics understand species as the smallest continuous segments of the so-called “tree of life,” the time-extended tree-shaped genealogy of all life on Earth. As the basic building blocks of the tree of life, species are conceptualized as diachronic objects, extending over evolutionary significant periods of time and having organisms long dead and gone as well as organisms that live today and (for not yet extinct species) in the future as their parts. The constituent organisms of such a species are bound

⁹ A brief personal history can be found with Ghiselin (1997: pp. 13–16).

¹⁰ For recent discussions, see Lee and Wolsan (2002), Stamos (2002, 2003, 2007), Brogaard (2004), Crane (2004), Futuyma (2005: p. 355); Mahner (2005), Reydon (2005).

together by relations of descent: they stand in parent-offspring relations to each other and all are descendants of the same ancestral population.¹¹

Bock (2004), among others, however repeatedly emphasized that these time-extended tree-segments of systematic biology (for which he uses the common term “phyletic lineages”) should not be confused with species:

“The species is a *real unit existing in nature* whereas the phyletic lineage represents the history of the species and *cannot be said to be a real unit existing in nature*. Species reproduce themselves generation after generation and can evolve. (...) Phyletic lineages no longer evolve, they are the result of past evolutionary change.” (2004: p. 179; emphasis added).

While for many systematic biologists the tree of life and its constituent segments are as real as anything, Bock denies the reality of such tree-segments.¹² According to Bock, a species is “(. . .) the complex of interbreeding individual organisms *co-existing at one point in time* which is genetically isolated from other such complexes” (2004: p. 179; emphasis added). On this view, in contrast to diachronic phyletic lineages, species are synchronic objects that do not extend in time.

This conceptualization of species is widespread in evolutionary biology, where the explanatory focus lies on the general *process* of evolution, rather than on its end products, and on the various past and present instances of this process on planet Earth (Futuyma 2005: p. 355). Species are often counted among the main units that participate in these processes (but this is by no means a general consensus among biologists and philosophers of biology—see, e.g., Hull 1980: pp. 327–328). As evolutionary process units, species are understood as organized systems that interact *as wholes* with their environments in much the same way as organisms do and that change through time as a consequence of these interactions. The way in which such systems are organized and in which their various parts (organisms on the basic level, local populations, etc. on higher levels) interact co-determines how they interact with their environments and thus which evolutionary trajectories they will take. On this view, species are (meta-)populations composed of synchronously existing parts (widespread populations, local demes, individual organisms) that are bound together in the system by causal interactions (interbreeding relations that connect populations and demes within the metapopulation, breeding relations and other relations of gene transfer that connect organisms within populations and demes). The synchronic view of species is prominently found with some of the pioneers of the Modern Synthesis in biology, e.g., Dobzhansky (1935, 1970: p. 23) and Mayr (1987, 1996). It is also found with contemporary proponents of species selection, who emphasize that in order for species selection to be possible, species must be able to act as cohesive, structured wholes in

¹¹ The conceptualization of species is advocated in various forms by biologists as well as philosophers of biology. One prominent advocate is Simpson (1961: pp. 153–154), other proponents include Lidén and Oxelman (1989), Kluge (1990), Hull (1997: p. 375; [1997] 2001: p. 207), De Queiroz (1998, 1999, 2005a,b), Millikan (1999: p. 55; 2000: pp. 19–20, 24, pp. 203–208) and Wiley and Mayden (2000: pp. 74–75).

¹² A realist interpretation of the tree of life could for example conceive of the tree of life as a real pattern in the sense of Dennett (1991).

selection processes (e.g., [Lloyd and Gould 1993](#), [Gould and Lloyd 1999](#), [Gould 2002](#): pp. 656–673, 703–712, 799–801).

Biologists in different fields of work thus endorse (at least) two distinct theories of the nature of species as individuals. The entities described by these two theories play different roles in biological science, synchronic species as process units and diachronic species as segments of a real pattern.¹³ A valid question, however, is whether these two theories merely represent different viewpoints from which one can look at the same objects in the world, or constitute different claims about what there is in the world. In other words, is the opposition between synchronic and diachronic conceptions of species purely epistemological (in which case parallels with the E–P debate would only be superficial), or does it have actual metaphysical import (in which case the same issue is at stake in both the E–P and the species debates)? Indeed, it is not obvious that the debate between proponents of synchronic and diachronic views of species actually involves an opposition between three-dimensionalist and four-dimensionalist ontologies.¹⁴ A closer look, however, suggests that in the E–P debate and the species debate similar metaphysical concerns are at stake, even though this is hardly ever made explicit in either of the two debates.

As many participants in the species debate explicitly assert, their concern is at least in part about what sorts of things species, as real entities in nature, are (e.g., [Mayr 1996](#): p. 263; [De Queiroz 1999](#): pp. 74–76; [Stamos 2003](#): p. 1). Whereas for instance [Bock \(2004](#); see the quotation given above) defends the view that synchronic species are real while denying the reality of diachronic lineages, [Kluge \(1990](#): p. 423) and [De Queiroz \(1999](#): pp. 74–76) take the opposite position. The opposition between synchronic and diachronic views of species thus is perceived by many of the discussants as a controversy about the nature of those particular objects that biologists refer to with names such as *Mus musculus* or *Quercus rubra*. It is a controversy about the nature of real things, not just about which view of things is preferred in which research contexts.

