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Sex eliminativism

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Abstract

The concept of biological sex guides research, clinical practice, science funding policy, and contemporary political discourse. Despite some substantive differences, all existing candidate philosophical accounts of sex assume its legitimacy as a biological concept. Here, we challenge this view. We argue against realism about biological sex, and that eliminating biological sex from large swaths of biological theory and practice may be preferable compared to conventionalist or fictionalist anti-realisms. There are serious social and epistemic costs to using "biological sex" in place of more specific alternatives. Because of this, biologists and philosophers of science should consider eliminativism about the concept of biological sex.

Biological sex eliminativism is worth taking seriously, and it can play important roles in philosophical debate and biological practice, even for those who remain skeptical. The methodological consequences of biological sex eliminativism are compatible with best practices for inquiry in the biological and biomedical sciences, with inclusive approaches to the study of sex and gender, and with feminist philosophical and methodological recommendations. Taking eliminativism seriously reveals important disagreement about the work that a concept of biological sex should do, and imposes a contrastive burden on would-be rivals.

Keywords Biological sex · Sex eliminativism · Antirealism · Sex contextualism

Introduction

The concept of biological sex guides research, clinical practice, science funding policy, and contemporary political discourse. Although there is disagreement among philosophers about what the right account of biological sex is (e.g., Griffiths 2020, 2021; Franklin-Hall 2020; Khalidi 2021; Richardson 2022; Rifkin & Garson 2023), all of these accounts assume — or explicitly assert — the legitimacy of sex as a

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biological concept. This paper first argues that these realist accounts of sex are wanting. We then present a positive argument in favor of anti-realism about biological sex, and argue that, in practice, eliminating biological sex from large swaths of biological theory and practice is preferable to conventionalism or fictionalism about sex, which would allow biologists to continue using sex concepts even if anti-realism is true.[1] The weight of these arguments together suggests that anti-realism and eliminativism are serious contenders as views about biological sex, even if we do not claim to offer herein all-things-considered reasons to adjudicate the merits of all the candidate views.

We argue that sex eliminativism can play important roles in philosophical debates and biological practice, even for those who remain inclined to realism or conventionalism. The methodological consequences of sex eliminativism are compatible with best practices for inquiry in the biological and biomedical sciences, with inclusive approaches to the study of sex and gender, and with feminist philosophical and methodological recommendations. Furthermore, taking eliminativism seriously reveals important disagreement about both the work that a concept of biological sex should do and how closely conceptual theorizing should hew to existing biological practices.

Against realism about biological sex

Most philosophers of biology, not to mention biologists themselves, are realists about biological sex. Such philosophers believe that the categories "male" and "female" are biologically real.[2] More permissive realisms might hold that sexes are biologically real if these categories play a legitimate epistemic role in biological inquiry (compare Spencer's 2012 notion of a "genuine kind"); stronger versions of realism attempt to render sexes as natural kinds. For the sake of argument, we'll allow that biological sexes need merely to adequately serve a legitimate epistemic purpose in biology to count as real. In this section, we present existing realist accounts of sex (monist and pluralist) and give reasons to think these accounts are unsatisfactory. The reasons we give are not all-things-considered — it is possible for these reasons against realism to be outweighed by reasons in favor — but they establish the plausibility of offering, and even endorsing, an anti-realist account of sex.

As will become apparent throughout this section, one major point of contention even among the realists is what (if any) epistemic work sex needs to do. Investigating the strengths and weaknesses of each view reveals this underlying disagreement and motivates increased attention to this question in further philosophical research.

[1] For the term "sex eliminativism," see, e.g., Richardson (2019). Richardson discussed this position in relation to sex contextualism and asked whether we should be eliminativists about sex (Richardson 2017).

[2] We will discuss in Sect. "In favor of sex eliminativism over sex conventionalism/fictionalism" the possibility that sexes are *socially*, rather than *biologically* real. Until then, we will only be dealing with the biological concept of sex and associated views about it.

The gametic account of sex

In everyday life, humans make judgments of which sex organisms belong to based on a number of different variables. Human babies, for instance, are typically sexed according to the presence or absence of certain external genitalia (for commentary, see Ainsworth 2015; Alpert et al. 2021). Humans are also (often) thought to have chromosomal sex determination; individuals with an XX karyotype develop into "females" and individuals with an XY karyotype develop into "males." However, many of the variables (genitals, chromosomes) we associate with human sexes are inadequate for sexing individuals within or across other taxa (Kelly & Moore 2016; Gorelick et al. 2017; McLaughlin et al. 2023). For example, in many species sexual development is not determined genetically.[3]

The general consensus, then, among biologists (at least, evolutionary biologists) is that "males" and "females" are distinguished by the type of gamete members of each category produce. Gametes often vary by size, and can be grouped into "large" and "small" size categories.[4] According to the gametic account of sex, organisms that produce large gametes are female, and organisms that produce small gametes are male.[5] The gametic definition generally does very well at applying to all forms of life that are "anisogamous," i.e., those organisms that produce gametes that are not all the same size. (Isogamous species produce only one size of gamete, but still reproduce sexually.)

Biologists usually present the gametic account of sex as a definition. For example, Roughgarten (2013) writes, "To a biologist, 'male' means making small gametes, and 'female' means making large gametes. Period! *By definition,* the smaller of the two gametes is called a sperm, and the larger an egg" (p. 23, emphasis added);[6] Lehtonen (2017) says, "Female gametes are larger than male gametes. This is not an empirical observation, but a *definition*: in a system with two markedly different gamete sizes, we define females to be the sex that produces the larger gametes and vice-versa for males" (p. 1, emphasis added); and Goymann et al. (2023) write, "With a few exceptions, all sexually reproducing organisms generate exactly two types of gametes that are distinguished by their difference in size: females, *by definition*, produce large gametes (eggs) and males, *by definition*, produce small and usually motile gametes (sperm)" (p. 2, emphasis added). So, according to the gametic account of sex, males are defined as organisms that produce small gametes, and females are defined as organisms that produce large gametes.

[3] Regarding the history of studying "sex chromosomes," see Richardson (2013), and for a discussion of exceptions to chromosomal sex determination in humans see Fausto-Sterling (2000). For an overview of systems of sex determination in nature, see Ah-King and Nylin (2010), Bachtrog et al. (2014).

[4] Other features of gametes are correlated with size, such as motility, and it is traditionally assumed that the smaller gametes are produced in much larger quantities than large gametes (see, e.g., Goymann et al. 2023).

[5] Some gametic accounts focus on the *capacity* to produce certain gametes, rather than the actual production thereof (e.g., Rifkin and Garson 2023), presumably in order to avoid the implication that individuals pass in and out of sex categories over time.

[6] Note that this is not always the terminology used for plants; thanks to Elliott Sober for pointing this out.

