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The Metaphysical Equivalence Between 3D and 4D Theories of Species

VANESSA TRIVIÑO* | MARÍA CEREZO**

Resumo

Neste artigo, vamos considerar o recente debate na metafísica da evolução, no que diz respeito tanto à persistência como à "mudança" em espécies biológicas, segundo a tese que considera a espécie como o agregado de indivíduos. Centrar-nos-emos na proposta de Thomas Reydon, que argumenta que em biologia, o termo "espécie" refere-se a duas entidades biológicas, por si denominadas *evolverons* e *phylons*, que desempenham vários papéis epistemológicos em pelo menos duas disciplinas diferentes, nomeadamente na biologia sistemática e na biologia evolutiva. Em particular, analisamos criticamente a alegação de Reydon, que estas duas entidades biológicas geraram um problema para a tese que sustém a equivalência entre duas teorias de persistência, desenvolvidas pela metafísica analítica contemporânea: o tri–Dimensionalismo (3D) e tetra–Dimensionalismo (4D). Neste artigo, pretende-se restaurar a tese da equivalência metafísica, recorrendo a uma tripla estratégia: promover a ideia de que os *evolverons* e os "phylons" são duas dimensões de uma mesma realidade; recorrer a uma noção menos problemática noção de endurantismo (persistência 3D) e, por último, destacar alguns problemas que surgem dos exemplos biológicos empregues por Reydon para basear o desenvolvimento dos seus argumentos.

Palavras-chave : conceito de espécie, endurantismo, equivalência metafísica entre 3D e 4D, espécies biológicas sincrónicas e diacrónicas, persistência

Abstract

In this paper we revise a recent debate on the metaphysics of evolution pertaining to both the persistence and change of biological species, and the species-as-individuals thesis. We focus on Thomas Reydon's proposal that, in biology, the term "species" refers to two different biological entities, which he calls *evolverons* and *phylons,* and plays different epistemological roles in at least two different disciplines in which it is used, namely, evolutionary and systematic biology. In particular, we critically revise Reydon's claim that these two biological entities raise a problem for the thesis of the equivalence between the two theories of persistence developed in contemporary analytic metaphysics: three–dimensionalism (3D) and four–dimensionalism (4D). In this paper, we aim to reinstate the thesis of metaphysical equivalence by a threefold strategy: motivation of the idea that *evolverons* and *phylons* are two dimensions of the same entity, shifting to a less problematic notion of endurance (3D persistence), and an exploration of doubts about the particular biological examples upon which Reydon bases his arguments.

Keywords : 3D/4D metaphysical equivalence, endurantism, persistence, species concept, synchronic and diachronic biological species

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Introduction

Most work in the philosophy of science in the 20th century has been centred on the epistemology and methodology of science due most likely to its neopositivist inspiration. Classic issues were the problems of induction, prediction and explanation, and some examples of important contributors to that tradition are Hempel, Popper or Goodman, to mention but a few. In general terms, the authors of this tradition did not pay much attention to the metaphysical commitments of scientific theories or to the metaphysical issues that arose as a consequence of scientific discoveries or findings, nor did they develop ontological frameworks to better understand scientific theories.

In recent years, however, there has been an increasing interest in issues at the intersection of metaphysics and science. Classic issues at this intersection are those concerning the laws of nature, causality and dispositions. In most cases, the work focuses on theories and concepts in physics and their implications for the characterisation of the laws of nature or causality, for example. The cross-fertilisation between metaphysics and biology is, however, less common. On this occasion we want to focus our attention on one specific example of such cross-fertilisation, in particular, between the contemporary theories of persistence in analytic metaphysics and the concept of species in post-Darwinian biology.

Michael Ghiselin and, later, David Hull were perhaps two of the first authors to highlight the issue of the ontological nature of species within the field of evolutionary biology. They thought that the idea that species can evolve, i.e., change through time, requires them to be thought of ontologically as individuals.[1] This conception of species is known as the *species-as-individuals* thesis, in opposition to the classic idea of *species-as-classes*. Other authors, such as Judith Crane and, in particular, Thomas Reydon, have paid attention to more tangible metaphysical issues in the philosophy of biology.[2] Given the *species-as-individuals* thesis, they focus on explaining the way in which such individuals persist. In order

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[1] Ghiselin, Michael – "A radical solution to the species problem". *Systematic Zoology*, 23 (4), 1974, pp. 536-544; Hull, David – "Are species really individuals?". *Systematic Zoology*, 25 (2), 1976, pp. 174-191; Hull, David – "A matter of individuality". *Philosophy of Science*, 45 (3), 1978, pp. 335-360.

[2] Crane, Judith – "On the Metaphysics of Species". *Philosophy of Science*, 71 (2), 2004, pp. 156-173; Reydon, Thomas – "On the nature of the species problem and the four meanings of 'species'". *Studies in History and Philosophy of Biological and Biomedical Sciences*, 36, 2005, pp. 135-158; Reydon, Thomas – "Species in three and four dimensions". *Synthese*, 164, 2008, pp. 161-184.

to develop such task, they appeal to the theories of persistence developed in contemporary analytic metaphysics, and the two associated theories of objects, three–dimensionalism and four–dimensionalism.

In particular, Reydon defends the view that the persistence of species raises a problem for the thesis, recently defended in contemporary analytic metaphysics, that upholds the equivalence between three–dimensionalism and four–dimensionalism. He claims that if we apply these two metaphysical theories of persistence to the case of species, metaphysical equivalence fails, and that three–dimensionalist and four–dimensionalist theories of species are not different ways of describing the same reality, but rather, descriptions of different entities.

In this paper, we aim to reinstate the metaphysical equivalence thesis by a threefold strategy: motivation of the idea that *evolverons* and *phylons* are two dimensions of the same entity, recourse to a less problematic notion of endurance (3D persistence), and an exploration of doubts about the particular biological examples upon which Reydon bases his arguments. Sections 1 and 2 include some background knowledge on the metaphysics of persistence and the species problem necessary to understand Reydon's account and our revision. Section 3 presents Reydon's position on the metaphysics of evolution, in particular on the *species concept issue* (section 3.1) and the *temporal dynamic issue of species* (section 3.2). Section 4 includes our critical revision of Reydon's arguments with a view to reinstating metaphysical equivalence between 3D and 4D theories of biological species, by motivating the idea that *evolverons* and *phylons* are two dimensions of the same entity (section 4.1), revising the notion of endurance he uses (section 4.2), and addressing the biological examples upon which he bases his conclusion that 3D and 4D theories of species are not equivalent: cases of hybridization and asexual species (section 4.3).

1. Contemporary analytic metaphysics of persistence

There is an important issue in contemporary analytic metaphysics concerning our understanding of the persistence of entities: how is it possible for an entity to be the same numerical entity over a period of time despite the compositional and qualitative changes it experiences over that time? The two standard replies to this question are perdurantism and endurantism.

According to the standard conception of endurantism, which Reydon takes into account, the entities persist by being "wholly present" i.e., by having all of their parts present at each point in time at which they exist.[3] In this account, change consists of having different spatial parts and/or properties at different times. Lowe and Simons, for example, have defended some versions of the endurantist view of persistence.[4] On the other hand, perdurantism claims that an entity persists by having different temporal parts each of which exists at the different times at which the entity exists. In this account, change means having different temporal parts (with different properties and/or composition) at different times. Quine, Sider, Armstrong and Heller are well-known defenders of perdurantism.[5]

Some endurantists have considered that the ontological status of the entities that persist by endurance consists in being three-dimensional entities. Enduring entities are objects that are extended in three spatial dimensions but not in time. This account is known as three-dimensionalism. However, perdurantists consider the perduring entities as being four dimensional insofar as they are extended in both spatial and temporal dimensions. This conception of the entities is called four-dimensionalism. Thus, an object *o* is composed of the temporal parts $o\text{-}at\text{-}t_1$, …, $o\text{-}at\text{-}t_n$, where (t_1 ,…, t_n) is the sequence of all the times at which *o* exists, from its coming into existence (at t_1) to its ceasing to exist (at t_n).

