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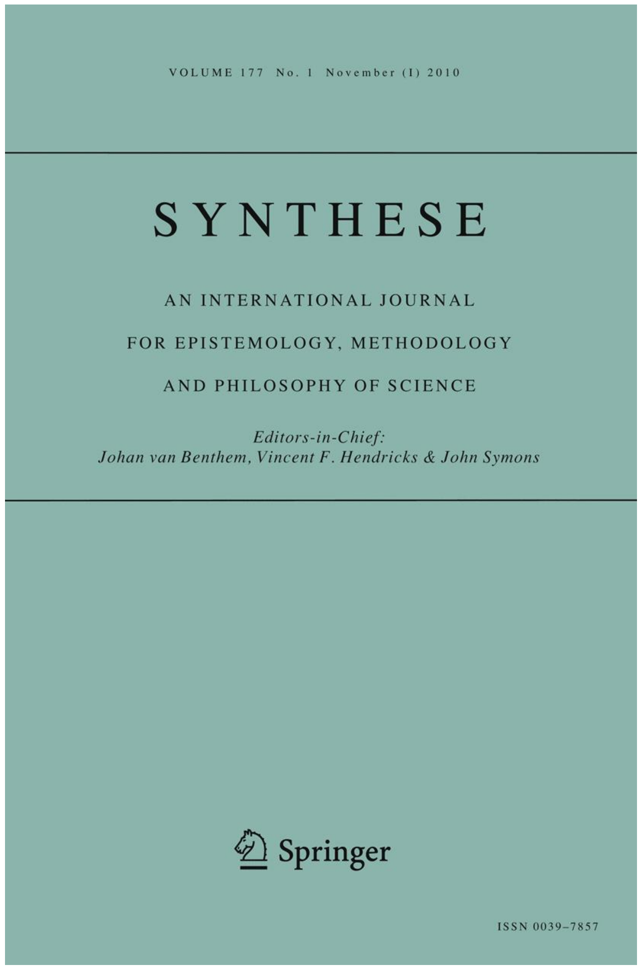

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Population thinking as trope nominalism

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Abstract The concept of population thinking was introduced by Ernst Mayr as the right way of thinking about the biological domain, but it is difficult to find an interpretation of this notion that is both unproblematic and does the theoretical work it was intended to do. I argue that, properly conceived, Mayr's population thinking is a version of trope nominalism: the view that biological property-types do not exist or at least they play no explanatory role. Further, although population thinking has been traditionally used to argue against essentialism about biological kinds, recently it has been suggested that it may be consistent with at least some forms of essentialism—ones that construe essential properties as relational. I argue that if population thinking is a version of trope nominalism, then, as Mayr originally claimed, it rules out any version of essentialism about biological kinds.

Keywords Biological explanations · Population thinking · Tropes · Property-type · Trope nominalism · Biological essentialism

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1 Introduction

The main aim of this paper is to argue for the claim that property-types are explanatorily superfluous in evolutionary explanations.[1] This leads to a version of trope nominalism about the biological domain. I also argue that this is the correct interpretation of the concept of population thinking and that it does the most important theoretical work this concept is supposed to do: to sink essentialism about biological kinds.

Ernst Mayr's concept of population thinking (Mayr 1959/1994) must be the most often invoked, yet, most unexplained concept in the philosophy of biology. It seems that no two philosophers of biology agree what this view is supposed to be. As the concept is supposed to capture the *right* way of thinking about the biological domain, it is a crucial question how population thinking is to be interpreted.

My strategy will be to argue that, properly conceived, population thinking is a version of trope nominalism: the claim that biological property-types are explanatorily superfluous. In other words, the right way of thinking about the biological domain is to endorse a version of trope nominalism about biological properties.

The plan of the paper is the following. I outline a trope nominalist picture of the biological domain, according to which biological property-types are explanatorily superfluous (Sect. 2). I point out that Mayr's concept of population thinking, properly conceived, is a version of trope nominalism (Sect. 3). I then give an argument for this trope nominalist metaphysical picture in biology (Sect. 4).

The correct interpretation of population thinking is an important question in and of itself, but it has become especially timely in recent years. Population thinking has been traditionally used to argue against essentialism about biological kinds. Recently, however, it has been suggested that it may be consistent with at least some forms of essentialism—ones that construe essential properties as relational. Whether this is the case depends on what we mean by population thinking. I argue that if population thinking is to be interpreted as a version of trope nominalism, then it excludes any version of essentialism about biological kinds—whether or not the essential properties it posits are relational (Sect. 5).

2 Trope nominalism about the biological domain

My claim is that evolutionary theory implies a version of trope nominalism about the biological domain: the view that biological property-types (or universals) do not play any explanatory role; only biological tropes (or property-instances) do. The neck size of a specific individual is a property-instance that does play an important role in evolutionary explanations, but the property-type of the (average) neck size in a population is only our statistical abstraction and it is explanatorily superfluous. To put it provocatively, evolutionary theory is not about types; it is about tokens.

[1] I will make some qualifications about this claim in Sect. 4. For now, I will use the following two claims 'biological property-types are explanatorily superfluous' and 'property-types are explanatorily superfluous in evolutionary explanations' interchangeably.

There are two versions of the trope nominalist stance about the biological domain, one stronger than the other: (a) biological property-types do not exist and (b) biological property-types do not play any explanatory role in evolutionary explanations. Although there may be reasons to hold (a), I will explicate and argue for the slightly weaker (b). I will use the label 'trope nominalism' to refer to (b) (although maybe 'explanatory trope nominalism' would be a more accurate description—more on the distinction between (a) and (b) in Sect. 4).

