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ARTICLE

Reduction as a Value: The Case of Genetic Reductionism in Evolutionary Theory

François Papale

Department of Philosophy, McGill University, Canada
Email: francoisppl@gmail.com

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Abstract

At least three meanings of the word *reduction* have been theorized by philosophers: epistemic, ontological, and methodological reductions. In this article, I suggest a fourth meaning to complement the literature: the axiological meaning. Theorizing reduction as an epistemic value refers to the normative pull that reduction sometimes has on scientific reasoning. The example of genetic reductionism in evolutionary biology shows that in cases of underdetermination of theory by evidence, reduction can influence theory acceptance just like other values do. I suggest that reduction, in this context, is involved in a value trade-off that also features parsimony and explanatory power.

1. Introduction

The notion of reduction has traditionally been analyzed by focusing on three meanings of the word: epistemic reduction, ontological reduction, and methodological reduction (Ayala 1974). In this article, I argue that a meaning of the word ought to be added to the list and theorized by philosophers interested in understanding scientific practices and the role of reduction therein: the axiological meaning. More specifically, I argue that it is useful to consider reduction as an epistemic value, something "worthy of pursuit" (Elliott 2017) because of its alleged privileged relationship to knowledge construction (Douglas 2013; Peels 2018). Although the three standard meanings of the term *reduction* are used by philosophers to describe relationships between theories or explanations, relationships between ontological categories, or scientific methodologies, the axiological meaning captures the normative pull that reduction sometimes has on researchers, which might lead them to privilege reductionist methodologies or explanations (Hopkins et al. 2016). Accordingly, this meaning of reduction is compatible with the others and complementary to them.

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The article is structured as follows. First, I give an overview of the fertile philosophical landscape that surrounds reduction (section 2). This overview is meant neither to be exhaustive nor to solve structural debates within the field. The main objective of this section is to illustrate that although reduction is often implicitly treated as a thing worthy of pursuit, it has never been explicitly theorized as a value. Second, I take a closer look at the notion of value and, more specifically, how epistemic values influence scientific reasoning. This helps me articulate in more detail what it means for reduction to be a value (sec. 3.1) before comparing this new meaning to the traditional ones (sec. 3.2). Section 4 is concerned with a case study: genetic reductionism in evolutionary biology. This example shows that reduction can be involved in trade-offs with other values that are necessary to overcome cases of underdetermination. As a result, I argue that in the context of evolutionary theorization, explanatory power has been sacrificed for the benefit of parsimony and reduction.

2. Reduction in the philosophy of science

Although it is beyond the scope of this article to provide an encyclopedic description of the various accounts of reduction that can be found in the philosophy of science, it is important to give at least an overview of the most important approaches that shaped the literature. By doing so, I hope to represent the diversity of meanings and to highlight that there is room for at least one more, the axiological meaning.

In the philosophy of science, the term *reduction* has a plurality of interrelated meanings. A typical way of approaching this constellation of meanings is by focusing on the "nothing but" locution. In short, if x can be reduced to y, this means that x is "nothing but ..." y (Silberstein 2002). The standard way of analyzing the "nothing but ..." family of concepts relies on a tripartite distinction, recognizing the existence of ontological, epistemic, and methodological reductions (Ayala 1974). As I hope the following discussion will make clear, the "nothing but ..." locution fails to cover all relevant approaches to reduction found in philosophy of science (witness the diachronic reduction and explanatory reduction as explored later in the article). It serves, however, as an adequate entry point because of its intuitive dimension (especially in the case of theory and ontological reductions).

Strong approaches to ontological reduction claim that all phenomena are mere arrangements of the same material entities, usually held to be the most "fundamental" entities studied by (particle) physics (or those studied by a hypothesized fully developed physical science). Nothing exists but these. Weaker variations of ontological reduction suggest that a given system's behavior is entirely determined by the intrinsic (nonrelational) properties of its parts (Guo 2023; Silberstein 2002). This can be seen as a more local form of reduction that can be used to tackle a system and its parts without attempting its full-fledged reduction to the most "fundamental" particles of physics (e.g., Tahko 2020).