Although the question about how entities in the world persist is different from the question about how they are ontologically, endurantism and perdurantism tend to be associated with three dimensionalism and four dimensionalism respectively (hereafter 3D and 4D).[6] As a result, the debate between endurance and perdurance is translated into the debate between 3D and 4D; and it consists in which of the two competing positions holds the correct view of the nature of the entities in the world and of their persistence.[7]

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[3] Miller, Kristie – "The metaphysical equivalence of three and four dimensionalism". *Erkenntnis*, 62, 2005, p. 110.

[4] Lowe, Edward Jonathan – "Lewis on Perdurance versus Endurance". *Analysis*, 47 (3), 1987, pp. 152-154; Simons, Peter – "How to exist at a time when you have no temporal parts". *The Monist*, 83, 2000, pp. 419-436.

[5] Quine, Willard Van Orman – "Identity, ostension and hypostasis". In: Quine, Willard Van Orman – *From a Logical Point of View*. London: Harvard University Press, 1950-1952; Sider, Theodore – "Four-dimensionalism". *Philosophical Review*, 106, 1997, pp. 197-231; Armstrong, David – "Identity through time". In: Van inwagen, Peter (ed.) – *Time and Cause*. Dordrecht: Reidel, 1980, pp. 67-68; Heller, Mark – "Temporal parts of four dimensional objects". *Philosophical Studies*, 46, 1984, pp. 323-334.

[6] Miller, Kristie – " The metaphysical equivalence of three and four dimensionalism", cit., p. 91.

[7] A useful presentation of the different positions held in the 3D-4D debate can be found in Sider (Sider, Theodore – *Four Dimensionalism: An Ontology of Persistence and Time*. Oxford: Clarendon Press, 2001) and in Miller (Miller, Kristie – *Issues in Theoretical Diversity: Persistence, Composition and Time*. Springer, 2010).

Despite the discrepancies between these theories, different authors have considered that 3D and 4D are, in fact, equivalent. The thesis of equivalence between endurantism (3D) and perdurantism (4D) was proposed by McCall and Lowe and afterwards defended by authors such as Hirsch, Butterfield and Miller.[8] In this article, we will only pay attention to McCall and Lowe's, and Miller's versions of the thesis of equivalence, upon which Reydon's work depends.

McCall and Lowe claim that both 3D and 4D theories of persistence are equivalent insofar as the different descriptions of the world they offer are intertranslatable without any loss of information.[9] They conceive of endurant objects as objects composed of particles at each time at which they exist, and change is accounted for in terms of spatial changes in those particles. Each endurant object at each time can be identified with the *sum-of-its-particles-at-such-time*. This allows the authors to intertranslate 3D to 4D, and vice versa, by correlating the *sum-of-particles-at-a-time* of a 3D object with the temporal part of that object conceived as a 4D object. The intertranslatability between 3D and 4D highlights the fact that the 3D/4D debate is metaphysically empty, i.e., "there is no "fact of the matter" in the world which makes one of the descriptions true and the other false".[10]

According to Miller, two theories T_1 and T_2 are metaphysically equivalent if

(i) T_1 and T_2 are empirically equivalent, i.e., they make the same observational predictions;

(ii) T_1 and T_2 have the same theoretical virtues (such as, for example, simplicity, explanatory scope and force); and

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[8] McCall, Storrs & Lowe, Edward Jonathan – "3D/4D Equivalence: The Twins Paradox and Absolute Time". *Analysis*, 63, 2003, pp. 114-123; Hirsch, Eli – "Physical-Object Ontology, Verbal Disputes, and Common Sense". *Philosophy and Phenomenological Research*, 70 (1), 2005, pp. 67-97; Butterfield, Jeremy – "On the Persistence of Particles". *Foundations of Physics*, 35, 2005, pp. 233-269; Miller, Kristie – "The metaphysical equivalence of three and four dimensionalism", cit.; Miller, Kristie – *Issues in Theoretical Diversity: Persistence, Composition and Time*. Springer, 2010.

[9] McCall, Storrs & Lowe, Edward Jonathan – "3D/4D Equivalence: The Twins Paradox and Absolute Time", cit., pp. 114-123; McCall, Storrs & Lowe, Edward Jonathan – "The 3D/4D Controversy: A Storm in a Teacup". *Noûs*, 40 (3), 2006, pp. 570-578.

[10] McCall, Storrs & Lowe, Edward Jonathan – "3D/4D Equivalence: The Twins Paradox and Absolute Time", cit., p. 118; McCall, Storrs & Lowe, Edward Jonathan – "The 3D/4D Controversy: A Storm in a Teacup", cit., pp. 570-571.

(iii) there is a truth-preserving assertability mapping between T_1 and T_2. An assertability mapping is a function that maps the sentences of one theory onto the sentences of another only if those sentences are assertable under the same possible situations.[11]

In Miller's account of equivalence, meeting the three criteria implies that two theories are metaphysically equivalent. However, Reydon favours McCall and Lowe's view on this point, separating epistemological and metaphysical equivalence, and considering that (iii) is a sufficient criterion for metaphysical equivalence. Criterion (i) depends on criterion (ii), since empirical equivalence between T_1 and T_2 requires that the two theories have the same explanatory scope[12]; and (ii) is a necessary criterion for epistemological equivalence, but not for metaphysical equivalence. As a consequence, it is possible to establish the metaphysical equivalence of two theories by considering only criterion (iii), i.e., the existence of an assertability mapping.[13] In this paper, and in particular in Section 4, when assessing the application of 3D/4D equivalence to the case of biological species, we will focus therefore only on criterion (iii), which is where Reydon centres his attention.

2. The species problem

The so-called "species problem" refers to a widespread debate that has been developed in both biology and philosophy in order to answer the question: *What are species?* In general terms, this question amounts to the problem about how biologists should identify species in nature and, therefore, how they should define the "species" concept. This question is actually a cluster of more particular problems that arise depending on the perspective adopted.

On the one hand, from an epistemological perspective, there is the *species concept issue,* which is the most common. The problem derives from the fact that there is a multiplicity of criteria for species membership associated with a multiplicity of species concepts. There are over twenty

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[11] Miller, Kristie – *Issues in Theoretical Diversity: Persistence, Composition and Time*, cit., pp. 7-8.

[12] Reydon considers (i) as an empiricist formulation of McCall and Lowe's claim that if intertranslatibility holds, the metaphysical questions (whether the world is really 3D or 4D) is empty (Reydon, Thomas – "Species in three and four dimensions", cit., p. 172).

[13] Reydon, Thomas – "Species in three and four dimensions", cit., pp. 172-174

different criteria that biologists use to classify organisms.[14] Some examples are the biological, morphological, genetic and phylogenetic species concepts.