My claim that property-types play no role in evolutionary explanations may seem preposterous: evolutionary theory talks about genotypes and phenotypes: about property-types. Even worse, as Elliott Sober and Richard Lewontin say in one of the most famous papers on natural selection, "selection theory is about genotypes not genotokens" (Sober and Lewontin 1982, p. 172; see also Wimsatt 1980, n. 2, p. 174; Dawkins 1982, p. 88—for some dissenting views; see Smith and Varzi 2001, 2002; Godfrey-Smith 2009; Rosenberg 1983 Nanay forthcoming). Nonetheless, I try to show that evolutionary theory is really about tokens and not about types: property-types, be they genotypes or phenotypes, are explanatorily superfluous. In order to do so, we'll need a bit of metaphysics.

The term 'property' is ambiguous. It can mean universals: properties that can be present in two (or more) distinct individuals at the same time. But it can also mean tropes: abstract particulars that are logically incapable of being present in two (or more) distinct individuals at the same time (Williams 1953; Campbell 1981, 1990; Schaffer 2001; Simons 1994; Sanford MS).

Suppose that the color of my neighbor's black car and my black car are indistinguishable. They still have different tropes. The blackness trope of my car is different from the blackness trope of my neighbor's car. These two tropes are similar but numerically distinct. Thus, the blackness of my car and the blackness of my neighbor's car are different properties.

If, in contrast, we interpret properties as universals, or, as I will refer to them, property-types, then the two cars instantiate the same property-type: blackness. Thus, depending on which notion of property we talk about, we have to give different answers to the question about whether the color-property of the two cars is the same or different. If by 'property' we mean 'trope', then my car has a different (but similar) color-property, that is, color-trope, from my neighbor's. If, however, by 'property' we mean 'property-type', then my car has the very same property, that is, property-type, as my neighbor's.

My claim is that property-types are explanatorily superfluous in evolutionary explanations. All the explanatory work is done by tropes. This claim needs to be clarified and qualified at a number of points. First, I want to remain silent about whether property-types play any explanatory role in non-evolutionary explanations. Maybe they do. When we are trying to explain why a certain gold sample melts at 1,948°F, we can explain this by referring to a property-type all gold samples have an instantiation of (maybe the property-type of having a certain atomic structure). In this explanation, we have a property-type as part of the *explanans*. The property-type may or may not be causally relevant, but it is explanatorily relevant. My claim is that this is not the case in evolutionary explanations, where the *explanans* refers only to property-instances.

Second, it is important to note that I do not claim that using tropes instead of property-types in the metaphysical framework *increases* the explanatory power of evolutionary theory. After all, it has been argued, convincingly, that statements about tropes and statements about instantiations of property-types are notional variants: one can always be rephrased in terms of the other (Daly 1997). All I claim is that adding biological property-types to a trope nominalist metaphysical framework *does not increase* the explanatory power of evolutionary theory. Hence, property-types are explanatorily superfluous.

3 Population thinking as trope nominalism

The claim that property-types are explanatorily superfluous in evolutionary explanations may seem provocative, especially given the repeated mention of genotypes and phenotypes in the literature. But it is not such a wild claim. In this section, I will argue that Ernst Mayr's influential idea of what makes the biological domain special, the idea of 'population thinking', could, and should, be interpreted as a version of the trope nominalism I advocate.

The interpretation of population thinking as trope nominalism is not self-explanatory, nor is it the most obvious, *prima facie* reading of Mayr's account. Yet, I will argue that this is the least problematic interpretation of population thinking. Here is Mayr's characterization of population thinking from 1959:

> Individuals, or any kind of organic entities, form populations of which we can determine only the arithmetic mean and the statistics of variation. Averages are merely statistical abstractions; only the individuals of which the populations are composed have reality. (Mayr 1959/1994, p. 326)

Mayr contrasts population thinking with typological thinking, according to which "there are a limited number of fixed, unchangeable "ideas" underlying the observed variability, with the *eidos* (idea) being the only thing that is fixed and real, while the observed variability has no [...] reality" (Mayr 1959/1994, p. 326). The contrast Mayr makes is a very sharp one: population thinking and typological thinking are exclusive of each other (Mayr 1959/1994, pp. 326–327 See also Mayr 1982).

Mayr's distinction between typological and population thinking may appear straightforward, but in fact it has been, and could be, interpreted in at least two ways.

Population thinking could be interpreted as an ontological claim about *entities*: only the individual is real. Everything else is abstraction. There are various problems with this reading. If only the individual is real, then populations and species should be thought of as groups of individuals that lack reality themselves. This would make much of post-Darwinian biology nonsensical from the population thinker's point of view. As Elliott Sober says:

> If [as Mayr claims] "only the individuals of which the populations are composed have reality," it would appear that much of population biology has its head in the clouds. The Lotka–Volterra equations, for example, describe the interactions of predator and prey *populations*. Presumably, population thinking, properly so called, must allow that there is something real over and above individual

organisms. [It does not] embody a resolute and ontologically austere focus on individual organisms alone. (Sober 1980, p. 352)

Even worse, Mayr himself is certainly not nominalist about populations and species (Mayr 1942, p. 120, 1963, p. 19, see also Mayr 1969/1976, 1996). His dictum that "only the individuals [...] have reality" seems to flatly contradict his famous 'biological species concept', which does indeed attribute reality to populations and species. It is tempting to resolve this seeming contradiction by dismissing Mayr's claim about the importance of the individual in evolution as an exaggeration or even as "rather silly metaphysics" (Ariew 2008, p. 65).[2]

Elliott Sober chooses this route when he says that "describing a single individual is as theoretically peripheral to a populationist as describing the motion of a single molecule is to the kinetic theory of gases. In this important sense, population thinking involves *ignoring individuals*..." (Sober 1980, p. 370). The conclusion he draws is that "population thinking endows individual organisms with more reality *and* with less reality than typological thinking attributes to them" (Sober 1980, p. 371).