This can be seen by examining the ontological commitments of the two sides in the debate. Virtually no biologist, whether proponent of a synchronic or diachronic view of species, would deny that both past organisms and currently living organisms can be attributed to species. The species called *Mus musculus* that exists today has existed for the past 2 million years or so ([Chevret et al. 2005](#)) and a house mouse that lived 100,000 years ago is as much a member of this species as the mouse that lives in my kitchen today (this is from the diachronic perspective; from the synchronic perspective the precise statement should be: just as the mouse in my kitchen is a member of *M. musculus* during its lifetime, the mouse that lived 100,000 years ago was a member

¹³ It is probably for historical and social reasons that both fields of work have appropriated the term “species” for the basic entities that they study. [McOuat \(2001](#): pp. 640–641), for instance, suggested that the term is linked to scientific prestige: species have always counted as the central units in biological science, so there is much social status to be gained for a field of work if it can appropriate the term for its own objects of study. [Stamos \(2002, 2007](#): p. 63, pp. 78–79) argued that a trend can be observed in the history of biology: while the rise of phylogenetic systematics in the 1960s caused a trend towards accepting diachronic views of species, at present the trend appears to be reversing towards increasing endorsement of synchronic views.

¹⁴ As mentioned in the Introduction (see also note 2), after all, the E–P debate and the species debate have only very sporadically been in contact. An anonymous referee raised this issue.

of this species during *its* lifetime). On both synchronic and diachronic accounts of species, then, species are understood as persisting objects. The crucial difference between synchronic and diachronic views of species is that on synchronic views species are conceived of as being *wholly* present at every time at which it exists, whereas on diachronic views species are conceived of as having only temporal parts present at those times at which they exist. That is, on synchronic views dead mice once were part of *M. musculus* but are no longer, whereas on diachronic views both past mice and the mouse in my kitchen are equally parts of this species.

These different views of species arise because in different fields of investigation different kinds of relations that obtain between the organisms of a species are in focus. As mentioned above, synchronic species are featured in accounts of evolutionary processes as the units that partake in these processes, while diachronic species are featured in reconstructions of evolutionary history as the basic building blocks of the tree of life. On synchronic views, what matters is how the organisms of a species interact with each other, i.e., how the organisms of a species are bound into a cohesive system that participates *as a whole* in evolutionary processes. As Ghiselin (1997: p. 52; see also Hull 1980: p. 328) pointed out, “If something is cohesive, then it is capable of doing things or participating in processes.” How a particular species evolves in its particular environment from an initial state at a particular time *t* depends on its composition at that time, not on its past composition. What matters for the further evolution of the species from *t* onward are the genetic makeup of those organisms that constitute it at that time, the actual interactions between these organisms (who mates with whom, who competes with whom, who cooperates with whom, etc.), the actual genetic mutations that occur and the actual selective forces that the environment exerts on this system of organisms. Past organisms no longer interact with other organisms and thus do not constitute parts of such cohesive evolving systems. On synchronic views, then, all a species’ parts exist at any time at which the species exists—i.e., species are wholly present at all times at which they exist.

On diachronic views of species, cohesiveness in the above sense is not in focus. What binds organisms together in a diachronic species is common descent: organisms are parts of a species because they stand in the same temporally extended ancestor–descendant line, not because they materially interact with one another in any way. Whereas for material interactions it is necessary that the interacting entities exist simultaneously, this is not the case for ancestor–descendant relations. Therefore, on diachronic views species do not necessarily—and in by far most real cases do not—have all their parts present at those times at which they exist. On diachronic views, then, species are four-dimensional “space-time worms” that have different temporal parts present at different times (see, for example, Hull [1975] 1989: p. 183, pp. 186–187, 1978, 1980, 1997: p. 375, [1997] 2001: pp. 206–207; Lee and Wolsan 2002; see also Crane 2004: p. 159).

On synchronic views of species, species must be wholly present at those times at which they exist: on diachronic views, they must (and usually are) not. This is precisely one of the crucial differences between three-dimensionalism and four-dimensionalism (see Sect. 2). Advocates of synchronic views of species are thus committed to three-dimensionalism (with respect to species, at least), while diachronic views usually go

hand in hand with species four-dimensionalism (although acceptance of a diachronic view does not necessarily commit one to four-dimensionalism).¹⁵

4 Metaphysics and the species problem

Given that the debate between proponents of synchronic views of species and of diachronic views of species involves an opposition between species three-dimensionalism and species four-dimensionalism, as I argued in the previous section, how is the debate to be resolved? Neither species three-dimensionalists nor species four-dimensionalists have so far been able to decide the debate in favor of their preferred ontology and the debate between the two positions is ongoing. Both views are defended by various authors and both seem to have good arguments on their side. In principle, however, four positions can be defended:

- (1) Species three-dimensionalism is true: species are *really* three-dimensional entities and the things the four-dimensional account talks about do not in fact exist.
- (2) Species four-dimensionalism is true: species are *really* four-dimensional entities and the things the three-dimensional account talks about do not in fact exist.
- (3) Neither view is true: the opposition between the two views has no metaphysical content but is a purely epistemological controversy; the two accounts of species may both be epistemically useful in different contexts of investigation, but neither can be singled out as the true description of reality, as they describe the same underlying reality.
- (4) Both views are true: the two accounts of species are true descriptions of reality, which means that they must describe different parts of reality.

In what follows I shall examine these positions in turn, beginning with the latter two.