The biological species concept is perhaps the most commonly accepted, and defines a species as an interbreeding natural population isolated from other such groups.[15] The morphological species concept appeals to morphological criteria to determine whether an organism belongs to a species: a species is a group of organisms based upon overall similarity, where such similarity can be established by ordinary means. This is the classic species concept, that used by Aristotle and Linnaeus.[16] The genetic concept considers that a species is a group of organisms that forms a genetic unity, in which a common gene pool is inherited and shared among the members of the community.[17] Finally, the phylogenetic species concept rests on the idea that classification of organisms must reflect their genealogy, and thus, a species is the smallest group of organisms that share a common descent, that is, the smallest cluster within which a parental pattern of ancestry and descent can be established.[18]

Such species concepts are only examples, but a problem arises because the different criteria used to decide whether an organism belongs to a species yield different and sometimes inconsistent results. The existence of so many species concepts commits most biologists and philosophers of science to a pluralist conception of species, but raises an important issue which could be referred to as the *realism species issue:* are species real biological entities existing in nature, or are they "part of the order-loving mind"?[19] In this paper, we leave aside this issue, but it is important to bear in mind that Reydon's approach, and in particular his solution to the *species*

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[14] Mayden, Richard – "A hierarchy of species concepts: the denouement in the saga of the species problem". In: Claridge, Michael; Dawah, Hassan & Wilson, Michael (eds.) – *Species: The Units of Diversity*. London: Chapman and Hall, 1997, pp. 381-423.

[15] Mayr, Ernst – *Populations, Species and Evolution*. Cambridge: Harvard University Press, 1970.

[16] For a recent defense of this concept, see Cronquist (Cronquist, Arthur – "Once again, what is a species?". In Knutson, Lloyd (ed.) – *BioSystematics in Agriculture*. Montclair NJ: Alleheld Osmun, 1978, pp. 3-20).

[17] Dobzhansky, Theodor – "Evolution in the tropics". *American Scientists*, 38, 1950, pp. 209-221.

[18] Eldredge, Niles & Cracraft, Joel – *Phylogenetic Patterns and the Evolutionary Process: Method and Theory in Comparative Biology*. New York: Columbia University Press, 1980.

[19] Dobzhansky, Theodor – "A Critique of the Species Concept in Biology". *Philosophy of Science*, 2 (3), 1935, p. 345.

concept issue, and to the *species ontology issue* (see below), commits him to a realist position. Indeed, his solution to the *species concept issue* can be seen as a way of defending realism by maintaining that there are different entities which are determined by such species concepts (see Section 3.1.).

On the other hand, from an ontological perspective, the *species problem* amounts to the issue of clarifying their ontological status, whether species are individuals or, rather, natural kinds or classes.[20] We will refer to this issue as the *species ontology issue.* The conception of species as natural kinds or classes has been defended by the earliest taxonomists. According to this view, species are groups of organisms that have necessary and sufficient properties in common. These properties refer to the *essence* of organisms and they are important in determining the species of which the organism is a member. Being kinds or classes, species are abstract entities; they are unchangeable, and they do not have spatio-temporal restriction. After the Darwinian revolution, since all of these elements did not allow us to think of species as evolving entities,[21] it was necessary to propose a new way of regarding them, and Ghiselin and Hull suggested the idea of biological species as individuals.

Considered as individuals, species are concrete entities, and the organisms that belong to a species are its spatial parts, and thus compose the species. The relation of a particular organism to its species is analogous to the relation of a cell to the organism which it belongs to. As cells are related to one another in an organism to form an integrated whole, the organisms that are part of a species are related to each other by biological relations, so that a species is a cohesive and structured whole.

Species-as-individuals are spatio-temporally restricted, they occupy a geographical space, and extend in time, since they have an origin and they become extinct. Thus, they are dynamic, evolving entities. This dynamic consideration of *species-as-individuals* raises a further issue which is crucial for our purposes: the *temporal dynamics issue of species*. The question now is whether species should be considered *synchronically*, that is, as the organisms that are part of a species at a particular time *t*, or *diachronically,* that is, as the organisms that are part of a species during an extended period of time, namely, the period of the life of such species.[22]

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[20] Mayr, Ernst – "The ontological status of species". *Biology and Philosophy*, 2, 1987, pp. 145-166; Ghiselin, Michael – *Metaphysics and the Origin of Species*. Albany, NY: SUNY Press, 1997.

[21] Mayr, Ernst – "The ontological status of species", cit., p. 148.

[22] Stamos, David – "Species, Languages, and the Horizontal/Vertical Distinction", *Biology and Philosophy,* 17, 2002, pp. 171-198; Stamos, David – *The Species Problem:*

3. Reydon's proposal on the metaphysics of evolution

In his work on the metaphysics of evolution, Reydon has aimed at solving the *species concept issue* by defending the view that the term "species" is homonymic, and he has also addressed the *temporal dynamics issue of species,* using contemporary analytic metaphysics as a tool to clarify his position.[23] In this Section, we introduce Reydon's views, and the relations between them, in order to discuss some of his arguments in the last Section.

3.1. *Reydon's solution to the species concept issue*

Reydon considers that the *species concept issue* has not yet been solved because neither philosophers nor biologists have realized the true causes of the difficulty: that there are various and independent species concepts which refer to different ontological entities and which play particular roles in different biological fields.[24] According to Reydon, a good answer to the species problem should highlight the autonomous character of the different species concepts at stake.

In looking for a proper way of answering the *species concept issue*, Reydon proposes the idea of "species" as a *homonymic term*, i.e., a term whose use is shared by various biological fields but that has different meanings in each field. Since each biological field has its own research questions, the term plays different epistemological roles (explanation, classification and generalization) depending on where it is used,[25] and refers to different entities (*evolverons*, *phylons*, *organism-kinds* and *evolveron-kinds*) in the diverse branches of biology.[26]

- *Evolverons* are dynamic entities that participate in the evolutionary process and interact with their environment and with other species as cohesive wholes. These are the entities referred to by the term "species" in *evolutionary biology*.

Biological Species, Ontology, and the Metaphysics of Biology. Lanham, MD: Lexington Book, 2003; Stamos, David – *Darwin and the Nature of Species*: New York: University of New York Press, 2007.

[23] Reydon, Thomas – "On the nature of the species problem and the four meanings of 'species'". *Studies in History and Philosophy of Biological and Biomedical Sciences*, 36, 2005; Reydon, Thomas – "Why does the species problem still persist?". *BioEssays*, 26, 2004; Reydon, Thomas – "Species in three and four dimensions, cit., p. 166.

[24] Reydon, Thomas – "Why does the species problem still persist?", cit., p. 301.

[25] Reydon, Thomas – "On the nature of the species problem and the four meanings of 'species'", cit., pp. 39-43.

[26] *Ibidem*, pp. 45-46.

- *Phylons* are static entities that result from the evolutionary process. They are what biologists in *systematic biology* call "species", and they are used to classify the biodiversity of the organic world due to their stability through time and their mutual exclusion.
- *Organism-kinds* and *Evolveron-kinds* refer, in the first case, to classes of organisms that exhibit similar structural and behavioural properties; and, in the second, to classes of organisms that occupy similar positions in evolutionary dynamics. These entities were called "species" by the earliest taxonomists, and they were used to establish explanatory and predictive generalizations. However, Reydon highlights the fact that they are still used in biological fields such as microbiology, the contemporary structuralist programme, and functional morphology and ecology, among others.[27]

And, what about the *species ontology issue?* According to Reydon, *organism-kinds* and *evolveron-kinds* are members of the ontological sort of classes,[28] whereas *evolverons* and *phylons* are members of the ontology of individuals.[29] Thus, both ontologies should be accepted when talking about species.

3.2. *Species-are-individuals* and the *temporal dynamic issue of species*

Although both ontologies (classes and individuals) are necessary in order to talk of species in different fields of biology, nowadays many biologists and philosophers defend the *species-are-individuals-thesis*[30] due to their commitment to evolutionary biology.[31] As we have seen, the theory of evolution presupposes a dynamic concept of species since the idea that they evolve requires both their persistence and change through time, and allows for a twofold consideration of species: synchronic and diachronic.