This conclusion prompted some to be "a little confused about which one, individuals or populations, are real" (Ariew 2008, p. 71). It also opened up the concept of population thinking to many diverging interpretations, some of which seems to contradict Mayr's original claims (Walsh 2006, pp. 432–433; Griffiths 1999, pp. 209–210 see Sect. 5 below).

I argue that population thinking is an ontological claim about *properties* and not about entities. It is indeed a version of nominalism. However, it is not nominalism about entities, but about properties. In other words, Mayr advocated a version of trope nominalism. For the population thinker, only the property-instances of individual organisms are real. Property-types are not real.

We have to be careful when formulating this claim. The population thinker presumably would not deny that groups of individual organisms do have properties and these properties are real. A population of 431 geese has the property of having the population size of 431, for example, and this property seems very real indeed. The distinction I am making (and the distinction I believe Mayr was making) is not one between the properties of individuals and the properties of populations. Rather, it is between individual property-instances (or tropes) and property-types (or universals) that can be instantiated in many different entities. In short, the population thinker can acknowledge the existence of populations and species. These entities are real in the same way as individuals are real. And all of these entities have very real property-instances or tropes. What the population thinker denies is that there are property-types.

My claim is that Mayr's provocative statement, according to which "averages are merely statistical abstractions; only the individuals of which the populations are composed have reality" should be read as "*property-types* are merely statistical abstractions; only the *tropes* of individuals (or of populations) have reality". Mayr's population thinking is a version of trope nominalism.

[2] It is worth noting that one way of defending Mayr's position from worries of this kind would be to embrace the recently popular view that populations are individuals and members of populations are the parts of this individual (Ghiselin 1974; Hull 1978).

Note that this reading makes the apparent contradiction between population thinking and the 'biological species concept' disappear. Mayr is indeed not nominalist about species and populations: these are real entities (that have real tropes). But this claim is consistent with trope nominalism: we can accept trope nominalism, the proposal according to which only tropes exist, and still allow for entities other than the individual—thus avoiding the conflict with the 'biological species concept'.

Although Mayr does not talk about tropes and he is not particularly clear about the metaphysical framework he presupposes, he does write that "All organisms and organic phenomena are composed of unique features and can be described collectively only in statistical terms" (Mayr 1959/1994, p. 326). Here Mayr talks about the uniqueness of *features*, that is, properties, and not the uniqueness of individual entities. The upshot is that individuals have "unique features" (tropes): individual i_1 has property p_1, i_2 has p_2, and so on. Suppose these individuals form a population. The question is how we can talk about the properties of these individuals 'collectively'. Mayr's point is that we can only describe them 'in statistical terms'. That is, the property-type that $p_1, p_2, \ldots, p_n$ belongs to is a statistical abstraction: it is not a property-type that exists independently of the specific individuals and their specific tropes.

Some final remarks about this interpretation of population thinking: it needs to be noted that there are various versions of trope nominalism.[3] According to the version I endorse, biological property-types play no explanatory role in evolutionary explanations. Mayr seems to have had a stronger claim in mind as he denies the reality of biological property-types: he claims that they are merely our statistical abstractions. I am not sure that we are justified in holding this stronger claim. My view remains silent about whether biological tropes exist. It is not committed to the claim that biological property-types do not exist either. I will argue that my (weaker) version of trope nominalism is enough to do the theoretical work Mayr intended population thinking to do, most importantly, to sink essentialism about biological kinds (see Sect. 5).

Depending on one's meta-metaphysical convictions, there may not be such a huge difference between these two versions of trope nominalism: Mayr's stronger version and my weaker 'explanatory trope nominalism'. One could, after all, use the weaker claim that biological property-types are explanatorily superfluous and, with the help of the principle of parsimony, conclude that we have no reason to postulate their existence.

But not everyone will find this last step unproblematic and I do not want to argue that it is unproblematic. If someone believes that we can infer from the fact that something is explanatory superfluous that it does not exist (as Mayr may have believed), then she will not find the distinction between my 'trope nominalism' and Mayr's population thinking a very interesting one. She can read the argument I will present in the next section as a vindication of Mayr's original ideas. But if someone does not believe that

[3] Versions of trope nominalism also differ significantly with regards to what they say about the way in which we can talk about universals or property-types. Maybe universals are sets of tropes? (for problems with this way of thinking, see Wolterstorff 1973). Or maybe they are only our ways of grouping the tropes? (see Nanay 2009). Without going into the respective merits of these proposals, it needs to be pointed out that Mayr advocates a distinctive view about the way in which a trope nominalist (at least about biological properties) can and should talk about property-types: they are statistical abstractions of tropes.

explanatory irrelevance implies non-existence, then she should read the argument I am about to present as an argument for ‘explanatory trope nominalism’.

4 An argument for (explanatory) trope nominalism in biology

I said that in the domain of biology, property-types do not do any explanatory work and property-instances do all the work. An important clarification about this claim: I talked about the biological domain, biological property-types and biological tropes. But it is not clear where the boundaries of the biological domain lie. Is DNA part of the biological domain or is it already part of the domain of chemistry? Also, there are many different kinds of explanations (Van Fraassen 1980). Saying that property-types play no role in any of them would be a difficult claim to argue for. So I will restrict the scope of my claim in the following manner: property-types play no role in evolutionary explanations. When I talk about the explanatory role (or lack thereof) biological property-types play, what I mean is explanatory role in an evolutionary explanation. Biological kinds are evolved kinds and biological entities are evolved entities. Thus, if a property-type is supposed to play some explanatory role in biology, like the atomic structure of gold explains why it melts at certain temperature, then, as the explanation of the properties of evolved entities is an evolutionary explanation, this means that this property-type is supposed to play at least some role in evolutionary explanations. I will attempt to show that this is not so: no property-type plays any role in evolutionary explanations.