Options (3) and (4) imply that there actually isn't any real deadlock between species three-dimensionalism and species four-dimensionalism that needs to be resolved. According to option (3) this is because the controversy between the two positions is actually not a metaphysical controversy. On option (4) this is because both positions are in fact true descriptions of the world, so it would be wrong to reject either. A consideration of some arguments that have been advanced in the E–P debate will come in handy when assessing the feasibility of these positions, for the same issues that are at stake in the species debate are also at stake in the E–P debate: both are about the nature of objects and how they persist. Thus, arguments from the E–P debate may help to advance the species debate and, conversely, the opposition between endurantism and perdurantism may be brought closer to a resolution by considering how this opposition is instantiated in the concrete case of species.

¹⁵ This was also argued by Crane (2004: p. 169). In a similar vein, Ghiselin (1997: pp. 51–61) argued for the need to make an ontological distinction between two kinds of individuals: “cohesive individuals” are held together by interactions between their parts that allow them to function as wholes in processes, “historical individuals” are held together by common descent and cannot partake in processes.

4.1 Not-3D and not-4D

How severe is the deadlock between species three-dimensionalism and species four-dimensionalism? Some participants in the E–P debate have suggested that empirical data cannot be decisive between three-dimensionalism and four-dimensionalism, since we always only observe three-dimensional entities. What we find in the world at a given time t is either the three-dimensional species as a whole or a three-dimensional temporal part of a four-dimensional species, while having no way of distinguishing between the two (e.g., Miller 2005: p. 99; this is, however, not the majority view—see note 1).

Accordingly, several authors—e.g., McCall and Lowe (2003, 2006), Hirsch (2005), Miller (2005) and Butterfield (2005)—have recently argued that the E–P debate should be seen as an issue in which there actually is no metaphysical bone to pick. Neither three-dimensionalism nor four-dimensionalism is true, these authors claim, the two are just alternative accounts of the same underlying (and unspecified) reality. Hirsch understood the debate as a verbal dispute, i.e., a dispute that is to be settled by questioning the meanings of statements *in relation to* the language community to which the persons uttering them belong and then assessing which of the languages used by the involved language communities is closest to ordinary language (Hirsch 2005: pp. 69–70).¹⁶ McCall and Lowe and Miller took a different approach, suggesting that the deadlock between endurantism and perdurantism can only be decided on epistemological grounds, using such criteria as intra-theoretical and inter-theoretical consistency, explanatory force, explanatory scope, simplicity, operationality, etc. With respect to the species debate, this is option (3) above; can this be a feasible way out?¹⁷

According to McCall and Lowe, “objects of the physical world can be described using either three-dimensional or four-dimensional language, and (...) the descriptions are equivalent in the sense of *intertranslatable*. Furthermore, there is no ‘fact of the matter’ in the world which makes one of the descriptions true and the other false.” (2003: p. 117; emphasis added). McCall and Lowe’s position involves two claims. The first is epistemological: the three-dimensional and four-dimensional descriptions of reality can be translated into each other without loss of information and we can freely switch between descriptions. According to McCall and Lowe, the three-dimensional and four-dimensional descriptions of the world are “intertranslatable without remainder” (2006: p. 570; see the quote given in Sect. 1), which means that a 1-1 mapping must exist between the two descriptions (ibid., p. 574) that allows the two descriptions to be freely transformed back and forth into each other. A similar claim was made by Butterfield (2005), who argues that the three-dimensionalist and four-dimensionalist descriptions of the motion of particles in classical mechanics are *formally* equivalent.

¹⁶ I have mentioned Hirsch’s view for the sake of completeness, as his position that “many familiar questions about the ontology of physical objects are merely verbal. *Nothing is substantively at stake in these questions* beyond the correct use of language.” (Hirsch 2005: p. 67; emphasis added) is similar to the views of McCall and Lowe, Miller and Butterfield. I shall however not further consider Hirsch’s position—this would involve a long digression away from my central concerns in the present paper.

¹⁷ 3D/4D equivalence seems to be gaining popularity in the E–P debate, but so far no one to my knowledge has defended this position with respect to the case of species.

McCall and Lowe's second claim is metaphysical: if the three-dimensional and four-dimensional descriptions of reality are indeed intertranslatable in the abovementioned way, then the question whether the world is *really* three-dimensional or four-dimensional is empty. "It may be both," they write, "or it may be neither, or it may be either, depending on which features of the world we wish to focus on. But it will never be one to the exclusion of the other; never the case that the 3D view is vindicated and the 4D view defeated, or vice versa." (2003: p. 18). There is no absolute way of disqualifying, say, the three-dimensional description of reality in favor of the four-dimensional description, McCall and Lowe claim, because the three-dimensional description can be transformed into the four-dimensional description and back without any loss of information. Metaphysically the two descriptions of the world are equivalent. The only way to break the deadlock between the two views would therefore be to argue that epistemological criteria such as simplicity, explanatory scope, etc. may tip the balance in favor of one of the competing views: "For some purposes the 4D picture is more illuminating (. . .), and for other purposes the 3D picture is preferable. But *ultimately it makes no difference* which ontological position we adopt." (2006: p. 577; emphasis added).