The epistemic notion of reduction is the one that has attracted the most attention in philosophy (van Riel and Van Gulick 2019). Nagel's work (1935, 1949, 1961, 1970) surrounding the notion and Schaffner's update to Nagel's model (Schaffner 1967, 1974, 1976, 1993) have been especially influential. They present reduction as a formal relation between theories. According to Nagel's model, reduction is an explanatory

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relationship between two theories, where the reduced theory is *entirely* derivable from (is nothing but) the reducing one plus a set of theoretical assumptions (including bridge laws, when needed). Schaffner's changes to the model were meant to introduce more flexibility, specifically by relaxing the formal relationship between the two theories (for a detailed discussion, see Dizadji-Bahmani et al. 2010).

The Schaffner–Nagel model of theory reduction generated pushback. As a result, other approaches to epistemic reduction were developed to address perceived problems or blind spots of the Nagelian model: the structuralist (Suppes 1967), functionalist (Lewis 1970; Lorenzetti 2023), and New Wave (Bickle 1998; Churchland 1979, 1986) models, for instance. Both the criticizing and the criticized views, however, share a commitment to treating reduction as an atemporal phenomenon, a formal relationship between theories. Debates surrounding the potential reduction of classical genetics to molecular genetics (Hull 1972; Waters 1994) illustrate how this meaning of reduction has been operationalized by philosophers. The question asked by philosophers was not whether molecular genetics had replaced classical genetics. Instead, they inquired into the formal relationship between the two sets of practices.

This focus on the formal dimension of epistemic reductions contrasts with an alternative body of work, which claims that a dichotomy is necessary to account for epistemic reductions (Crowther 2020; Dizadji-Bahmani et al. 2010; Dupré 1993; Rosenberg 2006; van Riel and Van Gulick 2019). This dichotomy has been described using different terms. On one side of the dichotomy, there is synchronic reduction (or reduction$_1$ [Nickles 1973] and explanatory reduction [Wimsatt 1980, 2006]), and on the other, we find diachronic reduction (or reduction$_2$ [Nickles 1973] and successional [Wimsatt 1980, 2006]).

The synchronic family of reduction concepts emphasizes atemporal relationships between theories. In Nickles's approach, synchronic reduction echoes the formal approach of the Nagel–Schaffner model: "'Reduction$_1$' (as I shall call it) is the achievement of postulational and ontological economy and *is* obtained chiefly by derivational reduction as described by Nagel; i.e., reduction$_1$ amounts to the *explanation* of one theory by another" (Nickles 1973, 181).

Although Wimsatt's notion of explanatory reduction can be tied to synchronic reduction and reduction$_1$, it should be noted that it differs from them in two important ways. First, according to Wimsatt, explanatory reduction cannot be reduced to the Nagel–Schaffner model because it concerns explanatory relationships between levels of organization rather than theories. Crowther (2020) synthesizes Wimsatt's explanatory reduction as follows: "Its aim is to provide a *compositional, mechanistic* and *causal* explanation of some large-scale phenomena in terms of shorter-length scale behaviours" (1442).

Second, Wimsatt's model moves away from the "nothing but . . . " locution. Indeed, despite the explanation of larger phenomena in terms that correspond to smaller scales or "lower" levels of explanation, the lower-level explanations involve contextual information that is often necessary to the articulation of the reduction. Because contextual information coming from higher levels is present, the "nothing but . . . " locution fails to apply. Nonetheless, Wimsatt's explanatory reductions are synchronic, in the sense that they avoid reference to the historical process by which a theory (targeting a specific level of organization) comes to replace another (at a higher level of organization).

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In contrast, diachronic reduction (as well as reduction$_2$ and successional reduction) involves a new and an old theory, with one replacing the other across time. Although there might also be a formal dimension to the relationship between the old and the new theory, diachronic reduction emphasizes other aspects of the relationship. According to both Nickles and Wimsatt, the historically situated and conscious attempt to relate the new theory to the old one serves, among other things, to strengthen the field that makes use of these theories: "It legitimates use of the older theory where they agree ... ; co-opts its evidence for the newer theory; may establish conceptual connections between them ... ; and locates places to pursue confirmation, test, and elaboration of the newer theory where they disagree" (Wimsatt 2006, 449). In other words, on this side of the dichotomy, we are more interested in scientific practice and justification, going beyond explanations and theory. As a result, this meaning also moves away from the "nothing but ..." locution, emphasizing dissimilarities as well as overlaps.