It is tempting to infer that the biologists have attempted to provide necessary and sufficient conditions for sex membership: an organism is male if and only if it produces small gametes, and an organism is female if and only if it produces large gametes. However, this "kind essentialist" (*sensu* Ereshefsky 2022) concept of biological sex is not a strong candidate view, for two reasons. First, the gametic definition fails in at least one version of the explanatory role we might expect it to play: John Dupré (1986) has argued that gametic sexes are not able to explain non-gametic sex differences, or trait variations between gametic "males" and "females," primarily because the germ cell lines that produce sperm/eggs and the somatic cell lines that produce every other phenotype have a common-cause relationship, not one where the gametes cause the other differences.

Second, the gametic definition is susceptible to counterexamples. For example, it is not guaranteed that all gametes with sperm-like morphology are necessarily smaller than all gametes with egg-like morphology; *Drosophila bifurca*, for instance, have gametes otherwise homologous to sperm but which range up to 5.8 cm in length (Lüpold et al. 2016).[7] Biologists are aware that such counterexamples are possible.[8]

As many philosophers of biology have recognized, the biological world is "messy" and not amenable to categorization using anything as strict as necessary and sufficient conditions. Likewise, it is unfair to expect a concept of biological sex to figure in lawlike generalizations that apply to all sexually reproducing organisms. This issue is familiar from the case of the species concept: while the species concept often favored by biologists (the "biological species concept") does offer necessary and sufficient conditions (a species consists of all and only those organisms that can successfully reproduce fertile offspring together; Mayr 1942), philosophers of biology have pointed out flaws with this definition and attempted to offer alternatives. Riffing on Sober (1997), we can trace a similar revolt against what we might call 'law and order philosophy of biology' with respect to the concept of biological sex.

The historical explanatory kinds account of sex

Certain philosophers and biologists were unsatisfied with the biological species concept because it neglects the shared history between members of the same species (their common descent). The phylogenetic species concept, by contrast, says that members of a species must be members of the same lineage (e.g., Kluge 1990).

Laura Franklin-Hall (2020) has, likewise, argued that sexes are best conceived of as *historical* kinds, which she says are "those grounded in shared relationships to the *past*, rather than in shared *current* properties" (p. 14, emphasis original). Her proposal is that "an animal is *male* (or *female*) just in case its reproductive traits came about by way of developmental processes linked via a sex development lineage to the developmental processes responsible for reproductive features in that animal's

[7] Articulations of the gametic definition of sex tend not to specify what "larger" and "smaller" means, exactly — should we measure in terms of mass? Volume? Length? Surface area? The *D. bifurca* case also illustrates that these variables can come apart; see Bjork and Pitnick (2006) for discussion.

[8] E.g., recall in the quote from Goymann et al. above the clause, "With a few exceptions…".

earliest *small-gamete* (or *large-gamete*) -producing animal ancestors. It is only those earliest ancestors whose sex, male or female, was set by gamete size directly" (p. 16, emphasis original). According to Franklin-Hall, the gametes produced by extant organisms "are *indicators only*, and fallible ones at that" (p. 14, emphasis original) for categorizing these organisms as male or female.

Franklin-Hall's account has two, distinct advantages over the standard gametic account. First, the historical kinds account is susceptible to fewer counterexamples. For example, sperm-producing *D. bifurca* individuals are straightforwardly male on Franklin-Hall's account, even though those sperm are (by some measures) larger than the eggs. Organisms with even more unusual gamete sizes or shapes (or which evolve to have these in the future) can still be categorized as males and females, on Franklin-Hall's account. Overall, her account is less sensitive to contingencies of gamete size/shape dimorphism than the traditional gametic account.

Second, Franklin-Hall's account purportedly makes sexes *explanatory* kinds, as well as historical kinds. Franklin-Hall thinks that, by focusing on the developmental pathways shared by members of the same sex within the same species, she can avoid Dupré's criticism of the traditional gametic view, and we agree.[9] Notice that trait differences between males and females within a particular lineage are the explananda about which Franklin-Hall thinks the concept of sex should help offer explanations.

However, Franklin-Hall's account still has to contend with some objections. First, although it is not susceptible to counterexamples like that of *D. bifurca*, in which gamete size and morphology doesn't correspond, her account is currently silent about anisogamous species with more than two gamete types (biologists often say these organisms have "mating types" rather than "sexes", although cf. Aanen et al. 2016).[10] While she could say that these species just do not have sexes by definition (as proponents of the traditional gametic view would also say), we worry that there is no *principled* reason to rule them out. We will say more about this objection in the next section.

Second, Franklin-Hall's historical explanatory kinds account rules out analytically the possibility of a lineage evolving to have no sexes. For example, in some shark species, many reptiles, and some birds, egg-producing individuals can reproduce asexually via parthenogenesis (Dudgeon et al. 2017). New Mexico whiptail lizards (*Aspidoscelis neomexicanus*) now only reproduce this way; there are no remaining 'males' (Lowe and Wright 1966).[11] On Franklin-Hall's account, the remaining,

[9] Although we refer the reader to Aya Evron (2023)'s recent and convincing argument that sexes conceived gametically are not explanatory in models of sexual selection for a new worry along the same lines of the argument offered by Dupré.

[10] Technically, Franklin-Hall herself is only concerned with *animal* sexes, so these examples do not run counter to her view. This objection can be seen as directed towards a Franklin-Hall-esque view that purported to apply more broadly to all sexed or sexually reproducing organisms. For example, biologists tend to think that the same sex concept applies equally well to (at least) sexually-reproducing plants as well as animals.

[11] Perhaps even more complicated are cases of gynogenesis, in which reproduction requires sperm but the egg provides all of the genetic material needed to reproduce (the sperm only trigger the development of the egg). For example, Amazon mollies (*Poecilia formosa*) are a species of fish consisting entirely of females that require the sperm of *other species* to trigger development of eggs into offspring (Schlupp et al. 2007).

egg-producing individuals are females, and all of their descendants will be females, because of shared sexual developmental pathways with past egg-producing individuals. However, we think it should be possible to evolve away from sexes, just as it is possible to evolve toward them — or, at least, that it should be an empirical question whether evolution away from sexes is possible, rather than something ruled out by fiat.

Third, Franklin-Hall's account, like the gametic account, is still susceptible to objections in general to the use of necessary and sufficient conditions for biological category membership.[12] Other philosophers of biology have argued against this kind of biological kind entirely, and some are now attempting to apply these insights to sex categories, as well.