Miller (2005) offered a similar but more detailed version of 3D/4D equivalence. According to Miller (2005: p. 92), two theories are metaphysically equivalent if three main criteria are met:

- There needs to be a mapping of the sentences of one theory onto the sentences of the other. This is Butterfield's formal equivalence claim and McCall and Lowe's intertranslatability claim.
- The theories need to be empirically equivalent in the sense that there are no (actual or possible) observational predictions of one theory that are not also made by the other. This is an empiricist formulation of a claim similar to McCall and Lowe's second claim.
- The theories need to have the same "theoretical virtues" to the same degree. This means that the two theories have to be equally simple, possess equal explanatory power, etc. Miller, however, does not provide an exhaustive list of what she calls "theoretical virtues" (her terminology—I shall further speak of "epistemological virtues").

Endurantism and perdurantism, Miller argues, meet these criteria and hence are metaphysically equivalent descriptions of reality.

Now, are species three-dimensionalism and species four-dimensionalism equivalent descriptions of reality?

Let me start with the criterion of sameness of epistemological virtues. The three-dimensional and four-dimensional theories of species do not exhibit precisely the same epistemological virtues to the same extent. In order to see this, it is not necessary to provide an exhaustive list of epistemological virtues that any scientific theory should possess. It will suffice to select some virtues that most scientists and philosophers of science would be likely to agree on and to show that the two views of species exhibit these to a different extent. I shall focus here on simplicity, explanatory force and explanatory scope. At first sight, species three-dimensionalism and species four-dimensionalism appear equally simple: both describe objects that have organisms as

their parts. Still, there is no way of deciding objectively on the simplicity of the two competing theories, for there is no generally agreed way of comparing any two theories with respect to simplicity (Miller 2005: pp. 104–105). The problem is even more pronounced with respect to explanatory force and scope. Does one of the two theories explain a larger domain of phenomena than the other, or does it provide a better explanation of the phenomena than the other? This is hard to say, since neither theory can be used to explain any natural phenomena directly; rather they explicate the ontological status of a particular category of biological entities (and thus function in biological explanations only indirectly) and they explain metascientific phenomena, such as why biology has not been able to discover any laws of nature pertaining to species and why no species essences have been uncovered.

The difficulty with assessing these epistemological virtues, I suggest, is in this case a symptom of a deeper problem that lies with the virtue of explanatory scope. It does not make much sense to investigate whether two accounts that describe entirely different phenomena are metaphysically equivalent; in order to assess their possible equivalence, different accounts have to pertain to the same group of phenomena in the first place—that is, they should have the same explanatory scope. As three-dimensional species concepts are featured in explanations of evolutionary processes while four-dimensional species concepts are featured in accounts of evolutionary history, it is questionable whether the two theories actually pertain to the same phenomena and hence whether they can be compared at all. But if they are incomparable, surely they cannot be equivalent descriptions of the same reality? Note that this directly affects the usefulness of the second of Miller's criteria: if two theories do not pertain to the same set of phenomena, they cannot be empirically equivalent; hence, we need to know *that* two competing theories have the same explanatory scope, before we can assess whether they are empirically equivalent.

The three-dimensional and four-dimensional theories of species thus fail to meet the criterion of sameness of epistemological virtues. However, this does not necessarily imply that the theories in question are not metaphysically equivalent. The problem here lies with the criterion that is used to measure the competing theories, I suggest, rather than with the theories themselves: the criterion is sufficient for metaphysical equivalence, but it is not necessary. On McCall and Lowe's view, for example, three-dimensionalist and four-dimensionalist descriptions of reality can be equivalent notwithstanding that they *do not* possess the same epistemological virtues. To the contrary, McCall and Lowe hold that in some cases a three-dimensionalist view may be preferable on epistemological grounds, whereas in other cases a four-dimensionalist view is more appropriate. Miller's third criterion, then, pertains to the possible *epistemic* equivalence of theories. If two theories have the same epistemological virtues to the same extent, they will probably be epistemically equivalent (depending on which epistemological virtues exactly are taken into consideration) and therefore also metaphysically equivalent. But conversely there seems to be no need for two metaphysically equivalent theories to be also epistemically equivalent. The failure to meet Miller's third criterion in the case of species three-dimensionalism and species four-dimensionalism thus does not say much about the possible metaphysical equivalence of the two theories.

A stronger criterion is intertranslatability. What is required for intertranslatability to obtain is the possibility of a mapping onto each other of the sentences in the two descriptions that express the composition of objects from their parts. Miller (2005: pp. 99–104) and McCall and Lowe (2006: pp. 573–574) explicate how such a mapping should work. McCall and Lowe focus on composition: the way to proceed is to show that the set of parts that make up a given object O at time t under the three-dimensional description of O and the set of parts that make up the temporal part of O at time t under the four-dimensional description of O have the same extension. Miller holds a more formalized notion of intertranslatability and elaborates it in terms of sentences that express the composition of objects and the truth conditions for these sentences under the two descriptions. The basic idea is that every sentence of the one description should be true under precisely the same conditions under which the corresponding sentence of the other description is true. In the case of species this operationalizes into the question under what conditions sentences like “Organisms O_1 and O_2 are both parts of the same species S .” are true.

That information about species composition should be fully preserved under translations seems straightforward: one would expect that all the organisms in the set that contains all organism-level parts of all temporal parts of a given four-dimensional species precisely constitute the set of all organisms that ever have been a part of the corresponding three-dimensional species and vice versa. However, three-dimensional and four-dimensional species descriptions attribute organisms to species on the basis of different criteria, so that the truth conditions under which a particular organism is counted as part of a particular species can be different under the two descriptions. As a consequence, organisms that are parts of a species on one description are not necessarily also parts of this species under the other description.