In summary, despite the diversity of approaches, epistemic reduction can be said to form a single category in that it serves to describe relationships between theories or explanations. Especially in philosophy of biology, debates surrounding diachronic reductions and explanatory reductions have gained more attention in past decades than formal approaches to *theory* reduction (Crowther 2020; Hüttemann and Love 2011; Kaiser 2015). Yet in all these cases, the concept is meant to describe reduction rather than emphasize its normative pull on working scientists.

Methodological reduction is, to my knowledge, the least theorized meaning of the term *reduction*. Hoyningen-Huene (1991) called it a *residual category*, claiming it refers to reductions that fit neither the ontological nor the epistemic concepts. More usefully, Ayala (1974) defined it as follows: "The *methodological* domain encompasses questions concerning the strategy of research or the acquisition of knowledge" (viii). More recently, Lausen (2014) insisted on the importance of theorizing this neglected meaning of reduction. He suggests that reduction can be conceived as a "research directive," a concept inspired by Lakatos's research programs (Lakatos 1970). Research directives are sets of ontological principles paired with epistemic activities (the notions of ontological principles and epistemic activities are borrowed from Chang's work [2009]). Methodological reduction, when conceived as a research directive, means behaving epistemically in accordance with metaphysical beliefs that are tied to ontological reduction (see Lausen 2014, 272).

The tripartite distinction (ontological, epistemic, and methodological) is just one way among others, albeit a common one, to capture the network of meanings tied to the word *reduction*. Hoyningen-Huene (1991), for example, adds a fourth category, that of explanatory reduction (which can also fall under epistemic reduction, as in Crowther [2020] or Wimsatt [2006]). Silberstein (2002), in contrast, works only on the ontological and epistemic meanings but provides a more detailed taxonomy of these two categories. In other words, I have only presented an overview of a very rich literature. What I tried to convey is that the tripartite distinction covers a lot of ground, yet it fails to embed the meaning of reduction that this article adds to the list. Reduction has yet to be theorized as a value, a claim I detail in the following section.

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3. Reduction as a value

3.1. The axiological meaning of reduction

A value is "something that is desirable or worthy of pursuit" (Elliott 2017, 11). For instance, equality or equity among members of a society can be valued, and we may act in the hope of reaching one or the other (or neither). All sorts of values exist, and they influence, in various ways, the work being done in academia and other scientific forums. For instance, if profit is valued by a pharmaceutical corporation, the research it produces might be oriented toward the development of treatments for diseases that are worrisome to the richest groups in a target population. The value here draws the attention of researchers toward certain objects of inquiry rather than others. Elliott's 2017 book, among other milestones in the literature concerned with the role of values in science (e.g., Douglas 2009; Longino 1990), is rife with examples of how values influence scientific work, having sometimes beneficial, sometimes harmful effects. The book is focused on what are usually construed as nonepistemic values, that is, moral, political, or social ones (Montminy and Papale 2018).

In contrast, other values can be said to be epistemic because of their alleged privileged relationship to knowledge or truth (Kuhn 1977; Douglas 2013; Peels 2018). Philosophers have traditionally attributed epistemic values (also called *cognitive values*) a role in filling gaps in scientific reasoning, a role they allegedly play in a constructive rather than harmful way. (Implicit to this line of reasoning is the belief that nonepistemic values are harmful to scientific inquiry, a belief that has been challenged in past decades; see Anderson [2004] and Elliott [2017].) Examples of widely accepted epistemic values are simplicity (or parsimony), explanatory power, precision, internal coherence, empirical adequacy, and fertility. These values and others are considered beneficial to knowledge construction, but their relative importance may vary from one epistemic context to the next (Douglas 2013).

I believe reduction should be added to the set of widely acknowledged epistemic values. In this light, reduction is considered something worthy of pursuit because of its alleged privileged relationship to knowledge or truth. Researchers who hold reduction as a value might end up promoting epistemic, ontological, and methodological reductions in their work and beyond (e.g., when reviewing papers or when doing editorial work) because they conceive of reduction as an ideal. Consequently, reduction may influence various dimensions of scientific practice: choices of subjects to inquire into, of methods to adopt, of metaphysical commitments to hold or discard, and so forth. It may also directly affect scientific reasoning and justification. That is the line of influence upon which I focus in this article, showing that reduction can shape the outcome of inferences made based on evidence. Future work will benefit from exploring the other lines of influence mentioned above.