The homeostatic property cluster account of sex

It is not news to philosophers that whether a category should count as a natural kind does not depend on whether there are exceptionless necessary and sufficient conditions for kind membership. Building on older ideas about "family resemblance" within categories, the homeostatic property cluster (HPC) view of natural kinds has been offered, most famously by Richard Boyd (1991, 1999) in the context of species. In general, HPC kinds are identified by a set of properties, such that the members of the kind all share at least some subset of the properties with other members and there is some causal mechanism that keeps that set of properties tied together (in homeostasis) over time.

As Boyd says, "it is a feature of such *homeostatic property cluster (HPC kinds)*… that there is always some indeterminacy or 'vagueness' in their extensions" (1999, p. 141; emphasis original). In the species context, it is not always definite whether a given set of organisms are members of the same species or not. HPC kinds thus have a general advantage over essentialist kinds: HPC kinds are not susceptible to (rare or unusual) counterexamples. If, on an HPC account of species, you are able to find an organism (or a handful) which cannot be readily classified, these organisms are not evidence that those species categories are not real; the "natural kind" status of a species is not at risk if some gray-area cases are identified.

Muhammad Khalidi (2021) argues that sexes are a natural kind according to a modified HPC conception of natural kinds, simple causal kinds.[13] Like Franklin-Hall, Khalidi takes his task to be modifying the standard gametic account to be more philosophically plausible, rather than starting from scratch. Khalidi follows the cue of many biologists in focusing on sex differences in energy investment in gamete production (eggs are much more energy-intensive to produce than sperm), which is thought to correspond with differences in mating behavior and investment in offspring. As Khalidi says, "For many evolutionary biologists, the relative size of female and male gametes is the causal factor that accounts for

[12] Assuming that when she writes "just in case" on p. 16 quoted above she means "if and only if."

[13] As Khalidi explains, simple causal kinds are less demanding than traditional HPC kinds because they do not require the properties to be homeostatic and they do not require a single mechanism to undergird this regularity (see Craver 2009).

different morphologies, mating strategies, parenting behaviors, and other properties of females and males…If these theories are right, then the classification of organisms into female and male across a range of animal species really does serve as the basis for a 'natural' rather than an 'artificial' classification scheme," according to an HPC account of natural kinds (p. 10–11). Khalidi, then, broadly agrees with Franklin-Hall's explanatory target — patterns of trait differences between the sexes — although his focus is more across-lineage than within-lineage patterns.[14]

Khalidi reiterates that this account is not vulnerable to counterexamples: "generalizations in biology are rarely if ever ironclad, and so we should not expect generalizations about biological natural kinds like female and male to be universal among sexually reproducing animals" (p. 12). Thus, Khalidi offers a modest modification of the standard gametic account of sex, reframed in terms of an HPC account of natural kinds. The main benefit is that his revised account explicitly permits occasional counterexamples and only claims to apply in general and for the most part.

Paul Griffiths (2020, 2021) presents a more ambitious revision of the standard gametic account, also in the spirit of an HPC account.[15] Griffiths' amendments to the standard gametic account are to claim (1) that sex categorization applies to individuals at a period of time, rather than throughout their entire lifespan (this enables the account to accommodate sequential hermaphrodites, which can switch from producing one type of gamete to the other; Griffiths 2021 calls this part of his view "sex as a process,"[16] p. 16), (2) that not all possibly-sexed organisms have exactly one sex (simultaneous hermaphrodites are both male and female, while many sterile or pre/post-reproductive individuals are sexless), and (3) that it is not always determinate at a particular moment in time whether a given organism is male or female (e.g., a sequential hermaphrodite may be in the process of switching which kinds of gametes it produces, or a pre-reproductive individual may be in the process of producing gametes for the first time). The following quotes summarize his view:

> "No animal is conceived with the ability to make sperm or eggs (or both). This ability has to grow, through a cascade of interactions between genes and environments. In some species, once an individual acquires a sex, it remains that sex for the rest of its life. In others, individuals can switch sex one or more times. But in every case, the underlying mechanisms are designed to grow organisms that make either male or female gametes (or both). The other changes the body undergoes as it becomes male, female or hermaphroditic are

[14] Readers familiar with the history of these claims may have noticed that Khalidi's posited across-lineage sex differences are reminiscent of the now-discredited paradigm proposed by Bateman (1948) and popularized by Trivers (1972) that correlates parental investment in offspring with type of gamete produced. For discussion, see Gowaty et al. (2012); Fine (2017).

[15] Griffiths does not label his account of sex an HPC account. However, he has long been a proponent of HPC accounts in general (e.g., Griffiths 1997, 1999). Griffiths (personal communication, November 2023) has confirmed to us that his view is reasonably interpreted as an HPC account of sex.

[16] We will not discuss herein the possibility that Griffiths is offering a "processual" account of sex, along the lines of a general processual ontology (see, e.g., Nicholson & Dupré 2018), but it is possible to interpret Griffiths this way.

designed to fit the reproductive strategies that this species has evolved" (Griffiths 2020).

And:

"Biological sexes (male, female, hermaphrodite) are defined by different gametic strategies for reproduction. Sexes are regions of phenotypic space which implement those gametic reproductive strategies. Individual organisms pass in and out of these regions — sexes — one or more times during their lives. Importantly, sexes are life-history stages rather than applying to organisms over their entire lifespan…the fact that a species has only two biological sexes does not imply that every member of the species is either male, female or hermaphroditic, or that the sex of every individual organism is clear and determinate" (Griffiths 2021, p. 1).

Griffiths' account, like Khalidi's, admits of gray-area cases (as is the general benefit of HPC accounts). For example, he says, "it is inevitable that there will be many individual organisms that aren't clearly of either sex. But that doesn't mean that there are many biological sexes, or that biological sex is a continuum. There remain just two, distinct ways in which organisms contribute genetic material to their offspring" (Griffiths 2020). So, organisms that do not fall clearly into the categories of male/female do not cause problems for Griffiths' view. Unlike Khalidi, though, Griffiths is (we believe rightly) more skeptical that there will be any other, non-gamete properties of males and females that they share in common, including phenotypes or behavioral tendencies. Instead, like Franklin-Hall, Griffiths focuses more on mechanisms of sexual development within a lineage as the homeostatic mechanism holding together the suite of sex-associated properties within that lineage (rather than across lineages).[17] According to Griffiths, "the payoff for this way of thinking about sexes is that it helps to explain the evolution of reproductive systems and how they differ across the diversity of life" (Griffiths 2021, p. 20).

So far, we have seen that Franklin-Hall, Khalidi, and Griffiths have different desiderata for a sex concept, namely, different explananda in mind. Franklin-Hall (and Dupré) thinks that a sex concept should be able to be used in explanations of within-lineage sex differences, such as sexual dimorphism. Khalidi instead wants a concept that can explain across-lineage sex differences, such as trends in dimorphic mating behavior. Griffiths, on the other hand, wants a sex concept that can help in explanations of the evolution of sexual reproduction and the various ways systems of sexual reproduction are instantiated. An examination of these views reveals this tacit disagreement about what work we want a concept of biological sex to do for scientific inquiry.