On four-dimensional accounts, species are defined by means of the ancestor–descendant relations that obtain between individual organisms: all the organisms in a four-dimensional species share a most recent common ancestor that they do not share with organisms of other species. Four-dimensional species of sexually reproducing organisms are usually pictured as genealogical networks of organisms connected by all the parental relations that actually exist between them. This way of picturing a four-dimensional species is common in the literature on phylogenetic theory since it was first introduced in the often-reproduced Fig. 6 of Hennig’s seminal book, *Phylogenetic Systematics* (Hennig 1966: p. 31). This structure can in principle be translated without loss of information into the structure of a corresponding sequence of three-dimensional species by mapping the ancestor–descendant relations of the four-dimensional species onto the actual breeding relations that obtain between the organisms of the three-dimensional species. For every breeding relation [parent 1]–[parent 2] there are $2n$ ($n = 1, 2, \dots$) corresponding parental relations: [parent 1]–[offspring n] and [parent 2]–[offspring n]. However, this procedure in most cases does not yield an exact mapping of four-dimensional species onto three-dimensional species and vice versa. Whereas four-dimensional species are always mutually exclusive (no organism is part of more than one species) and taken together exhaustively classify biodiversity (all organisms are allocated to a species), three-dimensional species may overlap and not all organisms are counted as parts of some three dimensional species.

There are various mechanisms that cause reproductive isolation between synchronic species, limiting the possibility of breeding to organisms of the same species (Futuyma 2005: pp. 359–363). These mechanisms, however, operate with varying degrees of effectiveness, leading to different degrees of reproductive isolation in different actual cases. Reproductive isolation between synchronic species thus is often not complete, so that hybridization occurs between two distinct synchronic species S_1 and S_2 .

In the case of sterile hybrids, such as mules, the organisms are not counted as parts of either S_1 or S_2 , even though they stand in ancestor–descendant relations with parental organisms in both S_1 and S_2 . Sterile organisms, after all, do not contribute their genes to the evolving gene pool of either S_1 or S_2 . Sterile hybrids are not counted as parts of their own synchronic species S_3 either, since they do not form a reproductive community (the taxonomic denotation of mules is simply *Equus asinus* × *Equus caballus*, indicating the hybrid origin of the organisms). Mules are included in the tree of life, however, in a four-dimensional tree-segment that springs from its two ancestor segments. Here, some of the parental relations in the four-dimensional tree of life have no pendants in three-dimensional species. In the case of fertile hybrids that can produce further offspring with organisms of both S_1 and S_2 , the two hybridizing species are understood as overlapping in the sense that the hybrid organisms are part of both gene pools (see Futuyma 2005: p. 357, pp. 373–376; for a case study of such hybridization in Darwin’s finches, see Grant and Grant 1998). Because of this, S_1 and S_2 are sometimes considered to be so-called semispecies rather than full-blown species. Such overlaps are, however, not represented in the tree of life, in which all species are mutually exclusive. Here, some of the breeding relations in the three-dimensional case have no pendants in the four-dimensional tree of life and the four-dimensional descriptions of species are incomplete in that they fail to include the relevant hybrid organisms.

The situation is even more problematic for asexually reproducing species, such as species of microbial organisms. It is unclear what the three-dimensional pendants of the clonal parental relations in the four-dimensional description would be (cf. De Queiroz 1998: p. 62, 1999: p. 52). In asexual species, after all, there are no breeding relations between contemporary organisms on which the parental relations of subsequent organisms can be mapped. In many microbial species, however, horizontal gene transfer occurs, i.e., direct transfer of genetic material between microorganisms of the same and sometimes also of different species. But occurrences of horizontal gene transfer do not at all map onto clonal parental relations. At most, clonal parental relations could be mapped on relations such as “organism O_1 descends from the same parent organism as organism O_2 .” This would, however, map a four-dimensional microbial species that is held together by parental relations onto a three-dimensional microbial *strain* rather than a three-dimensional *species*. In microbiology, genetic similarity is a crucial element of species definitions: microbial strains are held together by common ancestry, while microbial species are usually defined as *sets* of strains the organisms of which exhibit a high degree of genetic similarity and potential for horizontal gene transfer (e.g., Roselló-Mora and Amann 2001: pp. 52–53; Konstantinidis and Tiedje 2005: p. 2567; Reydon 2005: p. 146). The four-dimensional species descriptions that

microbiologists use thus do not generally map onto their three-dimensional species descriptions.

At this point, it has been established that three-dimensional and four-dimensional species descriptions are not intertranslatable *in principle*, i.e., that option (3) mentioned above is not a feasible position. However, before turning to the other options I want to point to an additional problem that exists for intertranslatability *in practice*. The descriptions of species that biologists actually use contain more information than just the organism-level composition of species. For assessments of whether three-dimensional and four-dimensional species descriptions are metaphysically equivalent, the relevant question thus is whether translation preserves not only the information about the material *composition* of the objects that the two theories describe (which it does not, as was just shown), but also whether it preserves information about their *structure* and *properties*. As I will argue shortly, species structure and species-level properties are not fully preserved under translation. This holds against McCall and Lowe's claim that we are *fully free* to choose between three-dimensional and four-dimensional descriptions or the world (see above): in some contexts biologists are forced to use a particular way of describing species by the nature of the information they are interested in.