To detail how values shape scientific reasoning and justification from within, it is important to return to the field-defining work of Rudner (1953), Kuhn (1977), and Longino (1990). All three authors rely on the *underdetermination argument* (Longino 1990). This seminal argument rests on the fact that observations underdetermine theory acceptance or rejection (Duhem [1906] 2007; Kuhn 1977; Quine 1961). In short, cases of underdetermination are cases where two (or more) theories or hypotheses are supported by the same set of observations. In these situations, empirical data cannot, in and of themselves, explain or justify theory acceptance or rejection. Theory

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acceptance or rejection can therefore only be obtained when data are paired with a diverse set of contextual factors. Among these, we find values: Both epistemic (Kuhn 1977) and nonepistemic (Longino 1990) values influence our acceptance or rejection of specific hypotheses or theories from within. Values are constitutive of scientific justificatory processes.

Hence, to say that reduction is an epistemic value means, among other things, that it may influence scientific reasoning from the inside by helping fill the gap between observations and theory acceptance or rejection. It should be conceived as a concept with a normative effect on scientific practice. It offers an ideal to which scientific justificatory processes may appeal and conform (whether scientists are aware of it or not) when evidence is insufficient to support a hypothesis or theory. We cannot expect reduction to act alone, however. It enters value trade-offs that end up determining theory choice. Reductionism, in this light, can be defined as the result of valuing reduction sufficiently for it to dominate value trade-offs. The example discussed in section 4 is one where some evolutionary theorists have preferred reduction over explanatory power, thereby justifying the use of the label *reductionism* to describe their stance.

3.2. Comparing the axiological meaning of reduction to other meanings

The fact that reduction is worthy of pursuit (that it is a value) is often implicit in discussions about other meanings of the term *reduction*. For example, Kemeny and Oppenheim (1956) claimed that theory reduction is a form of progress, that is, a form of theory change or replacement that is valued: "An especially important case of [scientific progress] is the replacement of an accepted theory (or body of theories) by a new theory (or body of theories) which is in some sense superior to it. Reduction is an improvement in this sense" (Kemeny and Oppenheim 1956, 7). This refers to the diachronic (epistemic) meaning of reduction described earlier but conflates it with scientific progress (see also Carnap 1934 and Neurath 1931), that is, with something worthy of pursuit (a value).

Yet to view reduction as a value influencing scientific work from the inside differs from saying that a theory reduces to another, even if this specific relationship between theories ends up being valued. *Reduction as a value* refers to the normative dimension of these claims by Kemeny and Oppenheim, whereas *epistemic reduction* refers to the descriptive dimension. Holding reduction as a value implies that one *might* attempt to produce such epistemic reductions because reduction *is* an ideal as well as a relationship between theories or explanations. In cases of underdetermination of theory or hypothesis by observation, reduction may similarly make researchers lean toward one research outcome instead of another in the name of reduction being something worthy of pursuit.

The claim that reduction is a value also differs from the characterization of reduction as an ontological matter. To suggest that something is nothing but a specific ensemble of its parts (reducing the thing to its components) tells us nothing about the role reduction may play in the inferential process; rather, it is the outcome of an inferential process. Of course, the *desirability* of both ontological and epistemic reductions has often been expressed by researchers (as stated above). Yet the next epistemological step—that is, to stress that this desirability entails the possibility for

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reduction, as a value, to influence scientific reasoning—has remained untheorized. The present article covers that blind spot.

It could be argued that the axiological and the methodological meanings of reduction overlap too much for them to be usefully theorized distinctly. If a scientist holds reduction as a research directive (Lausen 2014), for instance, we should assume that they do so because they believe reductions are worthy of pursuit. Nonetheless, the axiological and methodological meanings of reduction differ with respect to their respective levels of analysis. Methodological reduction, in the case of Lausen (2014), is meant to be programmatic, to structure specific research practices. In other cases, it can be used to describe scientific research strategies (Ayala 1974). In both cases, the descriptions and prescriptions concern structural aspects of research.