Further, what do I mean by evolutionary explanations? An evolutionary explanation is an explanation where the *explanandum* can be pretty much anything, whereas the *explanans* is an evolutionary process. Evolutionary processes, in turn, are defined conjunctively to include selection, founding effect, etc. I want to restrict this very liberal concept of evolutionary explanation for the purposes of the discussion in this paper; more precisely, I want to restrict the *explanandum* to why a specific token organism has the token traits it has. The concept of evolutionary explanation in my claim that no property-type plays any role in evolutionary explanations is to be understood this restricted way.

Why this restriction? Because (a) this is all I need in order to argue for anti-essentialism about biological (that is, evolved) kinds and (b) because I do not think that the stronger, unrestricted claim can be sufficiently supported. It is important to note the twofold disagreement between Mayr’s original account and my account at this point. Mayr makes a sweeping claim about the entire biological domain: there are no property-types in the biological domain. My claim is weaker in two respects. We have seen that my claim is about explanatory relevance, not ontology: no property type plays any role in evolutionary explanations. But my claim is also weaker in another respect. I want to remain neutral about whether it is possible to give lawlike generalizations about the biological domain, like the Lotka–Volterra equations I mentioned above. If we can then we have good reasons to suppose that property-types do play some role in at least some evolutionary explanations as lawlike generalizations connect property-types and not tropes. The claim I make is that property-types do not play any role in the explanation of why a specific token organism has a specific token trait.

Mayr's population thinking was a general account of the biological domain per se: the right way of thinking about the biological domain. My claim is much more limited: property-types do not play any role in one specific type of evolutionary explanation: the explanation of why a specific token organism has a specific token trait. Can this twice-weakened claim still be considered to be a version of Mayr's population thinking? I believe that it can, mainly as this version of population thinking can be used to argue against essentialism about biological kinds the way Mayr wanted to, but without opening up the account to some simple objections.

Thus, the claim I argue for is that adding property-types to the *explanans* of evolutionary explanations does not increase their explanatory power. Not everyone agrees with this.

As we have seen, Sober and Lewontin say that "selection theory is about genotypes not genotokens" (Sober and Lewontin 1982, p. 172; see also Sober and Lewontin 1983, p. 649). Or, as William Wimsatt says, "if evolution had to depend upon the passing on of gene-tokens, it could not have happened. Genotokens and phenotokens are not inherited, but genotypes and phenotypes may be" (Wimsatt 1980, n. 2, p. 174). Richard Dawkins is equally explicit: "Natural selection is the process by which replicators change their frequency in the population relative to their alleles. If the replicator under consideration is so large that it is probably unique, it cannot be said to have a 'frequency' to change" (Dawkins 1982, p. 88).[4] For some dissenting views, see Smith and Varzi (2001, 2002), Godfrey-Smith (2009), Rosenberg (1983), Nanay (forthcoming).

Thus, the suggestion is that natural selection operates on types, not on tokens.[5] Hence, we *have to* refer to property-types in the *explanans* of evolutionary explanations. Adding property-types to the *explanans* of evolutionary explanations does not only increase their explanatory power; it makes evolutionary explanations possible to begin with (see Sober 1981, esp. pp. 160–169, for an explicit defense of this claim, see also Sober 1984, pp. 118–120).

But not everyone thinks that selection operates on trait types. Ernst Mayr, for example, thinks, unsurprisingly, that it operates on trait tokens. One of his two considerations for population thinking is that any meaningful discussion of natural selection should presuppose population thinking. He writes that "evolution to [the typologist] consists of the testing of newly arisen "types". Every new type is put through a screening test and is either kept or, more probably, rejected." (Mayr 1959/1994, p. 328). According to the population thinker, in contrast, evolution by natural selection is the testing of the newly arisen "tokens". Specific individuals with specific traits are competing with each other. Mayr says that "it can be shown rather easily in any thorough analysis"

[4] Some of these quotes seem to imply that selection literally operates on property-types; some others may be interpreted as making a somewhat weaker claim: that it operates on tokens *qua* instantiations of types—this would be a similar claim as one that is popular in the causation literature: particular events cause other particular events *qua*, or in virtue of, having some property-types. For the purposes of the argument I will present, this difference is not a significant one: both of these ways of thinking of selection would still make reference to property-types as indispensable for evolutionary theory.

[5] Some may object to my use of the phrase that selection operate on traits, especially as it has been argued recently that selection is a statistical and not a causal process, so it does not 'operate' on anything. For them, my argument can be rephrased in terms of whether selection theory is about trait-types or trait-tokens. I am grateful to Mohan Matthen for reminding me of the partiality of the terminology used in this paper.

that selection operates on trait tokens and not on trait types (Mayr 1959/1994, p. 328). In fact, however, many biologists and philosophers of biology would proudly embrace a model of selection whereby selection operates on trait types.

Thus, we have two different ways of thinking about selection: as type-selection and as token-selection. The difference between these two ways of thinking about selection has some important implications to a number of debates about the nature of selection, but for our purposes it is enough to examine how this difference relates to the epic debate over what selection can explain. The conclusion will be that regardless of which way of thinking about selection we endorse, it remains to be true that trait types are explanatorily irrelevant in explaining why token organisms have the token traits they have. But let us proceed more slowly.

One of the most important recent debates in philosophy of biology is about whether natural selection can explain why organisms have the traits they have. The view that selection can play a role in explaining why organisms have the traits they have, to put it simply, in explaining adaptation, has been defended by Neander (1995a,b, see also Millikan 1990; Nanay 2005; Matthen 1999). On the other side of the trench the central figure is Sober (1984, 1995, see also Walsh 1998; Dretske 1988, 1990; Pust 2001; Lewens 2001; Cummins 1975).