Furthermore, we think that the HPC accounts have some unresolved issues of their own. Of course, any HPC account of sexes will be subject to general criticisms, including worries that HPC accounts are too narrow, too broad, or too ineliminably indexed to human interests in which clusters of properties or mechanisms

[17] Unlike Franklin-Hall's, though, Griffith's view does not have the consequence that lineages cannot evolve away from having sexes, although he does not discuss this possibility explicitly.

they admit to form a natural kind (e.g., Craver 2009; Ereshefsky and Reydon 2015; Chakravartty 2023). However, given that this paper is about biological sex, not natural kinds, we focus on objections to Khalidi's and Griffiths' accounts specific to the case of sex.

First, the HPC accounts of sexes presented by Khalidi and Griffiths have one problem that the other monist, realist accounts of sex discussed so far also have: they carve out a subset of the natural world to which their proposed sex concept applies, in such a way that precludes the possibility that we might find empirical evidence that their concept doesn't apply.[18] Various sex theorists are quite explicit about this; for example, Franklin-Hall and Khalidi limit themselves to "animal" sexes, and do so in order to avoid complications that come up in other kingdoms. Griffiths' view is intended to apply more broadly, to all anisogamous organisms with exactly two gamete types. For example, he says, "in species that make two different kinds of gamete – and where one gamete of each kind is needed to make a new organism – there are two sexes" (2020).

The problem is that when the reference class is circumscribed to be exactly those organisms to which the concept applies well, the concept itself cannot be tested for empirical adequacy — even if there is widespread agreement about the desiderata for the concept.[19] For example, Griffiths says, "evolutionary biologists have devoted a great deal of effort to explaining why there are no complex multi-cellular organisms with more than two sexes" (2021, p. 5). But, of course, there cannot be any taxa with more than two sexes, if sex is *defined* in such a way as only applies to organisms with two gamete types. Consider that not all anisogamous species have exactly two gamete sizes: some species of algae are anisogamous but produce gametes with sizes on a continuum (Umen and Coelho 2019; Umen 2020; Krumbeck et al. 2020). Griffiths is well aware of this case, and this is how he handles it:

> "there are some species at the boundary between unicellular and multicellular life, such as some volvocine algae, which can be seen as representing transitional states in the evolution of distinct biological sexes and might be described as having more than two sexes. They produce slightly anisogamous gametes and in a range of sizes rather than two discrete types. But in complex multi-cellular organisms like plants and animals we find two very different kinds of gamete, each associated with a fundamentally different reproductive strategy, and so two biological sexes" (Griffiths 2021, p. 23).

Griffiths thus admits the possibility of seeing the algae as having more than two sexes, but instead prefers to only apply the concept to life forms with "two very different kinds of gamete."

[18] Of course, if "male" and "female" have merely stipulative definitions like "bachelor" then this is not an issue. Our contention here is that perhaps at least some scientific concepts shouldn't be like this; we should be able to be wrong about what they mean or what they reference (see Ereshefsky and Reydon 2015).

[19] Compare Lemoine (2013) on "extensional stipulation" with respect to conceptual analysis and naturalized metaphysics in philosophy of medicine. Thank you to Sloane Wesloh for bringing this to our attention through her own work.

Another way to phrase our worry: why should the concept of sex apply to anisogamous-organisms-with-two-gamete-types, rather than anisogamous-organisms, or rather than sexually-reproducing-organisms (some of which are isogamous)? Why should we think that the concept of *sex* applies to anisogamous-organisms-with-two-gamete-types, while other concepts, like "mating types" apply to all other sexually reproducing organisms? The motivation for a focus on anisogamous-organisms-with-two-gamete-types should go beyond its ability to retain the verdict that there are exactly two sexes. If one thinks, instead, that the hypothesis that there are two sexes should be testable, the concept of sex should not itself rule out the possibility that there are more than two. For example, one could just say all sexually reproducing organisms have mating types; sometimes there is one mating type (isogamous organisms), sometimes there are two (anisogamous-organisms-with-two-gamete-types), sometimes there are more than two. We are not sure what's so special about the scenario in which there are two types.

Second, Griffiths, in particular, is explicit in his aim to reproduce as a philosophical view more-or-less what scientists already think about the concept of sex. For example, he says, "This approach to the evolution of sexes is very widely accepted in contemporary biology. That does not mean that it is the final word, but it does mean that a philosopher who wants to dismiss it as a mass of error had better have some powerful arguments" (Griffiths 2021, p. 10). Griffiths is indicating that he thinks the burden of proof lies with those who would disagree with biologists (specifically, evolutionary biologists — see p. 6, 14; see also Griffiths & Spencer 2024).

We are not convinced that deference to biological practice is justified in this case (and we will consider more general reasons to defer or to not defer to biologists about their concepts below). Biologists can be wrong, and part of the role of philosophers in relation to science is to provide guidance to scientists, including about whether the concepts that they are using are adequate (Chang 2008; Haber 2014, p. 886; cf. Pradeu et al. 2021). In the case of sex, one obvious reason to not defer to biologists is that there is disagreement among biologists themselves about what sex is and what role it should play in investigation (e.g., compare Roughgarden 2013 and Prum 2023). In addition, though, there are reasons to suspect that the sex concept used by evolutionary biologists is not a good starting place. First, the sex concept used by evolutionary biologists matches up very well with a folk concept of sex used in everyday life (including by those very same evolutionary biologists!). Feminist philosophers of science and other science studies scholars have long documented the various ways in which entrenched, preconceived notions of sex and gender (among other categories) have provided a lens through which scientists view the natural world, historically and today (e.g., Hubbard 1979; Hrdy 1981; Longino and Doell 1983; Keller 1985; Martin 1991; Tavris 1993; Bleier 1997; Lloyd 2005; Roughgarden 2013; Fine 2017). For example, Sarah Richardson (2013) argues that scientists' preconceptions about dichotomous sex contributed to their labeling of the X and Y chromosomes in humans and related species as "sex chromosomes," long before the relationship between these chromosomes and sexual development was well-understood (and despite some evidence to the contrary). In the case of the gametic view of sex and its close relatives, including the HPC views offered by Khalidi and Griffiths, it is not absurd to question whether broad scientific acceptance of this concept of

sex partly reflects its alignment with entrenched folk intuitions about human sex and gender. For instance, as we have stated above, we worry that the gametic sex concept precludes the possibility of disconfirming evidence for the hypothesis that there are really two sexes. Further historical work is needed to document the influence of the folk notion of sex on the development of the gametic notion (but see, e.g., Sanz 2017).