In the case of reduction as a value, I suggest it can be used for much more local analysis of justificatory processes (which may support research strategies or the adoption of research directives). Again, the case of genetic reductionism in evolutionary biology is useful. In the next section, I show that arguments by Williams and Dawkins draw on reduction as a value to overcome underdetermination. These arguments certainly contributed to the fact that so many evolutionary biologists have since then adopted reductionist methodologies, but this only shows that the influence of reduction as a value may lead to reductionist methodologies being accepted (hence, the two are distinct). This emphasizes the importance of avoiding conflations between different meanings of reduction.

The difference between methodological and axiological meanings of reduction is further illustrated by the fact that holding reduction as a value may lead to no concrete changes in practice because it is involved in value trade-offs. Trade-offs between reduction and other values (e.g., explanatory power or precision) may lead researchers, in certain contexts, to prioritize other values, thereby structuring their work around these values instead of reduction despite valuing the latter. Schematically put, *methodological reduction* refers to scientific practices that are or should be structured according to beliefs in the validity of (epistemic or ontological) reduction, and such structuring of research happens when reduction comes out on top of value trade-offs.

I believe the foregoing discussion shows that theorizing the axiological meaning of reduction fills a blind spot in the philosophical literature surrounding reduction: whether the term *reduction* refers to a formal relation between theories, an explanatory achievement linking distinct levels of organization, an event of theory replacement, a successful ontological reduction (e.g., the elimination of a superfluous ontological category), or a research directive, it may also be *valued* by researchers, thereby influencing core processes of scientific justification. This contributes to explaining the results of research according to which individuals prefer explanations featuring reductive information when faced with alternative explanations, even if the reductive elements tied to the explanation are irrelevant to the logic of the explanation (Hopkins et al. 2016). Reduction, as a value, runs deep both within and beyond academic circles.

The literature on values in science and, more broadly, the literature associated with the social turn in philosophy will also benefit from this new treatment of reduction. In that context, reduction has already been recognized by Longino (1990, chap. 10) as something that might *strengthen* or at least *accompany* epistemic values (simplicity or

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unification, for instance) and nonepistemic values (e.g., antiegalitarian values). Yet she defined reduction in methodological and ontological terms (Longino 1990, 225–26), not as a value in and of itself. Similarly, Elliott (2017) conceived of reductionism as a general frame for representing and communicating scientific work, but again, not as a value. Shiva (1988) ties reductionist science to a form of violence, thereby construing it as something that promotes certain values while going against others. Douglas's (2013) treatment of cognitive values also neglects reduction. In other words, theorizing reduction as a value covers untrodden ground across different subfields in philosophy.

4. Axiological reduction in action: Genetic reductionism and evolutionary theorization

This section fills two overlapping roles. First, it is meant to illustrate how the notion of reduction as a value can be used when analyzing the dynamics of scientific justification. Second, I leverage the axiological meaning of reduction to contribute to a better understanding of the justificatory structure of evolutionary theorization. I focus on genetic reductionism, as theorized by evolutionary biologists such as Williams and Dawkins, in the context of levels-of-selection debates. This allows me to show that acceptance of reduction, in this case, *requires* adopting reduction as a value to fill an acknowledged justificatory gap between evidence and theory.[1] This also illustrates how reduction may interact with other values, such as simplicity and explanatory power. It should be noted, however, that my analysis is not meant to establish whether Williams and Dawkins consciously or unconsciously held reductionism as a value. Rather, I hope to show that retrospectively, their arguments only make sense if reduction as a value influences reasoning.

The justificatory process that here concerns us is meant to establish the claim that although biological evolution can be theorized at various levels of organization (genetic, cellular, organismal, groups, species, etc.), multilevel theorizations (e.g., Lewontin 1970) are ultimately *nothing but* (and at best) reformulations of evolution at the genetic level. In other words, evolutionary theory should only be concerned with populations of genes. Williams's *Adaptation and Natural Selection* (1966) is an important milestone in the development of gene-centric views of evolution (Ågren 2021). Dawkins's *The Selfish Gene* (1976) was written to make gene-centric views more accessible to a wider public, but it ended up occupying center stage in theoretical debates surrounding evolution (Ågren 2021). To grasp the role that reduction, as a value, plays in the books of Williams and Dawkins, it is best to explore how they approach the problem of altruism.