Three-dimensional species possess more structure than the mere pattern of actual breeding relations. Three-dimensional species are not amorphous panmictic populations in which all organisms of one sex mate equally often with any organism of the other sex. They exhibit specific structural properties next to the structure of actual organismal breeding relations. On the three-dimensional view, species are organized systems that possess particular organizational structures and system-level properties. Three-dimensional species are structured and organized metapopulations, that is, geographically widespread populations of organisms that can be subdivided into smaller populations, still smaller local populations, etc. Examples of structural properties that co-determine the evolutionary trajectory of a three-dimensional species include the geographic distribution of the organisms of a species at a particular time, the degree of connectedness of the various subpopulations in the metapopulation, the temporally varying packing density of the organisms within a species (Gould 2002: p. 657), social interactions,¹⁸ collective behavioral phenomena (fish and bird schooling), the amount of horizontal gene transfer between bacteria in a population, etc. In addition, in theories of species selection species are attributed non-structural system-level properties that explain how species selection proceeds.¹⁹ The most prominent such property is

¹⁸ Meerkats (*Suricata suricatta*), for example, collectively take care of the young in the group and actively compete with their fellow group members for food. Such social interactions are important for how populations of these organisms will behave in evolutionary processes.

¹⁹ I am not accepting or denying *that* species selection occurs. Whether it occurs is an empirical question for biological investigation to answer and on which the last word has not yet been said. In addition, I am not advocating any particular view of which system-level properties could be important for species selection—this is also subject of discussion in biology; see for instance Lloyd and Gould (1993), Gould and Lloyd (1999), Gould (2002: p. 656–ff, pp. 670–673) or Crane (2004: p. 169). My point is that there is a three-dimensional conceptualization of species that is featured in theories of species selection and that as long as species selection has not been ruled out by biologists, philosophers should take this conceptualization seriously.

the variability of organismal traits. As Gould and Lloyd have emphasized, one central property of a species that co-determines its future evolutionary path is the variability that is present in its organisms' traits at a particular time (Lloyd and Gould 1993; Gould and Lloyd 1999; Gould 2002: p. 658ff.). This is a species-level property (the distribution around a mean value of the lengths of the organisms within a species at a given time, for example) that greatly affects the evolution of the species: more variability means more flexibility to accommodate future environmental changes.

Such structural and system-level properties constitute precisely the reason that three-dimensionally conceptualized species are interesting objects for study in evolutionary biology. It is in most cases, however, highly problematic to represent these properties in coherent four-dimensional accounts of species. The problem is that much information about the past structures and properties of three-dimensional species has been lost: we only know fragments of all there is to know about evolutionary history. There usually is no way of retrieving all the historical information regarding all relevant past structural and species-level properties that are needed to be able to construe a fully informative four-dimensional description of a species that includes information about species-level properties of the sort mentioned above. The three-dimensional descriptions of species that biologists use in their everyday research thus are richer than four-dimensional species descriptions: while the former include information about species structure and species-level properties, the latter do not. In biological practice, then, we are not free to choose between describing species in three-dimensional or four-dimensional terms.

For the species debate, the conclusion must be that the position that species three-dimensionalism and species four-dimensionalism constitute metaphysically equivalent theories is not a feasible choice. Note that the above considerations also shed some doubt on the general 3D/4D equivalence claim. The 3D/4D equivalence claim does not hold in the case of species, so it does not hold in general. However, within the confines of this paper I have only considered three particular criteria for the metaphysical equivalence of theories. The possibility thus needs to be left open that criteria other than the ones considered here are better suited to assess the metaphysical equivalence of theories and that on these criteria the 3D/4D equivalence thesis might be saved. What I have achieved, though, is reasonable doubt.

4.2 Both 3D and 4D

I now turn to option (4): both species three-dimensionalism and species four-dimensionalism are true. From a metaphysical perspective this is a somewhat peculiar view, since it involves the claim that persistence can take different forms for different entities of the same sort: some species persist by being wholly present at distinct times, while others persist by having different temporal parts at different times. In the species debate, however, this option was proposed as a potential solution to the deadlock between synchronic and diachronic accounts of species.

Lee and Wolsan (2002) recently discussed the differences between the synchronic and diachronic species concepts that are available in the literature and concluded that the two types of species concepts pertain to two ontologically different kinds of

entities: “Clearly there are two groups of species concepts, each referring to a *different ontological entity*. (. . .) The two types of species concepts attempt to define different entities, both biologically significant.” (2002: pp. 657–658; emphasis added). On this view, the species debate would not be a question of who is right and who is wrong, since both parties would be right: species three-dimensionalists and species four-dimensionalists talk about different ontological kinds of equally real entities that both are interesting subjects for biological investigation. This view acknowledges that both parties in the species debate have a good case, while neither has been able to decide the conflict in its favor. In addition, it acknowledges that the two ways of conceptualizing species are featured in different contexts of biological investigation and in accounts of different sorts of phenomena, which suggests that they actually do pick out different kinds of things.