Under the synchronic perspective, species refer to those entities constituted by the organisms given at a particular time (see, for example,

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[27] *Ibidem*, p. 49.

[28] *Ibidem*, pp. 49-52.

[29] *Ibidem*, pp. 46-49.

[30] From now on, we follow Reydon in using "species-are-individuals" instead of "species-as-individuals" to continue highlighting his (and our) concern with the metaphysical nature of species (see Reydon, Thomas – "Species in three and four dimensions", cit., p. 163, fn. 3)

[31] Reydon, Thomas – "Species in three and four dimensions", cit., p. 166.

Bock).[32] In this conception of species, a mouse, for instance, is part of the species *Mus musculus* only during its lifetime while dead mice are not part of the species any more.[33] From a diachronic perspective, species are the entities composed not only by the organisms given at a particular time, but also by the organisms given at previous times (see, for example, de Queiroz).[34] In this conception, dead mice are part of the species *Mus musculus* in the same way as a living mouse is part of it.

Given this twofold perspective under which species can be considered, Reydon addresses the following question: are synchronic and diachronic species referring to the same reality; or are they two different entities? In other words, are *evolverons* (synchronic view of species) and *phylons* (diachronic view of species) one and the same reality seen under two perspectives, or are they two ontologically different realities?[35] To shed light on this question Reydon's strategy consists in paying attention to the *temporal dynamic issue of species* appealing to the metaphysical debate on whether entities persist by endurance, i.e., being three-dimensional (3D) entities; or by perdurance, i.e., being four-dimensional (4D) entities.[36]

As we have seen in the previous subsection, evolutionary biology considers species (*evolverons*) as the subject of the evolutionary process. Species are systemic wholes that interact with the environment and with other species. Since only living organisms can interact and contribute in that way to the gene pool of their species, in the field of evolutionary biology, living organisms constitute a species only at the time at which they exist, so that dead organisms, properly speaking, are not part of a species at the present time. Systematic biology, on the other hand, considers species as the main units to classify the biodiversity of life on earth. In this field, species (*phylons*) refer to phylogenetic lineages constituted by relations of common descent. This criterion includes both living present and dead past organisms in a species.

Since *evolverons* are composed only of living organisms whereas *phylons* are composed of living and dead ones, Reydon associates

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[32] Bock, Walter – "Species: the concept, category and taxon". *Systematic Zoology*, 41, 2004, pp. 178-190.

[33] Reydon, Thomas – "Species in three and four dimensions", cit., p. 169.

[34] de Queiroz, Kevin – "The General Lineage Concept of Species and the Defining Properties of the Species Category". In: Wilson, Robert (ed.) – *Species: New interdisciplinary essays*. Cambridge: MIT Press, 1999.

[35] The synchronic and diachronic perspectives of species can be respectively associated with *evolverons* and *phylons;* in what follows, we will use "synchronic species" and *evolverons* interchangeably, as we will also do with "diachronic species" and *phylons*.

[36] Reydon, Thomas – "Species in three and four dimensions", cit., pp. 161-184.

evolverons with an endurantist conception of persistence, i.e., they are "wholly present" at each time at which they exist; while he associates *phylons* with a perdurantist conception of species. Hence, *evolverons* are 3D entities (since only 3D entities persist by being "wholly present" at each time at which they exist), while *phylons* are 4D entities (since they do not persist by being "wholly present" but by having temporal parts existing at different times).[37]

4. Three dimensional and four dimensional theories of species and the thesis of 3D/4D equivalence.

Due to the association of *evolverons* with 3D, and of *phylons* with 4D, Reydon considers that the debate between whether species are *evolverons* or *phylons* can be discussed by means of the debate between three dimensional and four dimensional theories of species. And therefore, it can be solved by paying attention to the four different alternatives that can be defended in the 3D/4D debate: 1) the supremacy of 3D over 4D (that is, 3D is true whereas 4D is false); 2) the supremacy of 4D over 3D (4D is true whereas 3D is false); 3) the equivalence between both theories; and 4) the mixed ontology in which there are both 3D and 4D entities persisting in the world.[38]

Reydon does not pay attention in detail to alternatives 1 and 2, since he considers that *evolverons* (3D entities) and *phylons* (4D entities) are equally necessary in their biological fields. Rather, he prefers to focus on whether both accounts of species, i.e., three dimensional and four dimensional theories of species, are metaphysically equivalent (alternative 3) or not (alternative 4), to determine whether they are two different entities or simply two ways of describing the same entity.

In order to answer this question, Reydon examines whether three-dimensional and four-dimensional theories of species meet the criteria of equivalence given in McCall and Lowe's account as well as in Miller's.[39] In particular, since he considers intertranslatability or the existence of a truth-preserving assertability mapping as sufficient for metaphysical equivalence, he focuses on this criterion.

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[37] *Ibidem*, pp. 169-170.

[38] *Ibidem*, p. 170.

[39] McCall, Storrs & Lowe, Edward Jonathan – "3D/4D Equivalence: The Twins Paradox and Absolute Time", cit., pp. 114-123; McCall, Storrs & Lowe, Edward Jonathan – "The 3D/4D Controversy: A Storm in a Teacup", cit., pp. 570-578; Miller, Kristie – "The metaphysical equivalence of three and four dimensionalism", cit.

As we have seen, in McCall and Lowe's sense, intertranslation is accounted for in terms of composition. The parts that constitute a 3D object O at a time t should be the same as the parts that constitute a temporal part P of a 4D object at a time t; and vice versa. Applying this idea to three dimensional and four dimensional theories of species, there would be equivalence between them only in the case that organisms that constitute a 3D species (*evolverons*) at a time t are the same as those organisms that constitute the temporal part P of the corresponding 4D species (*phylon*s) at time t; and vice versa.

On the other hand, to say that there is a truth-preserving assertability mapping between two theories means that the sentences of every pair of the assertability mapping between 3D and 4D have the same truth-value. In the case of species, Reydon claims that the sentence that needs to be truth preserving in both theories is the following: "Organisms O_1 and O_2 are both parts of the same species S".[40]

Reydon makes a distinction between being intertranslatable *in principle*, and being intertranslatable *in practice,* where the former refers to the theoretical possibility of there being an intertranslation between 3D and 4D theories of species, and the latter to the possibility of finding such intertranslation. He raises problems for both kinds of intertranslatability. We consider, as it seems Reydon does, that intertranslatability *in practice* is mainly an epistemological problem, and we share Reydon's skepticism about the possibility of finding an actual intertranslation between both theories. But the difficulties in accessing such intertranslation should not challenge metaphysical equivalence between the two theories if they are intertranslatable *in principle*. In what follows, we focus only on the latter issue, which concerns the metaphysics of evolution.

Reydon explores some cases that he finds challenging for intertranslatability, such as hybridization and asexual species, and he concludes that these cases provide support for rejecting the metaphysical equivalence between 3D and 4D theories of species. In terms of Miller's account, such rejection derives from the fact that the sentence "Organisms O_1 and O_2 are both parts of the same species S" does not have the same truth-value in both theories.

In the following sections, we offer a revision of Reydon's account with a view to reinstating the metaphysical equivalence thesis. We start by briefly motivating metaphysical equivalence of 3D and 4D theories of species (subsection 4.1.) and then, we revise the notion of endurance

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[40] Reydon, Thomas – "Species in three and four dimensions", cit., p. 174.

used by Reydon and present a version that is better suited to dealing with the issue of living and dead organisms (subsection 4.2.). In the last part (subsection 4.3.), we address Reydon's challenge to intertranslation, which stems from the difficulties raised by cases of hybridization and asexual species.