Altruism, in the context of evolutionary biology, refers to behavior that increases the fitness of another individual *at the expense of* the fitness of the individual that acts altruistically. Nothing is implied about the state of mind of the altruistic individual; the individual may consciously be acting altruistically or not. Examples of altruistic behavior may include the production of an extracellular polymeric substance matrix by some bacteria within a biofilm, the self-sacrificing behavior of sterile eusocial

[1] Implicit to the line of reasoning here presented is the idea that emergence (which can be thought of as reduction's opposite) could also work as a value. Accordingly, antireductionist approaches are also value laden. I leave a more detailed analysis of this point for further research.

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insects defending their colony, or the entering of a building in flames by a human hoping to save another human (or a cat).

At first glance, altruistic behaviors are problematic in the context of evolutionary biology because such behaviors, by definition, should be filtered out by natural selection since they decrease the fitness of the individuals that behave altruistically and increase the fitness of the beneficiaries. As a result, altruistic individuals should persist and reproduce less across time than selfish ones do, and this should lead to their extinction. Yet altruistic behaviors *are* observed in nature. This generates a vexing situation for the version of the theory of evolution by means of natural selection that focuses on individual organisms. Hence, evolutionary biologists have been debating alternative formulations of the theory of evolution for decades.

Indeed, a few options to solve this conundrum are available and were hotly debated in the 1960s and 1970s. These include gene reductionism and group selection. Gene reductionism suggests that natural selection is not operating on individual organisms (that behave altruistically), but instead on the genes that encode their altruistic behavior. Because copies of the same genes can be found in other organisms, it makes sense for genes to code for behavior that makes an organism behave altruistically. The mathematization of this rationale by Hamilton (1964) has led to the development of the theory of kin selection: a trait (behavioral or other) can be selected for because it promotes the fitness of closely related individuals, even if the trait involves a loss of fitness for the individual that bears it. Williams and Dawkins argue that this is coherent with typical evolution by natural selection acting on genes instead of individual organisms.

Another explanation for the existence of altruistic behavior at the level of organisms is available, however: Selection might be acting on groups of organisms instead of individual organisms or genes. The idea is straightforward: because groups in which altruistic behavior is more common fare better than groups in which selfish behavior dominates, these altruistic groups should prevail on evolutionary timescales. As a result of the success of these groups and despite the fact that individuals that behave altruistically are less fit than those that behave selfishly (again, by definition, in the context of evolutionary biology), altruistic behavior can still be expected to result from natural selection as long as it acts on *groups* rather than individuals.

In his 1966 book, Williams defends genetic reductionism as the best way to tackle various issues, including the explanation of altruism. However, he recognizes that the choice between evolutionary explanations that lie at different levels of biological organization is underdetermined. He states: "Various levels of adaptive organization, from the subcellular to the biospheric, might conceivably be recognized, but the principle of parsimony demands that we recognize adaptation at the level necessitated by the facts and no higher" (Williams 1966, 19). Hence, Williams explicitly refers to parsimony, a broadly recognized epistemic value, to justify his gene-centered approach when faced with underdetermination (underdetermination being implied in the fact that explanations at different levels "might conceivably be recognized"). Although I agree that empirical data are insufficient to settle the issue, I argue that parsimony is also is insufficient. Reduction, as a value, must be involved.

One could, based on parsimony, use the theory of evolution by natural selection *solely* at the level of groups of organisms to explain this altruistic behavior (as Wynne-Edwards did in 1962, albeit naively; see Nowak [2012], Jacquiod et al. [2025], or Oszoli

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and Zachar [2024] as examples of more recent discussions of group selection-related issues). Groups are selected, and in the long run, this explains individual-level altruistic behavior. When phrasing this in genetic terms, there are just as many cogs involved in the explanation: genes are selected, and in the long run, this explains individual-level altruistic behavior. Parsimony cannot help us here, at least not on its own.