If this view is correct, it has important consequences for the E–P debate as well as for biological practice. For biology the implication would be that there are two distinct kinds of individuals called “species” (I have argued in detail that this is indeed the case elsewhere; see Reydon 2004, 2005). It should be pointed out that this situation is not a case of conceptual relativism, according to which the same entities would be understood as three-dimensional objects on some conceptual schemes and as four-dimensional objects on other conceptual schemes.²⁰ It is not the case that species can be conceived of as three-dimensional or as four-dimensional objects, depending on which conceptual scheme one adopts. This, after all, would amount to the sort of view that was criticized in Sect. 4.1, on which species are not *really* three-dimensional or four-dimensional, but can be treated as either depending on which ontology is more suitable to the context at hand. On Lee and Wolsan’s suggestion, however, both species three-dimensionalism and species four-dimensionalism are true, i.e., both correctly tell us what the nature of some existing things is. The term “species,” then, is a homonymic term, used for two distinct ontological kinds (see also Reydon 2004, 2005). The biological community would have to decide for which of these henceforth the term “species” is to be used; after all, if there really are two different kinds of things denoted with the same term, scientific communication is not served by using the same term for entities of both kinds.

The position taken here with respect to the species problem might be interpreted as a form of pluralism. I believe, however, that such an interpretation would be off the mark. Pluralist positions presuppose that the different entities or phenomena denoted by the term in question have something in common (one can be a methodological pluralist, for example, by allowing that multiple methods—multiple instances of the same sort of thing, that is—are all suitable to achieve the envisaged aim). In the case of species, however, I interpret the term “species” as a homonym, i.e., as a word that denotes things of phenomena that are not all of the same basic sort. I have extensively discussed this issue elsewhere (Reydon 2005).

²⁰ An anonymous referee suggested this position. This is, in fact, the position that Hull defends when he writes that species names such as *Cygnus olor* are ambiguous between denoting four-dimensional lineages and three-dimensional time-slices of these: “*Cygnus olor* applies both to a spatiotemporally extended lineage and to a time-slice of that lineage.” ([1975] 1989). That is, species are four-dimensional “space-time worms,” but we use their names to denote both these “space-time worms” and *their* three-dimensional temporal segments. As I clarify in the main text, this is not the position that I hold.

With respect to the E–P debate, here we would have a case in which three-dimensionalism would be true with respect to some kinds of objects and four-dimensionalism would be true as well with respect to other kinds of objects. This would suggest a “mixed metaphysics” in which the world is understood as consisting of both three-dimensional and four-dimensional entities. The case of species would then constitute a case against a general, all-encompassing three-dimensionalism according to which *only* three-dimensional entities are real, as well as against a general, all-encompassing four-dimensionalism according to which *only* four-dimensional entities are real.

It is not possible to evaluate the general plausibility of such a mixed metaphysics within the confines of this paper. Suffice it to remark here that a mixed metaphysics, according to which some things are always wholly present at those times at which they exist whereas others have only a temporal parts present, it is at least not wholly implausible. There are no arguments to a priori exclude the possibility of such a metaphysics and it has been suggested as a feasible option in other contexts. On the adoption of a three-dimensional ontology for material objects, for instance, a four-dimensional ontology for events still seems appropriate (e.g., Butterfield 2005: p. 239). This is unproblematic, since material objects and events constitute two different ontological categories, so that things of one category may well be three-dimensional in nature while things of the other category are four-dimensional. In the case of species, a similar situation could hold. The material objects that take part in evolutionary processes are three-dimensional material objects, all the parts (organisms) of which are present at any time at which they exist. This they must be in order to function as wholes in evolutionary processes. The entities that constitute the basic parts of the tree of life are four-dimensional entities. This they must be if they are to function as segments of a historical, time extended pattern. Both sorts of entities are called “species”—but this is a matter of terminology only, which can be remedied easily by devising a new term for one of the two sorts of things.

From the perspective of philosophy of biology, Lee and Wolsan’s suggestion is attractive and I want to endorse it here. It is better able to make sense of how species are understood in biological science than its three alternatives. Option (3) fails on the criterion of intertranslatability; and on rejection of intertranslatability as an applicable criterion for assessing whether two theories are metaphysically equivalent, option (3) still comes with the difficult—if not impossible—task of showing *that* the two ways of conceptualizing species indeed pertain to the same entities. Options (1) and (2), to which I turn in the following section, stand in a deadlock and focus too much on particular domains of biological science, while tending to ignore other domains. Lee and Wolsan’s suggestion might come at the price of having to adopt a counterintuitive metaphysics. If it does come at such a price and exactly how high this price is, is ultimately a matter for analytic metaphysics to decide—but I do not think that it would necessarily be unaffordable.

4.3 Either 3D or 4D, but not both

The preceding discussion can provide us with a clearer understanding of why the opposition between species three-dimensionalism (option (1)) and species

four-dimensionalism (option (2)) has proven so hard to resolve in favor of one of the two contenders.

In recent work, the biologist De Queiroz (1998, 1999, 2005a,b) and the philosopher Stamos (2002, 2003: pp. 67–84) suggested that the synchronic as well as the diachronic species concepts that are on offer actually all pertain to the same sort of entities. De Queiroz made the more explicit case. According to De Queiroz (1998: p. 57), “Each species definition has a different emphasis, but the various phenomena that they emphasize are all aspects or properties of a single kind of entity.” The entities in question, De Queiroz argued, are segments of population-level lineages, i.e., four-dimensional entities that extend in space as well as in time (De Queiroz 1998: p. 60; 1999: pp. 49–53, 61; 2005a: pp. 1263–1264).²¹ In a similar spirit, Stamos (2002, 2003) distinguished between “horizontal species” and “vertical species,” understanding vertical species as lineages that extend over long periods of time and horizontal species as extended for comparatively short periods (“around 3,000 years to be safe,” Stamos 2002: p. 177). Although according to Stamos the horizontal dimension has priority over the vertical dimension, his ontological view of species still is four-dimensionalist because of the temporal extendedness of horizontal as well as vertical species.