4.1. *Motivating metaphysical equivalence between 3D and 4D theories of species*

As we have seen, Reydon bases his doubts about the equivalence between 3D and 4D theories of species upon the different ways in which evolutionary and systematic biology classify organisms. Both disciplines, however, consider species as evolving entities, even if the former regards species as the individuals that take part in the process of evolution and the latter treats them as the result of such a process. In terms of the whole process of evolution, *evolverons* and the organisms that constitute them are the entities directly involved in the *causal* mechanisms of the process of evolution (reproduction, natural selection and so on), and *phylons* and the organisms that constitute them are the *effect* of such causal mechanisms. Reydon separates the two entities, since he thinks that they are not metaphysically equivalent. But if this is so, how can we be really speaking about one and the same process of change of biological species? It would seem desirable that the species that participates in the process (*evolveron*) be the same as that whose history is represented in the tree of life (*phylon*). What sense does it make the idea that *phylons* are not the same as e*volverons*, if they represent their history? Which of them are the evolving entities referred to by the evolutionary theory? Should not we expect *evolving* and *evolved* species to be the same entities?

We actually think that this idea is behind the view defended by some biologists and philosophers of biology that the synchronic and diachronic conceptions of species are two dimensions of one and the same reality, like, for example, de Queiroz and Stamos.[41]

Let us illustrate this point by comparing the case of species with the case of organisms. When we introduced the *species ontology issue,* we said that, insofar as they are considered as individuals, species are spatio-temporally restricted. They have an origin and become extinct, so that we can speak of the life of a species, which persists by means of the

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[41] de Queiroz, Kevin – "Ernst Mayr and the modern concept of species". *Proceedings of the National Academy of Sciences of the USA*, 120, 2005b, pp. 6600-6607; Stamos, David – *Darwin and the Nature of Species*, ed. cit.

reproduction of its parts (organisms), in an analogous manner to the way in which we speak of the life of an organism, which is generated and dies, and persists by means of the reproduction of its parts (cells).

In the case of an organism, we can also distinguish the entity that interacts, which includes the *causal* mechanisms and operations that are responsible for the process of life (cell replication, nutrition, and so on) and the *resulting* life of the organism, extended in time. However, we do not say that there are two organisms involved, but there is rather only one that is considered under two different perspectives. Similarly, we also think that a conception of species as entities that can be considered under different temporal perspectives allows us to understand the sense in which the 4D *phylons* are the result of the processes in which 3D *evolverons* participate.

4.2. *Endurance and the case of living and dead organisms*

There is a tension in Reydon's approach between the idea that, under any perspective, both dead and living organisms are parts of a species, or as he puts it, "can be attributed to species",[42] and the idea that *evolverons* endure by being *wholly present* at every time at which they exist, which leads to the view that only living organisms can be considered as parts of *evolverons*.[43]

Reydon appears to overcome this tension by a twofold strategy. On the one hand, he distinguishes between *organisms being attributed to a species* (regardless of the time at which they exist) and *organisms that are part of a species* (at particular times). When we consider attribution of organisms to species, 3D and 4D theories of species are temporally on a par: at any time, past, present and future organisms are all included in a species. However, part-whole relations make a difference, because *evolverons* are wholly present at the times at which they exist, so that 3D and 4D theories of species are not temporally on a par: at any time, past, present and future organisms are part of diachronic *phylons,* but only present organisms are part of synchronic *evolverons*.

On the other hand, Reydon holds that the phylogenetic network structures in which 4D species are represented can be translated without any loss of information into 3D species by mapping 4D ancestor-descendant relations onto 3D breeding relations.[44] But the tension is not

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[42] Reydon, Thomas – "Species in three and four dimensions", cit., p. 168.

[43] *Ibidem*, p. 169.

[44] *Ibidem*, p. 174.

really overcome. For such translation to have metaphysical import, past organisms must be considered *to be part* of *evolverons* too.

If we take the notion of endurance as *being wholly present* seriously, there seems to be a problem with intertranslation. Since a dead organism that is part of a diachronic species *(phylon)* cannot be part of the synchronic species (*evolveron*), it is not possible to intertranslate from *phylon* to *evolveron* without the loss of information. Hence, there is no equivalence in the sense of intertranslation as proposed by McCall and Lowe. Similarly, there is no truth-preserving assertability mapping either. The reason is that, if at a time t organism O_1 is a living organism of a species S, and organism O_2 is a dead organism of the same species S, then the sentence "organisms O_1 and O_2 are both parts of the same species S" will not be true in both theories at t. It will be true for systematic biologists insofar as they consider O_1 and O_2 to be part of the species S; whereas it will be false for evolutionary biologists who consider that only the living organism O_1 is part of the species S.

We consider that the problem can be overcome if the notion of endurance is adequately rectified. Reydon's argument for the association between synchronic species and 3D entities is based upon the notion of endurance proposed by Lewis.[45] But this conception of endurance has been criticised due to the fact that Lewis does not specify what he means by an entity being *wholly present*, and therefore, what endurance really means.[46] The difficulty lies in explaining how an entity can be *wholly present* at each time at which it exists, if some of its parts and properties are not manifested at all at those times. In our example, how can a species be wholly present at a time t if dead (and future) organisms are not living at that time?

Fortunately, various alternative definitions of *endurance* have been proposed by authors such as, Merricks, Sider, McKinnon, Hawley, McCall and Lowe and Miller, among others.[47] Under some of these notions of

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[45] Lewis, David – *On the Plurality of Worlds*. Oxford: Blackwell Publishers, 1986.

[46] Lowe, Edward Jonathan – "Lewis on Perdurance versus Endurance", cit., pp. 152-154; McCall, Storrs & Lowe, Edward Jonathan – "The Definition of Endurance". In: *Analysis*. 69 (2009), p. 277-280; Miller, Kristie – *Issues in Theoretical Diversity: Persistence, Composition and Time*, ed. cit.

[47] Merricks, Trenton – "Persistence, Parts and Presentism". *Noûs*, 33, 1999, pp. 421-438; Sider, Theodore – "Four-dimensionalism". *Philosophical Review*, 106, 1997; and Sider, Theodore – *Four Dimensionalism: An Ontology of Persistence and Time*, ed. cit; McKinnon, Neil – "The Endurance / Perdurance Distinction". *Australian Journal of Philosophy*, 80, 2002, pp. 288-306; Hawley, Katherine – *How Things Persist*. Oxford: Clarendon Press, 2001; McCall, Storrs & Lowe, Edward Jonathan – "The Definition of Endurance", cit.,

endurance, the tension generated by dead organisms can be solved. We will focus only on McCall and Lowe's notion since their metaphysical equivalence thesis is that challenged by Reydon.

According to McCall and Lowe, to say of an entity that it endures does not amount to say of it that it is "wholly present" at each time at which it exists.[48] They offer the following definition:

> For such an object to endure, we shall say, is simply to exist at more than one time. To this can be added the notion of "continuous endurance". A 3D object X endures continuously from t_1 to t_2 (i.e., is a continuant) if X exists at t_1, t_2 and at every time between t_1 and t_2. These definitions are simple yet precise, and rest on no dubious ideas of something being "wholly present".[49]

In this sense, it is not difficult to think about a 3D entity that is composed of past, present and future parts.[50] In the case of species, dead organisms are part of a 3D species precisely because the species exists for the interval of time of its life, and there is a time in that interval at which the organisms are present in the species in the same way as past cells of an organism are parts of an organism because the organism exists for the interval of its life, and there is a time in that interval at which those cells were present in the organisms. In other words, for an organism *to be part of* a 3D species *simpliciter,* it is sufficient that there is a time at which the organism was present in the species, even if all the organisms that are part of a species are not present at each and every time at which the species exists.