Implicit in Williams's claim is a commitment to reduction, which is *almost* explicit in the use of the word *higher* to characterize rejected levels of explanation that are not "necessitated by the facts." It is only by coupling parsimony with reduction that Williams, when faced with underdetermination regarding levels of selection, can defend a gene-centered version of the theory of evolution by natural selection. Because he hopes to avoid multiplying levels of explanation (parsimony), he focuses on a single one, which he considers to be "lower" than the others and to be able to sustain epistemic reduction (theoretical reduction through kin selection and other related theoretical developments in population genetics). The normative pull of reduction, considered as something worthy of pursuit, bridges the gap between empirical data and theory choice, where parsimony is insufficient to do so. This situation would remain puzzling without the axiological meaning of reduction and the related retrospective analysis that sheds new light on an important theoretical debate.

Although Williams never explicitly recognized the role of reduction *as a value*, his work clearly posits the notion as an ideal for scientific research. Already in his 1966 book, Williams highlights that the importance of reduction is to be found in the way it fosters progress, not in its relation to truth. He emphasized this rationale in his 1985 "A Defense of Reductionism in Evolutionary Biology." In that paper, Williams acknowledges that both the selective process (which is an ecological phenomenon) and macroevolutionary dynamics (the long-term changes generated by natural selection) are *irreducible* to gene-centered models (Williams 1985, 8–11). He states that "even if the natural selection of populations and taxa has only a thousandth part of the potential of individual selection for causing change, its effect in, for example, a million years could be appreciable" (Williams 1985, 9). He adds that "it may be that the adaptationist programme based on selfish-gene reductionism will have little to contribute for an understanding of macroevolution" (Williams 1985, 9) before reiterating, three pages later, that "the important predictions in evolutionary biology derive from a concept of adaptation based on a selfish-gene model of natural selection . . . No compromise with any other goal, like the survival of the species, is expected" (Williams 1985, 12).

In other words, Williams concedes that a gene-centric view of evolution fails to account for ecological dynamics and macroevolutionary phenomena, yet he counterintuitively adopts a strong reductionist perspective that abstracts away other levels of explanation shortly after having vindicated them. This counterintuitive epistemic move made by Williams can be explained in retrospect by a trade-off between values. When it comes time to articulate a theoretical framework for evolution by natural selection, explanatory power is sacrificed to satisfy reduction and parsimony. Beyond showing how useful it is to think of reduction as a value, the present analysis thus identifies an important fact about the choices that are often made when providing accounts of evolution by natural selection. Indeed, with the adoption of genetic reductionism, crucial evolutionary phenomena remain outside the scope of evolutionary theory: "Although this theory is conceptually simple and

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logically complete, it is seldom simple in practice *and seldom provides complete answers to biological problems*" (Williams 1966, 57; my emphasis).

The rationale just identified in Williams's work can hardly be attributed to him alone. It is, in short, the evolutionary perspective that was fostered by the successes of population genetics in the first half of the 20th century, coupled with the promises of the molecular turn (Provine 1971; Smocovitis 1992, 2023). Although history proves that genetic reductionism is a useful, fruitful, and fertile perspective on evolution, this analysis highlights that it is also value-laden and partial (see also Papale et al. [2024] for an analysis of some of the limits of having evolutionary biology, as a discipline, centered on the legacy of population genetics). Accepting antireductionist perspectives on evolution, and pluralism more broadly, should therefore be seen as complementary to, rather than competing with, gene-centric views.

Nonetheless, the developments tied to the molecular turn and population genetics *are* good reasons to value reduction in the context of evolutionary theory, and they may explain why other authors, like Dawkins, have been unapologetic defenders of the gene-centered approach to evolution. In his 1976 book *The Selfish Gene*, for instance, Dawkins also recognized that the choice between levels of selection is underdetermined. Many chapters of the book are meant to analyze alleged evidence sustaining the evolutionary importance of group selection and to show that these phenomena can just as well be explained by gene selection. As Dawkins states: "It is a well documented fact that overcrowding sometimes reduces birth-rates. This is sometimes taken to be evidence for Wynne-Edwards's theory [of group selection]. It is nothing of the kind. *It is compatible with his theory*, and it is also just as compatible with the selfish gene theory" (Dawkins 1976, 128; my emphasis). If we accept this line of reasoning, however, we must also apply it to gene-centric views. That is, even if phenomena are compatible with the selfish-gene theory, they cannot be counted as evidence for it. Yet that is precisely the rationale that Dawkins adopts in chapter 7 of *The Selfish Gene*: because some phenomena used as evidence for group selection (population regulation by individuals within that population through reduced rates of childbearing) are compatible with the selfish-gene theory, we should accept the latter. As a result, that chapter is a perfect illustration of the influence that reduction, as a value, may have on scientific reasoning.