Furthermore, some might point to the empirical (predictive, explanatory) success of the gametic view as a means of justifying using this view as the default. However, we worry that this argument ignores the nefarious purposes that the gametic view of sex has served. Most importantly, the gametic view (and other "biological" accounts of sex) has been used to argue that individual humans are "really" male or female, despite how they might identify or various changes they may have made to their bodies. This emphasis continues to perpetuate significant harms, especially for transgender and nonbinary persons. In sum, we think the legitimate research purposes to which the biological concept of sex has been used should be weighed alongside the nefarious purposes to which the biological concept of sex has also been used.

This point is not lost on other philosophers of sex. Griffiths, for example, argues that, "the concept of biological sex remains essential to understand the diversity of life. It shouldn't be discarded or distorted because of arguments about its use in law, sport or medicine" (2020) and "The biological understanding of sexes has been shaped for the comparative study of reproductive systems across the diversity of life, not for making decisions about the social or legal status of human beings" (Griffiths 2021, p. 6). Rifkin and Garson (2023) likewise disavow such uses of the sex concept. We agree that there is no necessary connection between the definition of sex evolutionary biologists use and how people should be treated; for example, even if all sperm-producing humans were "really" male, this would not imply that these individuals should be denied access to women-only spaces (e.g., restrooms, sports teams). The analytic distinction between sex and gender has helped to make this point. However, the alleged "reality" of biological sex is, in fact, being used to deny trans people equal access to societal goods and services (e.g., healthcare and identity documents; Karkazis 2019; Dembroff 2020, 2021). It's at least worth acknowledging that realism about biological sex is serving these abhorrent purposes quite well, just as it is serving some more innocuous purposes in evolutionary biology. Just as Kukla (2017) characterizes the role of epistemic risk in disease definitions and Neto (2024) argues that non-epistemic risks legitimately figure in metaphysical theorizing about the biological race concept, we maintain that foreseeable (if illegitimate) harmful uses of the biological sex concept may count against adopting a realist view of biological sex.[20]

[20] Brigandt (2022) argues that non-epistemic aims, including those of non-scientists, are relevant to the evaluation of scientific kinds in general and perhaps sex in particular, and other ameliorative accounts likewise make even more room for non-epistemic values in our treatment of kinds (e.g. Haslanger 2000, Richardson 2022). While we endorse these approaches, we can get a role for non-epistemic values, specifically with respect to foreseeable harms, off the ground without a stronger ameliorative orientation, thanks to these variants on the argument from inductive risk (Douglas 2009).

In summary, we think that even the HPC account of biological sex still has not motivated (1) applying the sex concept selectively across forms of life with various reproductive systems, nor (2) deference to biologists as a starting place.

Pluralist accounts of sex

Let's take stock of a couple of points. First, it appears that even among HPC-type accounts of biological sex, there are multiple definitions of sex, serving distinct, if sometimes compatible, aims.[21] Second, while gametic accounts have some explanatory value, they vary in their ambition with respect to the scope of these explanations: Griffiths' account applies to anisogamous organisms that make two types of gamete, Franklin-Hall's account applies across animal taxa, and Khalidi concedes that his account may only apply *within* animal taxa. This is not inherently problematic — a scientific generalization with narrow scope can be useful if that narrow scope applies to an important phenomenon. But it does leave us with both a variety of definitions of sex and a variety of explanatory goals, not to mention some indication of meta-disagreement about what makes some concepts better or worse than others and what the appropriate relationship between philosophy and biology should be.

Although this variety is evident among accounts of sex that prioritize so-called "ultimate," or natural historical explanations, the picture becomes even more interesting when we admit notions of "biological sex" from more "proximate" research contexts, like molecular biology and health sciences.[22] For example, the National Institutes of Health (NIH) Office of Research on Women's Health (ORWH) conceptualizes sex as "a multidimensional biological construct based on anatomy, physiology, genetics, and hormones" (NIH ORWH 2024; see also Rehmann-Sutter et al. 2023). Likewise, the 2015 NIH Sex As a Biological Variable policy guidance instructs researchers that "Sex is a biological variable defined by characteristics encoded in DNA, such as reproductive organs and other physiological and functional characteristics" (NIH 2015; see also Clayton & Collins 2014). Epidemiologist Greta Bauer (2023, Table 1) reports eight aspects of the "multidimensionality" of sex as a variable in population health, including six that may change over an organism's lifetime (hormonal milieu, reproductive sex/gametes, organ-specific status, sexed physiology, intersex status, and pregnancy). The scope of the generalizations that molecular biologists and health scientists draw from these dimensions of sex is often restricted to specific species, or specific life-history stages of organisms, yet these generalizations are at least sometimes extremely scientifically useful and serve as a basis for important, robust, and reliable interventions.

What are we to make of this thrilling heterogeneity of sex concepts? One option is a winner-take-all approach: find the concept that can do the most of these scientific tasks, and jettison the rest. This approach seems best suited to cases in which we have multiple candidate concepts trying to do the same "work." But in cases

[21] For an argument that an HPC approach to sex can motivate pluralism, see Guerrero Mc Manus (2022).

[22] "Ultimate" and "proximate" in Mayr's (1961) sense.

where competing concepts have different goals, such an approach seems uncomfortably similar to the law-and-order approach to philosophy of biology that we rejected above.[23] Unless one concept is clearly preferable in service of these many aims, we would need to privilege some aims as more properly "scientific," "biological," or simply more important than others in order to adjudicate such a contest. The gametic concept, for instance, while a strong candidate concept for explanations of the existence of dimorphic sexes in many taxa, does not have much to offer those biologists who use gonadal hormone levels to explain behavior. So, the winner-take-all approach is not very promising as an explanatory strategy or as an account of scientific practice.

There are ways of wrangling this dimensionality to better accommodate the heterogeneity of sex concepts, conceding that we should have multiple, potentially independent concepts of sex, each suited for different research purposes or subsets of the natural world. For example, in the context of species concepts, some philosophers have offered ontological pluralist accounts of species as an alternative to monist accounts, including HPC accounts (e.g., Ereshefsky 1992, 1998; Brigandt 2003). Here we present two existing versions of sex pluralism: functionalism and contextualism.

Functionalism

One strategy is to look for something uniting diverse sex concepts: perhaps a feature that they all have in common, such as a biological function that they all perform. Since this strategy seems especially unpromising for definitions of sex that aim to cut across taxa, an alternative strategy might involve thinking of sex as a multiply realizable functional kind, as has been suggested for some concepts in philosophy of mind (Bickle 2020).

Rifkin and Garson (2023) offer the most obvious candidate in this vein. They argue that the function of producing large or small gametes can unify many biological uses of "sex": traits "designed" to have the function of production of large or small gametes are what make an (animal) organism male or female on their account, and the presence of any such trait is sufficient for maleness or femaleness. While promising and worthy of further inquiry, this account prioritizes a subset of biologists' interests in anisogamy; namely, evolutionary biologists. It reduces uses of "sex" which do not refer to traits designed for this function to mere operationalizations.