To conclude, considering McCall and Lowe's notion of endurance, the synchronic species (*evolveron)* would be conceived of as an entity that exists at all times over an interval without having temporal parts and without being "wholly present" at any time within the interval. Hence, a synchronic species S can be considered as a 3D entity that persists by endurance. But, in this case, it would not be a problem to say that the species S that endures is composed of organisms O_1, O_2, O_3 and O_4 at

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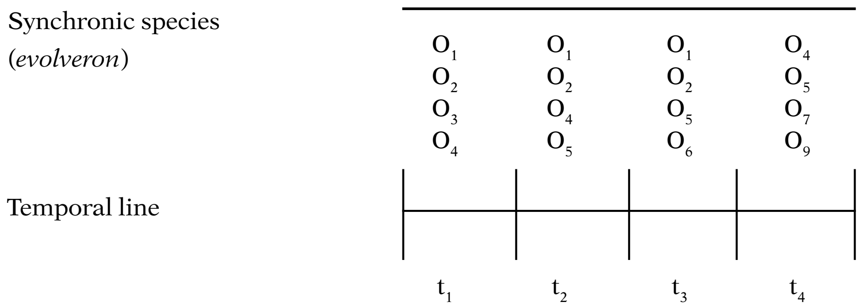
pp. 277-280. Miller presents a good synthesis of the problem of defining endurance in this sense of an entity being "wholly present" (Miller, Kristie – *Issues in Theoretical Diversity: Persistence, Composition and Time*, ed. cit.).

[48] McCall, Storrs & Lowe, Edward Jonathan – "The 3D/4D Controversy: A Storm in a Teacup", cit., pp. 570-578; McCall, Storrs & Lowe, Edward Jonathan – "The Definition of Endurance", cit., pp. 277-280.

[49] McCall, Storrs & Lowe, Edward Jonathan – "The 3D/4D Controversy: A Storm in a Teacup", cit., p. 572.

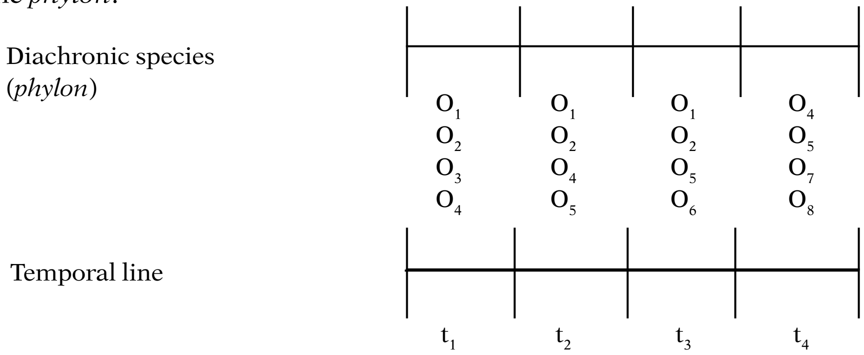
[50] McCall, Storrs – "Philosophical consequences of the twins paradox". *Philosophy and Foundations of Physics*, 1, 2006, p. 198.

time t_1 and of organisms O_4, O_5, O_6 and O_7 at t_4, even if all those organisms are parts of the species.



In this image we have a synchronic species (*evolveron*) that persists by endurance in the sense proposed by McCaII and Lowe (2006, 2009), i.e., by existing at different times over an interval (from t_1 to t_4), without having temporal parts and without being wholly present at each time within the interval.

This notion of endurance allows for an intertranslation between *evolverons* and *phylons* without loss of information in the following terms: let us consider a synchronic species *(evolveron)* that extends over the interval of time from t_1 to t_4. At t_1, the *evolveron* is composed of organisms O_1, O_2, O_3 and O_4; at t_2 of organisms O_1, O_2, O_4 and O_5; at t_3 of organisms O_1, O_4, O_5 and O_6, and finally, at t_4, the *evolveron* is composed of organisms O_4, O_5, O_6 and O_7. To translate from *evolverons* to *phylons*, we only have to take into account those organisms that constitute the synchronic species at the different times over the interval $t_1 - t_4$, which are the same organisms that constitute the different temporal parts tp_1, tp_2, tp_3 and tp_4, respectively, of the *phylon*.



In this image we have a diachronic species (*phylon)* that persists by perdurance, i.e., by having different temporal parts that exists at different times over an interval, from t_1 to t_4.

In order to translate from *phylons* to *evolverons,* we consider the organisms that constitute the different temporal parts of the *phylon*, which correspond to the organisms that constitute the synchronic species (*evolveron*) at different times over an interval. So, organisms O_1, O_2, O_3 and O_4 that constitute tp_1 under the diachronic view of species, constitute the species at t_1 in the synchronic view. And, in the same way, organisms that constitute the other different temporal parts of a *phylon* constitute the synchronic species at the corresponding times, over an interval.

In terms of Miller's notion of equivalence, there is also a truth preserving assertability mapping between the three dimensional and four dimensional theories of species. Let us suppose that O_1 and O_2 are living and dead organisms respectively. The sentence "organisms O_1 and O_2 are both parts of the same species S", is true under both 3D and 4D theories of species, since O_2 is part of the *evolveron* in the same way as O_1 is (there is a time at which O_2 was present in S).

Dead organisms do not thus raise a real problem for the thesis of equivalence, and the tension between the attribution of dead organisms to a species, under the synchronic perspective, and the concept of endurance as being *wholly present* can be overcome.

4.3. *Failure of intertranslation.*

As we have said, Reydon considers that 4D species can be translated without any loss of information into 3D species by mapping 4D ancestor-descendant relations onto 3D breeding relations.[51] But he claims:

> 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.[52]

Reydon presents hybridization and asexual species as cases for which such mapping does not yield an exact correspondence. It is to these cases that we turn our attention now. In what follows, we will examine these cases in terms of McCall and Lowe's and Miller's definitions of 3D/4D metaphysical equivalence. That means that we will reformulate the issue

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[51] Reydon, Thomas – "Species in three and four dimensions", cit. p. 174.

[52] *Ibidem*, p. 175.

in terms of composition (organisms that are part of a species) and truth-preserving assertability mapping rather than in terms of mapping of ancestor-descendant relations onto breeding relations.

Case 1: Hybridization

According to Reydon, evolutionary and systematic biology do not classify sterile and fertile hybrid organisms in the same way. Systematics is the study of biological diversity and its origin. As we have seen, systematic biologists attempt to classify organisms by paying attention to ascent-descent relations: all organisms of one species share a common ancestor that is not shared by other species. Diachronic species *(phylons)* are phylogenetic lineages, which are represented in genealogical trees. One of their principal characteristics is that they are mutually exclusive.