Sober (1984, Chap. 5) claims that selection is a negative force: it does not create; it only destroys. Random mutations create a variety of traits (or genetic plans) and selection eliminates some of these, but the explanation of the traits of one of these individuals is provided by random mutation and inheritance (and some developmental factors), not by the elimination process. Selection can explain why certain individuals were eliminated, but it cannot explain the traits of the ones that were *not* eliminated.

Neander (1995a) argues against the validity of this argument, which she calls the argument for the Negative View of selection, at least as far as cumulative selection is concerned. After a couple of rounds of exchanges without any sign of rapprochement, one gets the sense that there is some sort of miscommunication between Neander and Sober. One gets the sense that the opponents and the advocates of this argument may not mean the same by the term ‘selection’.

My claim is that this disagreement is due to the fact that while Sober takes selection to be the “testing of newly arisen types”, Neander takes selection to operate on tokens.[6] This disagreement is the most explicit in the way they treat cumulative selection. Cumulative selection is a selection process, whereby changes accumulate through generations. For Sober, this means that the change in *trait frequencies*, that is, the frequencies of certain property-types in a population, accumulates: in the first generation, we have 50% trait F and 50% trait G in a population. If there is selection for F,

[6] It is important to note that this distinction between selection operating on types and selection operating on tokens is not the same as the recently influential distinction between population-level and individual-level interpretations of the ‘heritable variation of fitness’ model of evolution by natural selection (Matthen and Ariew 2002; Walsh et al. 2002; Millstein 2006; Brandon 2006; Bouchard and Rosenberg 2004; Rosenberg and Bouchard 2005; Ariew and Lewontin 2004; Stephens 2004). Although it is difficult to see how token-selection could be thought of anything other than an individual-level phenomenon, it is far from clear that the individual-level interpretation of ‘heritable variation of fitness’ must be token-selection, as it could be argued that any interpretation of the notion of fitness presupposes that fitness is an attribute of types (see, for example, Sober 1981). I discuss the logical relation between these two distinctions in Nanay (ms).

in a couple of generations, the ratio can change to, say, 60%/40%. Importantly, F and G are property-types. Selection for F, one of Sober's key notions, is always selection for a property-type (see Sober 1981; 1984, pp. 118–120 for a detailed defense of this claim). As Sober writes, "if there is selection for X, every object which has X has its reproductive chances augmented by its possessing X" (Sober and Lewontin 1982, p. 171).

Hence, in Sober's model of selection, property-types are competing with one another. But while the relative frequency of these property-types can and does change if there is selection, these property-types themselves do not change (or, at least, they do not need to change for there being a selection process). The entire process can be described in terms of property-types (see also Sober 1980, p. 370). What is crucial for our purposes is that if we think of selection this way, then, as we can have selection without any change in the selected property-types, Sober is right that selection does not explain anything about why the selected property-type is the way it is. If we use a model of selection that operates on property-types, then Sober is justified in saying that selection fails to explain adaptation.

Take the alternative model, where selection operates on property-tokens. Here is a very simplified example (where I ignore sexual reproduction and limit the traits relevant for selection to only one). The neck size of giraffe x is 12 feet. She has three offspring, a, b and c. Giraffe a's neck size is 10 feet, b's is 12 and c's is 14 feet. If the branches are very high up, then c is more likely to survive, than a and b. Thus, c makes it to the next generation and she has three offspring, d, e and f. As c's neck size was 14 feet, this will be the trait that gets transmitted to her offspring, who will have the neck size of 12, 14 and 16 feet respectively. Again, f, who has the longest neck is the most likely to survive. And so on. What we have here is a cumulative selection process: changes accumulate. But as this selection process operates on trait tokens, it is not only the frequency of the selected traits that change: the selected traits in one generation will also be different from the ones in the previous generation: c's neck is longer than x's and f's is longer than c's. In the first generation, x's neck size was 12 feet, in the nth generation, the neck size of the individuals in the population will be close to the height of the lowest branches of the trees in the environment; it will *adapt* to the environment.[7]

In short, if we take selection to be a process whereby property-types compete, as Sober does, then we would be justified to say that selection cannot explain adaptation. But if we take selection to be a process that operates on property-tokens, then Sober's argument fails to apply and Neander's point that cumulative selection explains adapta-

[7] We need to be clear about what it is that adapts to the environment: trait tokens cannot be said to adapt to anything as they only exist for one generation. And as I aim to show that we can explain adaptation in terms of cumulative selection without appealing to property-types, we should hope that it is not property-types that adapt to the environment. The short answer is that the token traits of particular lineages adapt to the environment. A lineage is traditionally defined as "an entity that changes indefinitely through time as a result of replication and interaction" (Hull 1980, p. 327): in the giraffe example, the entity consisting of individuals x, c and f, etc. would constitute a lineage. If we take the sequence of the neck size of these individuals, they converge to the height that is optimal in the given environment: we can say that the token traits of this particular lineage adapt to the environment.

tion stays untouched (maybe positing some additional conditions, such as the limitation of environmental resources, see Nanay 2005).

Thus, the question is not whether selection can explain adaptation, but *which model of selection* can explain adaptation. The one that takes selection to operate on types (Sober's) can't. The one that takes selection to operate on tokens (Neander's) can.