Although Griffiths is more easily read as advocating for a monist account of sex, his account is also friendly to functionalism. He concedes that there may be multiple "operational criteria for sex determination underpinned by the gametic

[23] See Taylor and Vickers (2017) for this and other reasons to think "conceptual fragmentation" of this sort may be increasingly common across scientific concepts, and for general reasons to be pessimistic about winner-take-all approaches.

definition of sex and valid only for one species or group of species" (2021, p. 5).[24] However, Griffiths himself confronts the fact that gamete size is independent of phenotypes, karyotypes, and so forth (2021, p. 4–5). This makes it more challenging to find a shared function to anchor a multiply realizable functionalist account of sex. Griffiths attempts to resolve the discordance by arguing that the underlying concept of biological sex should be the exclusive purview of evolutionary biology, which seeks to explain why there are sexes in evolutionary terms. According to Griffiths, other definitions, such as those in the health sciences, are parasitic on these strategies for their unity: "the operational definitions of sexes used in biomedical fields all rely on the more fundamental definition that comes from evolutionary biology" (2021, p. 7). Griffiths & Spencer (2024) explicitly advocate for the primacy of evolutionary biology in defining sex: "As with so much of biology, sex makes better sense when viewed in the light of evolution" (p. 275).

However, like Rifkin and Garson's approach, this move privileges the aims of one research program over legitimate alternatives. Given that health scientists recognize that their operational definitions of sex may not be tightly correlated with or directly caused by the "more fundamental" gametic definition (see, e.g., DuBois and Shattuck-Heidorn 2021), we worry that this approach relies on an untenable hierarchy of disciplines in the life sciences, tacit assumptions about the relationships between biological theories and practices, or, following Brigandt (2022), an insufficiently granular analysis of aims in biology. The suggestion that some biological disciplines provide more "fundamental" concepts than others also raises an important methodological question, namely, if we are going to defer to biologists about the explanatory usefulness of their concepts, but not all biologists are in perfect agreement with each other about which concepts are the most useful, how should philosophers decide which biologists' views to prioritize over others? In light of this disagreement, the hunt for a functionalist account which can unify our full set of scientific uses of "sex" remains ongoing, although, we think, a worthy pursuit.

Sex contextualism

A different form of pluralism could hold that there are simply multiple operational definitions of sex, without demanding that they have anything further in common. This kind of pluralism is the core of Richardson's (2022) sex contextualism, an account of sex developed to capture the use of sex as a biological variable in biomedical research. As Richardson describes it, sex contextualism is the view that "the definition of sex and sex-related variables, and whether they are relevant in biomedical research, depends on the research context" (2022, p. 9). Her view is explicitly constructed in opposition to a "sex essentialist" view (2022, p. 10). On her account, each instantiation of sex is an operationalization of "sex" in a particular research

[24] Griffiths (personal communication, November 2023) is also sympathetic to a kind of pluralist view under which both his account (which focuses on *analogous* properties with similar functions held within sex categories across taxa) and Franklin-Hall's historical kinds account (which focuses on *homologous* properties held within sex categories across taxa) are compatible and complement each other as concepts best suited for distinct purposes within evolutionary biology.

context. The relationship among operational definitions of sex seems like a cluster or family resemblance, with operational definitions unified under the banner of a concept of "sex," in some cases despite their incommensurability. Sex contextualism is metaphysically agnostic about distinct ways of operationalizing a single concept, but could be compatible with modest realisms (e.g., realism about gametes, chromosomes, etc.).

Richardson is refreshingly explicit about the desiderata that a concept of sex should satisfy. Richardson argues that a concept of sex should facilitate mutual intelligibility among researchers and be explanatorily and empirically adequate. However, Richardson also argues that scientific theorizing about sex must be "sensitive to the ethical implications of claims-making about the biology of sex differences" (2022, p. 9). Finally, Richardson argues that our concept of sex should be pragmatic, and not require an "unrealistic revision of vocabularies" across domains that appeal to the concept of sex (2022, p. 9). Sex contextualism, according to Richardson, helps us achieve these goals. Richardson's desiderata for sex contextualism raise at least three questions for the would-be realist. First, what should we do if Richardson's desiderata trade off against one another? Second, does sex contextualism really serve the aim of mutual intelligibility? Third, what kind of realism about biological sex is compatible with sex contextualism? Let's consider each of these.

As a general point, the first question indicates both a possible worry about sex contextualism and a promising avenue for developing alternative pluralist accounts. If some desiderata (e.g., mutual intelligibility and conserving our vocabulary) are in tension, alternative ways of prioritizing them could motivate alternative ways of thinking about sex. Second, as with functionalist pluralism, the idea that operational definitions of sex are all operationalizations *of sex* still motivates the question of what they have in common that warrants calling them "sex," even in a contextualist sense (see Karkazis 2019). Sex contextualism rejects the idea of a single property or even a correlation among properties that might do this work. It is unclear what else might unify these operational definitions on a contextualist account, but it cannot be any underlying metaphysics; Richardson writes that, "[t]here is only sex as pragmatically constituted in an observational frame" (2022, p. 10). This is not a problem for Richardson, but rather a feature of her view, as it motivates indexing each operationalization of sex to a distinct research context.

However, as a result, "sex" doesn't seem to be doing much work in facilitating comparisons *across* research contexts. As historian of science Beans Velocci (2024) writes, "because it is so many things at once, all we can say for sure about what sex is is what a given scientist does with it" (p. 1345). We thus worry that calling such distinct operationalizations as gametes, chromosomes, and hormones, "sex," may risk misleading or hindering researchers' understanding of one another if they call each of these operationalizations "sex" when they do not reliably correlate (Ritz 2017).[25] For instance, Albert and Delano (2022) theorize the popular assumption that such operationalizations align as a source of "sex confusion" in machine learning research. Sex contextualism addresses this by demanding that researchers be

[25] Note that this is an assumption not unique to sex contextualism; we could press a similar worry against a multiply realizable functional account of sex if the realizations were too heterogeneous.

more precise and explicit about what they mean by "sex" in each context (e.g., Pape et al. 2024) — an approach resembling what Taylor and Vickers (2017, p. 32) call "selective stipulativism." However, as Taylor and Vickers point out, this runs into the problem we described above, where the more precise definitions are the ones doing the work. Therefore, by the lights of mutual intelligibility as a desideratum for a concept of sex, however, one cannot straightforwardly endorse this particular pluralist interpretation of sex contextualism.[26]

Where does this leave the prospects for realism about biological sex? First, recall that sex contextualism is metaphysically agnostic, and merely compatible with realism about various phenomena that might be used as operational definitions of sex. This is a very minimal realism indeed. Projecting a stronger cohesion onto sex contextualism would revert to (or require) a form of pluralism such as functionalist pluralism. In fact, with the stated aim of avoiding a major revision of our language, sex contextualism hints at a conventionalist approach to unifying the variety of ways researchers use "sex" in practice. As we'll argue below, this suggests that those who would look to sex contextualism for realism about biological sex have little to lose and much to gain by considering eliminativism.