This character of mutual exclusivity among species generates a problem in cases of hybridization in which the hybrid is fertile. Reydon points out that in evolutionary biology a fertile hybrid is considered as a part of the two parental species it comes from since it can interbreed with them and contribute to both gene pools. Evolutionary biologists sometimes consider the two species that generate the hybrid as "semispecies", i.e., species among which reproductive isolation is not completed and which thus overlap.[53] Reydon then claims that such overlaps are "not represented in the tree of life, in which all species are mutually exclusive".[54]

As a consequence, this case seems to raise a problem for intertranslation between three dimensional and four dimensional theories of species: the fertile hybrid seems to be part of both species *(evolverons)* in evolutionary biology, whereas it seems to be part of neither *(phylons)* in systematic biology. In Miller's terms, there does not appear to be a truth-preserving assertability mapping. If an organism O_1 is a fertile hybrid organism, and an organism O_2 is a non-hybrid organism of one of the parental semispecies, the sentence "organism O_1 and O_2 are both parts of the same species S", seems to be true for evolutionary biology but false for systematic biology.

Similarly, in the case of sterile hybrids, mules, for example, Reydon claims that [they] "are included in the tree of life, however, in a four-dimensional tree-segment that springs from its two ancestor segments",[55] whereas evolutionary biology does not consider them either as part of any of the two parental species or as a different species, since being sterile,

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[53] *Ibidem*, p. 173.

[54] *Ibidem*, p. 175.

[55] *Ibidem*.

the hybrid does not contribute to the gene pool of any of the species. As a result, there does not seem to be either intertranslation or a truth-preserving assertability mapping.

Our rejoinder to case 1

Fertile and sterile hybrid organisms represent a challenge for classification in biology. The difficulties stem from the fact that hybrids play a twofold role in evolution as mechanisms of speciation. Fertile hybridization constitutes a mechanism for the generation of new species, whereas sterile hybrids constitute a case of post-mating mechanism. Post-mating mechanisms avoid the successful production of offspring between organisms of different species: hence, if organisms of species S_1 interbreed with organisms of species S_2 and, in most cases, their offspring turn out to be sterile then, evolutionary biologists can accurately conclude that S_1 and S_2 are two different species. Of course, for sterile hybrids to be such an isolating mechanism and criterion for distinguishing species, they must not be classified as part of any of the two parental species.

Reydon's use of hybrids as a difficulty for 3D/4D equivalence is based on two assumptions that we believe contemporary biologists challenge. The first assumption is that patterns of evolution can be adequately represented in phylogenetic trees. The second is that the populations to which those problematic organisms (fertile and sterile hybrids) are attributed when intertranslation fails should be considered, properly speaking, as *phylons* and *evolverons*.

Trees of life are the methodological tool used in systematic biology to classify and represent the evolution of species, i.e., relations of descent (with modification) from common ancestors. Classic phylogenetic trees represent speciation by means of the bifurcation of branches. But the presence of hybridization as a mechanism of evolution, frequent in plants, and the phenomenon of *horizontal genetic transfer* (see case 2 below) has challenged such classic representation of phylogeny, turning towards the idea of reticulate evolution, in which the relations between lineages are more complex. As the molecular biologist Ford Doolittle put it, "molecular phylogeneticists will [fail] to find the 'true tree', not because their methods are inadequate or because they have chosen the wrong genes, but because the history of life cannot properly be represented as a tree".[56]

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[56] Doolittle, Ford – "Phylogenetic classification and the universal tree". *Science*. 284, 1999, pp. 2124-2129.

Further examples of this tendency are contemporary biologists working in phylogenetics and philosophers of science reflecting on such scientific fields, for instance Velasco, Dupré, Gregory, and Arenas, Valiente and Posada, among others.[57] As a consequence, whether or not an organism can be adequately represented in classic phylogenetic trees should not be considered as a criterion of membership to a particular *phylon,* which is what Reydon seems to do.

However, the second assumption is even more problematic. Reydon himself acknowledges that the two species which the sporadic fertile hybrid comes from, are usually called "semispecies". In evolutionary biology, the terms "semispecies", "subspecies" and "superspecies" refer to populations that do not satisfy the classic definition of biological species (isolated interbreeding communities). In particular, semispecies are natural populations whose gene exchange is not as free as among conspecific populations, that is, a group of populations that have reduced gene flow between them yet are not completely reproductively isolated.[58] Their status as species is therefore dubious.

Insofar as these examples of fertile hybrid populations do not properly speaking constitute species, recourse to them to challenge the equivalence between 3D and 4D theories of species should be questioned. In these cases, in order to show that intertranslatability between the two theories fails, we need an example of an organism that *is* part of an *evolveron* at a time, and that is not part of the *phylon´*s temporal part existing at that time. However, cases of fertile hybrids are not clear examples of such components; they are rather challenging cases for classification in both evolutionary and systematic biology, even if (arguably) stipulations are made to classify them.[59]

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[57] Velasco, Joel – "The Future of Systematics: Tree-Thinking without the Tree". *Philosophy of Science*, 79, 2012, pp. 624-636; Dupré, John – *Processes of Life: Essays in the Philosophy of biology.* Oxford: Oxford University Press, 2012; Gregory, T. Ryan – "Understanding Evolutionary Trees". *Evo Edu Outreach*, 1, 2008, pp. 121-137; Arenas, Miguel; Valiente, Gabriel & Posada, David – "Characterization of Reticulate Networks based on the Coalescent with Recombination". *Molecular Biology and Evolution*, 25 (12), 2008, pp. 2517-2520.

[58] Mayr, Ernst – *Populations, Species and Evolution: an Abridgment of Animal Species and Evolution*. Cambridge: Harvard University Press, 1970.

[59] Ellison, Aaron, *et al.* – "Pitcher Plants (*Sarracenia*) Provide a 21st Century Perspective on Infraspecific Ranks and Interspecific Hybrids: A Modest Proposal for Appropriate Recognition and Usage". *Systematic Botany*, 39 (3), 2014, pp. 939-949; Robe, Lizandra; Cordeiro, Juliana; Loreto, Elgion & Valente, Vera – "Taxonomic boundaries, phylogenetic relationships and biogeography of the Drosophila Willistoni subgroup (*Diptera: Drosophilidae*)". *Genética*, 138 (6), 2010, pp. 601-617; and Mallet, James – "Subspecies,

What about sterile hybrids? We agree with Reydon that sterile hybrids generate a problem of classification for evolutionary biologists, which is reflected in the taxonomic nomenclature (mules are named *equus asinus* × *equus caballus*). In this case, they cannot form their own species also due to the fact that they do not satisfy Mayr's criteria of species, namely: to be an interbreeding natural population that is isolated from other such groups. But even if sterile hybrids can be represented as a separate segment in the phylogenetic tree, the crucial point is whether systematic biologists agree on them being considered as a separate species, and in fact there is no agreement on this.[60] As a result, when facing the difficulty that this case raises for intertranslation and truth-preserving assertability mapping, similar considerations to those we made for the case of fertile hybrids hold.

Case 2: Asexual species

Reydon proposes asexual species as another case that shows non-equivalence between synchronic and diachronic perspectives of species. In asexual species, the relations of descent are not established as a consequence of interbreeding relations, but by clonal parental relations, i.e, cell division. So, to study asexual species from the point of view of systematics means that all organisms that are in clonal parental relations between them are part of the same species. For example, if an organism O_1 produces offspring O_2 and O_3, and organism O_4 produces offspring O_5 and O_6; systematists will conclude that O_1, O_2, and O_3 are part of one species $S_{\underline{1}}$, whereas O_4, O_5 and O_6 are part of another, S_2.

However, this does not seem to be what an evolutionary biologist would claim. Evolutionary biology uses gene transfer as a criterion to establish whether an organism is part of a species or not. Horizontal gene transfer (hereafter, HGT), refers to the transmission of genes between organisms in a way that is different from traditional reproduction, for example, transformation, transduction or bacterial conjugation, among

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Semispecies, Superspecies". *Encyclopedia of Biodiversity*, 2007 [Consult. 4 Marzo 2015]. Available in <URL: http://www.ucl.ac.uk/taxome/jim/sp/sub-semi.pdf>.