It is ultimately an empirical question whether De Queiroz and Stamos are correct, but the above discussion suggests that they are not. De Queiroz (2005b: pp. 6601–6602) implicitly assumes that synchronic and diachronic accounts of species are intertranslatable and that synchronic and diachronic species concepts thus constitute merely different ways of looking at entities that are ontologically of the same sort. Similarly, Stamos assumes that horizontal species are best conceptualized as four-dimensional entities with a comparatively short temporal extent and thereby presupposes that horizontal and vertical species concepts should be intertranslatable. The species-are-individuals thesis, in their view, thus adequately answers the question regarding the nature of species. However, neither De Queiroz nor Stamos show *that* intertranslatability indeed obtains between the various species concepts. And even if intertranslatability would have obtained, both De Queiroz and Stamos still fail to make the metaphysical case in favor of four-dimensionalism over three-dimensionalism. There is nothing in De Queiroz’ solution to the species problem that would conflict with the claim that four-dimensional accounts of species might be preferable for epistemological reasons while pertaining to objects that are *really* three-dimensional. The same holds regarding Stamos’ view. Their attempts to reconcile synchronic and diachronic species concepts, then, remain unconvincing.

The reason why the opposition between synchronic and diachronic accounts of species remains in a deadlock, I suggest, is the same as why it could not be shown that the two theories are metaphysically equivalent. The ontological status of species is *underdetermined* by the species-are-individuals thesis, so that the controversy between synchronic and diachronic accounts of species is a metaphysical controversy in which species three-dimensionalism is pitted against species four-dimensionalism.

²¹ “[D]efinitions that equate species with populations consider the entities of interest over relatively short time intervals, whereas those definitions that equate species with lineages consider them over longer time intervals. (...) [T]hey merely describe time-limited and time-extended versions of the same species concept.” (De Queiroz 1999: p. 54; see also, 1998: p. 63; 2005a: p. 1263).

Proponents of synchronic accounts of species and advocates diachronic accounts of species, it seems, really are talking about different kinds of things (cf. [Reydon 2004, 2005](#))! This, then, is one important reason why the species problem has so far resisted all attempts at a resolution and why attempts to reconcile the opponents like the ones presented by De Queiroz and Stamos are destined to fail.

5 Conclusion

The principal issue in this paper was whether the metaphysical worry about three-dimensionalism and four-dimensionalism can help us to better understand the nature of the species problem and the claims that biologists and philosophers of biology make regarding the nature of species. Of additional interest was to see whether from the analysis of the case of species conclusions can be drawn regarding the feasibility of particular positions in the endurantism–perdurantism debate. These questions can now be answered.

I have shown how the case of species can serve as a case study for the E–P debate to illuminate the various positions that can be taken there. In this respect, Sect. 4 provided the following result. It is unlikely that species three-dimensionalism and species four-dimensionalism are metaphysically equivalent theories in the sense of the 3D/4D equivalence thesis that is defended in the E–P debate (but I have only considered a few criteria for metaphysical equivalence). The case of species thus constitutes a case in which McCall and Lowe’s 3D/4D equivalence claim does not hold and sheds doubt on the general validity of their claim. In the case of species we cannot “freely choose whether to describe it in 3D or 4D terms” ([McCall and Lowe 2006](#)). Second, the case of species points in the direction of the position that three-dimensionalism and four-dimensionalism are both true descriptions of different sorts of real entities. If species three-dimensionalists and species four-dimensionalists indeed do not talk about the same objects, the case of species points in a direction where analytical metaphysics might look for a resolution of the E–P debate, namely in the direction of a mixed metaphysics.

Conversely, the metaphysical worry about endurantism and perdurantism is instructive for the species problem for at least three reasons. First, the E–P debate provides tools for scrutinizing the various positions that can be defended in the species debate. I have used some of the criteria that have been advanced to defend 3D/4D equivalence in the E–P debate to assess the feasibility of a similar position in the species debate—with a negative result. Moreover, considerations from the E–P debate help us to understand what it can mean to claim that species are individuals. The species-are-individuals thesis underdetermines the nature of species and can be interpreted in two metaphysically different ways. Species three-dimensionalism and species four-dimensionalism say different things about the nature of species, so asserting that species are individuals without explicating what sort of individuals one has in mind just will not do (cf. also [Stamos 2002](#): p. 172). And third, considerations from the E–P debate help us to clarify the nature of the species problem and in this way to see why the species problem has not yet gone away.

The cross-fertilization of the E–P debate and the species debate undertaken here has served to clarify what exactly is at stake in the two debates and why the opponents in the debates stand in apparently irresolvable deadlocks. To be sure, I have not presented any decisive arguments in favor of or against any position in either of the two debates. But pending such arguments, I have attempted to distinguish the more promising avenues in the two debates from the dead ends. The broader moral of the present paper is, of course, that a lot may be gained for both analytic metaphysicians and philosophers of science by looking at each other's fields—and that a lot may be missed by remaining for too long within the confines of one's own field.

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