Many of the preceding arguments for and against each of the realist views should be familiar to philosophers of biology, especially given the analogy we have drawn between sex and species concepts. Indeed, some of these arguments about what makes one version of realism about concepts better or worse than another may apply to many different concepts throughout philosophy of biology and beyond. In summary, the following set of options are available to the realist:

1. Definitions with strict necessary and sufficient conditions (including sophisticated versions such as is offered by a historical kinds account). These are broadly endorsed by biologists, despite recognition of the presence of counterexamples.
2. A cluster concept (such as by an HPC account), which has the primary benefit of permitting these counterexamples due to the revised concept having explicitly blurry boundaries.
3. Pluralism, as a more-or-less radical departure from unified accounts, either focusing on multiple operationalizations of the same fundamental concept or multiple, distinct concepts.

None of these options are wholly satisfactory, leaving open the debates about the "best" concepts of species, sexes, and more.

In favor of anti-realism about biological sex

The previous section presents some realist views of sex, in ascending order of plausibility. The most plausible realist account of sex, we argued, would be a pluralist account (Richardson's sex contextualism provides a good indication of what such

[26] We can, however, endorse a different reading sex contextualism, as we explain in Sect. "In favor of sex eliminativism over sex conventionalism/fictionalism".

views would involve). However, sex pluralism has unresolved issues. Thus, the cumulative effect of the previous section has been to suggest that there are some general reasons to reject sex realism. We do not wish to suggest that these reasons against sex realism are all-things-considered.

In this section, we present a positive case in favor of sex anti-realism, drawing on an analogy with Carlos Santana's (2014, 2018) position on the concept of "biodiversity." Santana's argument for anti-realism about biodiversity[27] says:

(1) If "biodiversity" is biologically real, then the kind of view we should have about biodiversity is a pluralist one. According to Santana, pluralism about biodiversity would involve:

   (a) The biodiversity concept should involve multiple operationalizations, suited for different ways of valuing biodiversity, different levels of biological organization, and different research contexts.
   (b) These multiple operationalizations should be highly correlated.
   (c) The concept should reliably facilitate meaningful comparisons of biodiversity across contexts.

(2) However, while the biodiversity concept currently used by biologists does involve multiple operationalizations suited for different contexts (a), these multiple operationalizations are not highly correlated (b), and, consequently, do not facilitate comparisons across contexts (c).
(3) Therefore, "biodiversity," at least as currently conceived by biologists, is not biologically real.

(1)(a) and (1)(c) are uncontroversial desiderata. Whether (1)(b) is true is an empirical matter: the multiple operationalizations are not highly correlated. Because of this, (1)(c) likely won't be satisfied.

An analogy with Santana's argument can help to show why a pluralist account of sex will not do. The analogous argument goes like this (with changed phrases underlined):

(4) If "sex" is biologically real, then the kind of view we should have about sex is a pluralist one. By analogy with biodiversity, this is what sex pluralism would involve:

   (a) The sex concept should involve multiple operationalizations, suited for different ways that we study sex, different taxa, and different research contexts.

[27] Note that Santana calls his view "biodiversity eliminativism," rather than "biodiversity anti-realism." We will get to eliminativism about sex in Sect. "In favor of sex eliminativism over sex conventionalism/fictionalism", now only dealing with the weaker view of anti-realism. For now, we have taken the liberty of translating Santana's argument into one about anti-realism, rather than eliminativism.

(b) These multiple operationalizations should be highly correlated (perhaps due to a shared function or homeostatic mechanism).
(c) The concept should reliably facilitate meaningful comparisons of sex across contexts.

(5) However, while the sex concept currently used by biologists does involve multiple operationalizations suited for different contexts (a), these multiple operationalizations are not highly correlated (b), and, consequently, do not facilitate comparisons across contexts (c).
(6) Therefore, "sex," at least as currently conceived by biologists, is not biologically real.

Although sex pluralisms yet to be developed may involve different criteria than (4)(a-c) — and we encourage development of such views! — Richardson (2022), for instance, includes (4)(a) and (4)(c) as desiderata in her account. As was the case with the argument for biodiversity anti-realism, the fact that (4)(a) holds and (4)(b) doesn't hold are empirical, and (4)(c) doesn't hold as a consequence of the fact that (4)(b) doesn't hold. Note that the uses for which the biodiversity and sex concepts are suited differ; this is to be expected. In particular, the sex concept needs to work across taxa: "the criteria for classifying an organism as male or female have to work with worms to whales, with red seaweed to redwood trees" (Roughgarden 2013, p. 23). The biodiversity concept, by contrast, is supposed to work well across different levels of organization (species, genera, etc.).

Insofar as Santana has provided a plausible argument for biodiversity anti-realism, the analogous argument for sex anti-realism is also plausible. Again, we have not attempted to give definitive, all-things-considered reasons for anti-realism over realism about sex. We have only argued that anti-realism about biological sex is a tenable position. We now proceed to discuss two types of sex anti-realism and their relative merits.[28]

In favor of sex eliminativism over sex conventionalism/fictionalism

So far, we have presented some reasons against realism about biological sex and some reasons in favor of anti-realism about biological sex. These reasons are not intended to be definitive; this debate is ongoing, and we hope that the preceding

[28] As an anonymous reviewer and several interlocutors have pointed out, if these desiderata apply to other biological concepts, they may motivate anti-realism, and/or eliminativism, about those concepts, too. Sex and biodiversity seem to be two examples where mutual intelligibility is particularly important. By contrast, Neto (2020) argues that imprecision about the concept of lineages is actually a feature rather than a bug. Likewise, pragmatic considerations may favor conventionalism over eliminativism about other biological concepts. Therefore, it seems we must evaluate other biological concepts on a case-by-case basis (and perhaps reevaluate them as pragmatic factors change over time). This approach is indebted to the contextual analysis of "conceptual fragmentation" advanced by Taylor and Vickers (2017), who also offer some general clues as to when mutual intelligibility may be more or less important or hard to come by.

discussion inspires adjustments to existing accounts of sex as well as fresh attempts to define sex. Nevertheless, we do think that anti-realism about sex should be taken seriously as a candidate view, on the basis of the reasons offered so far.