[60] Ellison et al., for example, analyse problems and inconsistencies arising in phylogeny as a consequence of hybridisation, and recommend that "sterile hybrids that arise through occasional syngamy from two distinct species should not be named. The ability of different species to form sterile hybrids could be noted in their written descriptions" [Ellison, Aaron *et al.* – "Pitcher Plants (*Sarracenia*) Provide a 21st Century Perspective on Infraspecific Ranks and Interspecific Hybrids: A Modest Proposal for Appropriate Recognition and Usage", cit., pp. 939-949].

others.[61] But, in the case of asexual organisms, gene transfer does not always coincide with clonal parental relations. Let us imagine that among organisms O_1, O_2, O_3, O_4, O_5 and O_6, gene transfer is produced between O_1, O_5 and O_6, on the one hand; and between O_4, O_2 and O_3 on the other. In this case, evolutionary biologists would consider that the species S_1 is composed of O_1, O_5 and O_6; whereas S_2 is composed of O_4, O_2 and O_3.

In this case, as in the case of hybridization, there does not seem to be an intertranslation between 4D asexual species and 3D asexual species, and vice versa, without the loss of information insofar as there are organisms that are part of species S_1 and S_2 under one perspective, which are not part of them under another. S_1 and S_2 thus stand for four species, since two different individuals are determined under each of the two temporal dimensions. In Miller's terms, there is no truth-preserving assertability mapping either, since the sentence "Organism O_1 and O_2 are both parts of the same species S" would not have the same truth-value in both theories.

Our rejoinder to case 2

Inspection of the way in which systematic biologists currently elaborate phylogenetic lineages of asexual species allows, however, the reinstatement of equivalence between 3D and 4D theories of species. In fields such as microbiology (which is what Reydon considers), the phylogenetic trees are not constructed only on the basis of the clonal parental relations among organisms. As in the case of hybridization, the presence of HGT between organisms has questioned the adequacy of the tree diagram to represent the relations among species. As we have highlighted in the previous section, contemporary biologists represent such relations in reticulate networks and graphs.[62]

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[61] Gyles, Carlton & Boerlin, Patrick – "Horizontally transferred genetic elements and their role in pathogenesis of bacterial disease". *Veterinary Pathology*, 51 (2), 2014, pp. 328-340; Gregory, T. Ryan – "Understanding Evolutionary Trees", cit., pp. 122-123.

[62] Velasco, Joel – "The Future of Systematics: Tree-Thinking without the Tree", cit., pp. 624-636; Dupré, John – *Processes of Life: Essays in the Philosophy of* Biology, ed. cit. Doolittle, Ford – "Phylogenetic classification and the universal tree", cit., pp. 2124-2129; Gregory, T. Ryan – "Understanding Evolutionary Trees", cit., pp. 121-137; Arenas, Miguel; Valiente, Gabriel & Posada, David – "Characterization of Reticulate Networks based on the Coalescent with Recombination". *Molecular Biology and Evolution*, 25 (12), 2008, pp. 2517-2520; Ellison, Aaron *et al.* – "Pitcher Plants (*Sarracenia*) Provide a 21st Century Perspective on Infraspecific Ranks and Interspecific Hybrids: A Modest Proposal for Appropriate Recognition and Usage", cit., pp. 939-949; Robe, Lizandra; Cordeiro, Juliana; Loreto, Elgion & Valente, Vera – "Taxonomic boundaries, phylogenetic relationships and biogeography of the Drosophila Willistoni subgroup (*Diptera: Drosophilidae*)", cit., pp. 601-617.

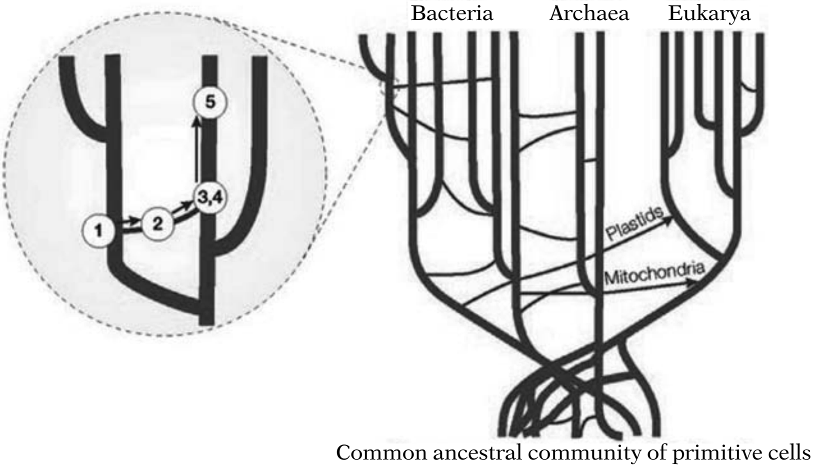

Figure from *Nature Reviews,* Microbiology, 2005[63]

Systematic biologists pay attention to the role that HGT plays between asexual organisms, and consider that two organisms that exchange genetic material are part of the same species. By taking into account the relevance of HGT in systematic biology, it seems that we can conclude that there is intertranslation between systematic and evolutionary asexual species since both fields use the same criteria to attribute organisms to asexual species.

To illustrate this, imagine that an asexual organism O_1 produces offspring O_2 and O_3, and an asexual organism O_4 produces offspring O_5 and O_6, and that horizontal gene transfer occurs between O_1, O_5 and O_6, on the one hand; and between O_4, O_2 and O_3 on the other. In this case, according to evolutionary biologists, organisms O_1, O_5 and O_6 constitute one asexual species S_1, whereas organisms O_4, O_2 and O_3, constitute another, S_2.

However, since systematic biologists take into account the relevance of HGT in order to consider an organism as being part of an asexual species, they will claim that species S_1 and S_2 are constituted by the same organisms as evolutionary biologists consider. Furthermore, since gene transfer occurs not only horizontally but also vertically, there is also gene transfer between organisms that are in clonal parental relation, and therefore, these organisms are part of the same asexual species. There is thus intertranslation and a truth-preserving assertability mapping between

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[63] Smets, Barth & Barkay, Tamar – "Horizontal gene transfer: perspectives at a crossroads of scientific disciplines". *Nature Reviews Microbiology*, 3, 2005, pp. 675-678.

the two theories in the case of asexual species: the sentence "Organisms O_1 and O_2 are both part of the same species S", is true under both accounts.

Conclusions

In this paper we have shown the possibility of metaphysical equivalence, at least *in principle*, between 3D and 4D theories of species and, therefore, that *evolverons* and *phylons* are not two different ontological entities, as Reydon claims, but one entity that can be considered under two different perspectives. In order to show this, we have firstly motivated metaphysical equivalence between 3D and 4D theories of species by pointing to the fact that it is desirable that *evolving* species (those actively involved in evolution) are the same entities as *evolved* species (the historical results of evolution). Secondly, we have suggested that the notion of endurance proposed by McCall and Lowe does not give rise to the tension between the attribution of living and dead organisms to species and the fact that enduring entities persist by enduring. Finally, we have addressed the biological cases that raise difficulties for the possibility of intertranslation between both theories, namely, hybridization and asexual species. In these cases, we have pointed out the limitations of representation of phylogenies in evolutionary trees. In addition, in the case of hybridization, we have cast doubts on the status of examples of species that generate trouble for intertranslation. The examples of organisms that are differently attributed to 3D and 4D species are not clear cases, but problematic ones, and the species-status of the entities of which they are part is not always clear.

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