Despite mounting evidence that gene-centered approaches to evolution are partial and limiting (see chap. 3 of Ågren's [2021] work for an overview of the many critiques of the gene's-eye view of evolution), Dawkins held on to the central ideas of *The Selfish Gene*. Almost 20 years after the publication of *The Selfish Gene*, in a response to a paper by Sober and Wilson in which they claim that groups can be selected because they fit Dawkins's own concept of *vehicle*, the latter claimed: "Natural selection chooses replicators for their ability to survive in an environment that includes other replicators and their products. Sometimes cooperation among replicators is so strongly favoured that units coherent enough to be called vehicles emerge." That, shortly after having declared: "I coined the 'vehicle' not to praise it but to bury it" (Dawkins 1994, 617 for both citations). And indeed, according to Dawkins, replicators are all we need for evolutionary explanations, and the only relevant biological replicators are genes: "The DNA content must be a small proportion of the total, so why did I say it was raining DNA rather than cellulose? *The answer is that it is the DNA that matters*" (Dawkins 1986, 111; my emphasis).

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Yet in those years (from 1976 to 1994), the underdetermination that characterizes the levels-of-selection debates remained a central issue in evolutionary biology, which led to the development and maturation of multilevel selection theory (Damuth and Heisler 1988; Okasha 2006; Wilson and Sober 1994). As a result, conventionalism regarding levels of selection is still very present and relevant today (Bourrat 2021), and multilevel selection is thriving (Doolittle 2024). I suggest that the normative pull of reduction must be acknowledged to understand Dawkins's stance, in retrospect. Making this normative pull explicit may also help advocate adequately between alternative versions of a theory like the theory of evolution by natural selection: as long as the influence of reduction as a value remains obscured, it cannot be assessed properly. At the very least, acknowledging the role of reduction as a value will help understand why explanatory power is readily sacrificed by some researchers when it comes to formulating general accounts of evolution. Further research will be needed to explore whether past successes of reductionist practices, both within and outside evolutionary biology, are sufficient to warrant such a strict commitment to reduction as the one embodied by the gene's-eye view of evolution.

Conclusion

In this article, I have argued that the triptych portrait of reduction, which is a standard way to analyze the notion in the philosophy of science, should be given a fourth panel. Ontological reduction describes a postulated relationship between entities and their parts. Epistemic reduction describes relationships between theories or explanations. Methodological reduction describes sets of practices. Axiological reduction, which is theorized in the present article, captures the normative pull of reduction. It highlights that reduction can play the role of a value influencing scientific reasoning in cases of underdetermination of scientific theory by evidence for instance. In these situations, various contextual factors influence theory acceptance or rejection, including epistemic and nonepistemic values.

To illustrate both the validity and the usefulness of my claim that reduction is a value (among other things), I explored a case study, namely, genetic reductionism in evolutionary biology. More specifically, I analyzed Williams's rationale for defending genetic reductionism as an imperative for evolutionary theorization. Williams explicitly recognizes that the situation features underdetermination while defending the importance of the gene-centered approach to evolution. I suggest that it is best to understand the role of reduction, in this situation, as an ideal, a value that helps fill the gap between the available evidence and Williams's reductionist conclusions. This perspective can be generalized beyond his work to other gene-centered approaches to evolution, as I illustrated with a discussion of Dawkins's work. As such, this case study not only illustrates how the axiological meaning of reduction can be used, but it also contributes to a better understanding of the scientific justifications that underlie mainstream evolutionary biology.

Feminist philosophers of science played a leading role in showing that underdetermination is widespread in scientific contexts, as well as how epistemically and socially harmful it can be when values distort all dimensions of scientific inquiry, from funding to theory acceptance, from experimentation design to data interpretation. Nonetheless, as Anderson (2004) reminds us, value judgments are also helpful to

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scientific endeavors when used properly. Value judgments become problematic only when they are being made unquestioningly, without any real possibility of critique. Making the influence of values visible is an important step in avoiding that. I hope this article will contribute to making the influence of reduction more visible in various scientific practices, thereby enabling its most epistemically rewarding use.

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