Now we can return to the original claim, according to which property types play no role in explaining why a token organism has the token traits it has. If we think of selection as token-selection, then Neander is right and selection, taken to operate on tokens, can explain why token organisms have the traits they have. This explanation does not use any property-types as the concept of selection Neander uses is token-selection. But if we think of selection as type-selection, then selective explanations will make a necessary reference to property-types, but, as Sober rightly points out, if we think of selection this way, it will not be able to explain why token organisms have the traits they have. What will explain why token organisms have the traits they have is mutation in the previous generation, inheritance and developmental processes (Sober 1995). And mutation, inheritance and development should be taken to be token phenomena here: the mutation in a token ancestor of the organism, inheritance from one token organism to another and the developmental processes of the organism are all processes that operate on token traits. Thus, regardless of whether we think of selection as type-selection or token-selection, we can explain why token organisms have the traits they have without any reference to any property-types.

It is important to be clear about the structure of my argument. I argued that property-types are not indispensable in evolutionary explanations, where, again, evolutionary explanation is to be interpreted as evolutionary explanation of why token organisms have the traits they have. Thus, we don't *have to* use property-types in evolutionary explanations. Of course, it does not follow from this that we *can't* do so: we can use property-types to pick out the tokens selection operates on, for example. Giraffe x's neck size in the example I used above can be referred to as the exemplification of a universal '12 feet tall'. But, and this is the important point, we don't have to use property-types in order to give a full selective explanation and we don't gain anything by doing so. We can explain why certain traits are the way they are without appealing to property-types—adding them to our metaphysical picture would not give us any explanatory advantage. Thus, it seems that biological property-types are explanatorily superfluous.

Of course not all evolutionary explanations are *selective* explanations. I was focusing on the explanatory role of selection above, but similar arguments could be given with regards to non-selective evolutionary processes, such as the founding effect. Like selection, the founding effect can also be fully accounted for by individual token level processes, without appealing to any trait types. It is the token traits of the token members of the founding population as well as the inheritance of these traits from one token organism to the other that explain why organisms in the present population have the traits they have. Again, the explanation can be given without any reference to any property-types.

Thus, we have no reason to attribute any explanatory role to any property-type when explaining why token organisms have the traits they have.

5 Trope nominalism and essentialism about biological kinds

The way we should think about population thinking is an important question in and of itself, as it is supposed to tell us the right way of thinking about the biological domain. But this concept has recently become even more relevant, because of the recent debate concerning essentialism about biological kinds, where population thinking has been used to support both the essentialist and the anti-essentialist position. Population thinking has been traditionally used to argue against essentialism about biological kinds (Mayr 1959/1994, 1988; Hull 1986; Dupré 1993). Recently, however, it has been suggested that it may be consistent with at least some forms of essentialism—ones that construe essential properties as relational. I will argue in this section that if population thinking is a version of trope nominalism, then it excludes any version of essentialism about biological kinds—whether or not the essential properties it posits are relational.

One big question about natural kinds is whether they have essential properties: properties all and only members of a natural kind have in all possible worlds. Hilary Putnam and Saul Kripke argued that they do (Putnam 1975; Kripke 1980). However, biology has always been considered to be a problem case for essentialism or at least a potential exemption. According to the traditional and rather strong “anti-essentialist consensus” (Okasha 2002, p. 195; Walsh 2006, p. 325) among biologists and philosophers of biology, at least regarding biological kinds, essentialism is false (Dupré 1993, 2002; Hull 1965; Ghiselin 1974; Hacking 2007). Putnam and Kripke may be right about chemical kinds, but biological kinds do not have (and cannot have) any essential properties (Wilkerson 1995; Ellis 2001).

It is not an easy task to pin down what is meant by essentialism about biological kinds. A couple of preliminary remarks need to be made. First, one can be essentialist about individuals and about kinds. I will not say anything here about essentialism regarding individuals. Maybe, as Kripke claims, specific individuals have essential properties, maybe not (on this important and complex question, see, for example, Robertson 1998; Hawthorne and Gendler 2000; Matthen 2003). Essentialism about individuals is logically independent from essentialism about kinds (see also Okasha 2002, p. 192). The question I am interested in is whether biological kinds have essential properties.

Second, there are a number of potential definitions for essentialism about kinds. As I intend to argue against essentialism in biology, I will use the most general of these. Richard Boyd identified a widespread and fairly strong version of essentialism, according to which natural kinds “must possess definitional essences that define them in terms of necessary and sufficient, intrinsic, unchanging, ahistorical properties” (Boyd 1999, p. 146). Essential properties in, say, chemistry may all be intrinsic, unchanging and ahistorical. But it is not clear that essential biological properties need to satisfy any of these three requirements. In fact, a rather easy way of arguing against essentialism about biological kinds is to point out that biological properties are extrinsic, historical and they change over time, because biological entities are evolving over time (Hull 1965; see objections to arguments of this kind in Sober 1980, p. 356; Okasha 2002, pp. 195–196; Walsh 2006, p. 431). I don’t think arguments of this kind will defeat essentialism about biological kinds. A new wave of biological essentialists all seek to specify essential properties of biological kinds that are extrinsic and that are neither unchanging nor ahistorical (Griffiths 1999; Okasha 2002; Walsh 2006). The simple argument from the observation that biological entities are evolving over time cannot be used to argue against these versions of biological essentialism.

Thus, if we want a target that is worth arguing against, we need to weaken this strong definition of essentialism. As most of the new essentialists, I am also happy to go along with David Hull's characterization, according to which "each species is distinguished by one set of essential characteristics. The possession of each essential character is necessary for membership in the species, and the possession of all the essential characters sufficient" (Hull 1994, p. 313). I will use Hull's definition as my starting point for characterizing kind-essentialism in what follows.[8]

In the last couple of years, more and more philosophers have argued for a version of essentialism about biological kinds. Paul Griffiths, for example, argues that biological kinds have "essential relational properties"—not essential intrinsic properties, and claims that if we accept that essential properties can be relational, then all the traditional considerations against essentialism about biological kinds lose their appeal (for a similar claim, see Okasha 2002; the idea of using relational properties for defining biological kinds, not necessarily in an essentialist manner, comes from Matthen 1998, Millikan 1999 and Elder 1995). Denis Walsh goes even further and claims that "recent evolutionary developmental biology provides compelling evidence" (Walsh 2006, p. 425) for essentialism. Thus, if we take contemporary biology seriously, we should reject the anti-essentialist consensus.

Unsurprisingly, all of these recent attempts to resurrect essentialism about biological kinds find it important to show that their version of essentialism is consistent with population thinking (Walsh 2006, pp. 432–433; Okasha 2002, pp. 195–196). As Paul Griffiths says, "it would be quite consistent to be a Darwinian [population thinking] essentialist, given the right choice of essential properties" (Griffiths 1999, p. 210). Or, more explicitly (for a similar claim, see Okasha 2002):

> Population thinking excludes essential intrinsic properties, but it does not exclude essential relational properties. (Griffiths 1999, p. 210)

Whether these attempts to carve out an essentialist way of construing population thinking succeed depends on the way we interpret population thinking. Conversely, whether population thinking really gives us some reason to have doubts about essentialism about biological kinds also depends on the way we interpret population thinking. My claim is that these attempts to make population thinking consistent with essentialism rely on a false reading of what population thinking is. If we take population thinking to imply the claim that biological property-types play no explanatory role, then essentialism about biological properties is unlikely to be a viable option.

Essentialism about kinds is a complex thesis that goes beyond the simple claim that there are some properties that all and only members of a natural kind have in all possible worlds. Importantly, it implies that, as Marc Ereshefsky put it, "knowing a

[8] There may be ways of weakening essentialism even more by denying that essentialism implies that all and only the members of a kind must have a kind-specific essence (Boyd 1999). I will say a bit more about the relevance of the argument I present in this paper to such accounts in the next footnote.

kind's essence helps us explain and predict those properties typically associated with a kind" (Ereshefsky 2008, Sect. 2.1).

This tenet of kind-essentialism is crucial: it is not enough that all and only members of a kind have an essential property. This property also needs to do some explanatory work. As Ereshefsky says, "knowing the essence of a kind […] allows us to predict and explain the properties associated with the members of a kind. For instance, the atomic structure of gold provides the basis for explaining why gold conducts electricity, and it allows us to predict that a particular chunk of gold will conduct electricity". (Ereshefsky forthcoming, p. 1). Or, as Philip Kitcher says, "natural kinds are distinguished by some special underlying feature that explains the behavior of members of this kind—like atomic number, for example, in the case of the elements" (Kitcher 2007, p. 294; Dupré 2002, pp. 176–181; Wilson et al. forthcoming; see also Platts 1983 for a classic summary; Okasha 2002, p. 203 for some critical remarks).

It is very important to emphasize that this tenet of kind-essentialism is not an optional add-on, but a necessary feature of any version of kind-essentialism. If essences did not have to play any explanatory role—if they didn't have to "allow us to predict and explain the properties associated with the members of a kind", then it is not clear how we could draw the line between 'real' and 'nominal' essences. All members of species X have the property of being an X (or of being categorized by us as an X), but this property is supposed to be a nominal and not a real essence precisely because it has no causal/explanatory role. In short, if we can show that this tenet of essentialism is unjustified, then we have a good way of arguing against essentialism per se.

And, at least in the biological domain, we do have good reason to doubt this essentialist claim, although it may be true in some other domains: the atomic structure of gold, for example, may indeed be an explanatorily relevant essential property. So let us see what makes the biological domain special. The important consideration is that essential properties that all and only members of a kind have are essential *property-types*. The set of essential properties that defines biological kinds is a set of essential property-types. The *instantiation* of each essential property-type is necessary for membership in the biological kind and the *instantiation* of all the essential property-types sufficient. And if biological property-types play no role in explaining why token organisms have the traits they have, then *essential* biological property-types don't either. But if this is true, then essential biological property-types also fail to "explain the properties associated with the members of a kind" (Ereshefsky forthcoming, p. 1). Thus, biological essences, even if they do exist, and even if they are necessary and sufficient for kind-membership, cannot satisfy the explanatory tenet of kind-essentialism. Essentialism about biological kinds fails.[9]

[9] Richard Boyd argued that we can give an even weaker formulation of essentialism than the one we have considered so far. More precisely, essentialism does not necessarily imply that all and only the members of a natural kind must have a kind-specific essence. According to his 'homeostatic property cluster theory', the members of a kind share a cluster of similar properties, but no property is necessary for membership in this kind (Boyd 1999). Boyd's 'homeostatic property cluster theory' is quite complex and I do not intend to give a definitive argument against it. But we may be able to use the considerations above to make the following conditional claim. Boyd explicitly states that "the homeostatic clustering of properties […] is causally important" (Boyd 1999, p. 143). If this is to be understood in such a way that it is also explanatorily relevant and if the 'homeostatic clustering of properties' is supposed to be understood as a type that can have

Take the following example for a property-type that is considered to be a good candidate for a property that all and only members of a species have in all possible worlds: the property of being a member of a population with such and such distinctive evolutionary history (Griffiths 1999; Okasha 2002; the idea, again, comes from the anti-essentialist Matthen 1998). It can be argued that all and only members of a species have this property and maybe this is even true across possible worlds. But what matters for our discussion is that this property-type has no explanatory power with regards to explaining the traits of the members of this species. Again, if essentialism about biological kinds were correct, these essential property-types would be able to "explain the properties associated with the members of a kind" (Ereshefsky forthcoming, p. 1). But they don't. If selection is taken to be token-selection, then selection, a process that operates on tokens, explains why these members have the traits they do. And if selection is taken to be type-selection, then individual mutation, inheritance and development explains why these members have the traits they do. No property-types, let alone the property type of being a member of a population with such and such distinctive evolutionary history, are required. Again, biological essences, even if they do exist, fail to play any role in evolutionary explanations.[10]

How could the new essentialist respond to this argument? One possible way of doing so would be to deny that biological essences have to play any explanatory role. This is Samir Okasha's strategy. He writes that "there is no *a priori* reason why the same thing should play [...] both a semantic role and a causal-explanatory role" (Okasha 2002, p. 203). He adds: "Simply because atomic structure performs both roles in the case of chemical elements does not mean that the two roles must always be played by the same thing". Okasha's strategy is to use relational essences to play the semantic role and insist that we should not expect these relational essences to play any causal-explanatory role.

The problem with this strategy is that, as we have seen, if essences did not have to play any explanatory role, then it is not clear how we could draw the line between 'real' and 'nominal' essences. All members of species X has the property of being an X (or of being categorized by us as an X), but this property is supposed to be a nominal and not a real essence precisely because it does no causal/explanatory role.

Footnote 9 continued
a number of different token instantiations, then Boyd's view contradicts the considerations I presented above in favor of the claim that property-types play no role in biological explanations. See Nanay (forthcoming).

10 Some of the proponents of the new essentialism about biological kinds take kinds and individuals to be the same kinds of entities (see esp. Okasha 2002). Although this way of thinking about kinds was originally introduced as a way of resisting essentialism about biological kinds (Hull 1965, 1978; Ghiselin 1974), it has been pointed out that taking kinds to be spatiotemporally discontinuous individuals is not inconsistent with kind-essentialism (see LaPorte 2004 for a summary). One worry about my argument would be the following then. If we accept that kinds are individuals, then we could maybe give an essentialist account of kinds without talking about any property-types (after all, we will try to specify the essence of an individual). So my attack on the explanatory relevance of biological property-types will fail to hit the target in the case of this version of kind-essentialism. My response is that it would not even be possible to talk about kinds as individuals without presupposing property-types: what will make the spatiotemporally discontinuous parts of an individual parts of this specific individual (rather than another one)? The answer cannot even be formulated without helping ourselves to property-types. What keeps the various parts of this individual together is not some kind of spatiotemporal unity (as kinds as individuals are spatiotemporally discontinuous) but some shared feature, that is, some property-type all of these parts of this individual have instantiations of.

Okasha's biting of the bullet means that his new essentialism is really about nominal essences.[11]

We have reason to resist the claim that essential property-types play a role in evolutionary explanations; hence, we have reason to resist essentialism about biological kinds. And this is exactly the conclusion Mayr's population thinking was meant to justify. If we take population thinking to imply that biological property-types are explanatorily superfluous, then essentialism about biological kinds is not an option—in spite of the recent attempts to make biological kind-essentialism consistent with population thinking.[12]

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[11] Denis Walsh's version of new essentialism is significantly different from Okasha's and Griffiths' version. Walsh wants to resist not only the anti-essentialist, but also what he perceives to be the anti-individualist consensus in contemporary biology and philosophy of biology. Somewhat puzzlingly, he takes Mayr to be defending both anti-essentialism and anti-individualism. He writes:

> Mayr tells us that Darwin's greatest intellectual triumph (apart from the banishment of typological thinking) was the shift to 'population thinking'. According to Mayr, Darwin realized that in order to explain the diversity of organic form one had to understand the principles by which populations change their constitution over time. The explanandum, for Darwin, shifted from being a property of individual organisms to being a property of populations. (Walsh 2006, pp. 432–433)

This conclusion seems very different from Mayr's "only the individuals of which the populations are composed have reality". Walsh quotes (on p. 343) Sober's claim that "population thinking involves *ignoring individuals*" (Sober 1980, p. 370), but forgets to mention that Sober rushes to add that "this conclusion contradicts Mayr's […] assertion that for the populationist, "the individual alone is real" (ibid).

Walsh takes biological essentialism to be an explanatory doctrine (see esp. Walsh 2006, p. 430). As he says, "Organismal natures play a teleologically basic role in explaining why organisms have the traits they have and why they resemble one another in the ways they do." (Walsh 2006, p. 430). By organismal natures, he means natures "the goal-directed capacities of organisms to develop and maintain viability" (Walsh 2006, p. 444). But, as we have seen, the token 'goal-directed capacity' of a token organism 'to develop and maintain viability' may be explanatorily relevant in explaining why this organism has the traits it has, it is doubtful that the property-type of organismic natures would or even could play this role.

[12] We need to be careful about what version of trope nominalism the anti-essentialist strategy I outlined here needs to endorse. Many trope nominalist accounts define property-types as sets or resemblance-classes of tropes. Thus, according to these accounts, although the existence of property-types in some sense reduces to the existence of tropes (and, as a result, in some sense they are not 'real'), they do have mind-independent existence: there is a fact of the matter about whether a trope subsumes under a certain set or resemblance-class. The version of trope nominalism that could be used to argue against essentialism needs to be more radical than this: it cannot allow for there being a fact of the matter about whether a trope subsumes under a certain set or resemblance-class: if it did allow for this, then the essentialist view could be rephrased in terms of 'essential' sets or 'essential' resemblance-classes of tropes. In order to block the essentialist argument, the trope nominalist needs to claim that property-types are just our ways of grouping tropes: they do not have mind-independent existence (Nanay 2009). Note, however, that population thinking takes property-types to be 'merely statistical abstractions'; and Mayr explicitly denies that they have mind-independent existence (they do not have 'reality', as he puts it). So population thinking is trope nominalism is of this radical kind.

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