However, there are (at least) two ways to be an anti-realist about sex: sex eliminativism or sex conventionalism.[29] Sex eliminativism is biological sex anti-realism plus the claim that the use of the concept of sex should be eliminated from (at least) large swaths of biological practice. Sex conventionalism is biological sex anti-realism plus the claim that the use of the concept of sex can be maintained in biological practice, perhaps because the concept is pragmatically or heuristically useful. For example, Greenlee (2024) argues that we should understand some scientific uses of binary sex categories as uncredentialed fictions, along the lines of Bokulich (2016). In this section, we will argue for the plausibility of eliminativism over conventionalism about biological sex. Our argument for eliminativism over conventionalism makes the case that eliminating the concept of sex from biological practice would (1) have manageable downsides, given that other variables besides biological sex are readily available to scientists from a range of biological disciplines, and (2) actually have some upsides, because using these other variables is often preferable to using "sex" itself.

In brief, we think that existing biological research programs could largely continue on without using biological sex concepts in practice. For example, in biomedical research, sex categories are often used as proxies for more relevant variables of interest, e.g., hormone levels, reproductive strategies, etc. (Pape et al. 2024). Elimination of sex would not mean that such research cannot be conducted, but that researchers should look more directly at variables of interest. Thus, the same research questions can be pursued without reliance on sex categories. For example, researchers interested in the effects of hormone levels on health outcomes can investigate this without reference to "sex" or "sex hormones," and would thereby avoid obfuscating variations in hormone values that are unrelated to sex (Shattuck-Heidorn and Richardson 2019; DuBois and Shattuck-Heidorn 2021). Similarly, immunologists interested in the relationship between karyotype and autoimmunity (e.g., Klein 2007) can study this without using "sex" as a variable or referring to "sex chromosomes." Abandoning sex in biomedical research could spare us the practice of assuming that patterns of health and disease associated with "sex" are best explained by "sex-related factors" (see, e.g., Shattuck-Heidorn et al. 2021; Danielsen et al. 2022; Miyagi et al. 2021; DiMarco et al. 2022; Rushovich et al. 2021). Whereas Richardson's sex contextualism holds that researchers should take responsibility for deciding whether and how to use sex as a biological variable, sex eliminativists merely go one step further and recommend that researchers use other variables instead of sex; in this sense, biological sex eliminativism is a position already made available by way of (or within) sex contextualism.[30]

In evolutionary biology, eliminating sex categories might also simply involve asking questions in different ways, with more precise variables in mind. For example, instead of asking, "Why are there only two sexes?" (which begs the question;

[29] Some might prefer the label "fictionalism" (e.g., see Greenlee 2024).

[30] Thank you to Sarah Richardson for helpful discussion on this point.

e.g., Hurst 1996; Birdsell & Wills 2003), one might ask, "Why are there (usually) exactly two types of gametes?" This latter question is more metaphysically neutral and would allow researchers to get directly to the point. Evolutionary biologists would still be able to investigate dimorphism, distribution of labor in caregiving, etc. without invoking sex categories (as recommended by Evron 2023). As is the case with biomedical research and conservation biology, posing research questions in ways that focus more precisely on what is actually of interest would benefit scientific practice (Fehr 2001; Santana 2014; Lloyd 2015). There would also be reduced risk of naively importing value-laden assumptions about sex if use of sex categories was eliminated from research methodology. As Velocci (2024) suggests, "Imagine what we might find out if we were to let go of a category that hundreds of years of history demonstrates to be more useful for maintaining social hierarchies than for generating scientific knowledge" (p. 1346).

A more modest sex eliminativist could recommend that researchers only use sex in contexts where it is clear that sex is not *biologically* real. This parallels the argument that biological race eliminativism does not entail that it is inappropriate to talk about racism, or that we should accept narratives of "color blindness" (Wodak 2021). Rather, biological race eliminativists could say these are uses in which it is clear that racial categories are social constructs.[31] Furthermore, in order to mitigate the continuing negative effects of racism, it is probably necessary to diagnose it as such, which may require invoking racial categories (Haslanger 2012).

Sometimes, there are gray area cases. For example, there has been productive debate over whether it is acceptable to use race as a variable in biomedical contexts, e.g., as a proxy for genes or ancestry (Root 2003; Braun et al. 2007; Hardimon 2013; Perez-Rodriguez & de la Fuente 2017; Tsai 2018; Spencer 2018). A race eliminativist would say that these are generally not good uses of racial categories: socially constructed categories are ill-equipped to serve as biological variables, and use of race categories in these cases may contribute to their illicit reification (Gannett 2004; Caulfield et al. 2009). However, there may be contexts in which even race eliminativists would say it is responsible to use racial categories as biomedical variables. For example, research on social determinants of health may reveal racism in medical practice or a racialized distribution of environmental risk factors (e.g., Krieger 2000). Eliminating the *biological* concept of race thus does not entail eliminating 'race' from all scientific endeavors.

Likewise, biological sex eliminativism might recommend heavily circumscribing use of sex categories to research contexts where it is clear that the categories are not

[31] Haslanger (2012) distinguishes "constructionism," the view that races are socially but not biologically real, from eliminativism, which holds that if race is real, it is a natural rather than a social kind (and finds that race is not real *qua* natural kind). By contrast, Wodak (2021), building on Mallon (2006), argues convincingly for understanding what is at stake in discussions of eliminativism in terms of *use*, suggesting "a continuum of views, ordered in terms of how extensively and strongly they endorse or oppose ordinary uses of 'race' talk" (p. 56); Taylor and Vickers (2017) likewise argue that eliminativism can be selective, rejecting and retaining uses of a term on a case-by-case basis. We think similar considerations apply to sex (including perhaps the plausibility of divorcing eliminativism from questions of realism and antirealism). Though Wodak questions whether positions that retain some uses of a word deserve the label 'eliminativism,' we are less concerned with what to call this view than we are with making room for it.

biologically real. For instance, biomedical research practices which serve as candidates to retain the concept of "sex" include studies of how health outcomes are distributed along lines of sex, gender, or Sari van Anders' (2015, 2022) notion of gender/sex, which reflects an entanglement between the two (see also Krieger 2003). For these researchers, as well as other social and political scientists, it makes more sense to use sex (or gender) as a social rather than biological category (see, e.g., Butler 1990; Currah 2022). We do not conflate sex as socially constructed with gender as reflecting social relations, but rather emphasize that sex, like gender, is an organizing construct rather than a biological reality and many aspects of "sex" in human biology are sensitive to gendered social relations, rendering sex a "biosocial" variable (Shattuck-Heidorn and Richardson 2019).[32] Social sex reflects common practices of data collection, which often simply ask research participants for their gender/sex or offer them a set of gender/sex categories to choose from (Perret et al. 2021). Furthermore, it suggests sex and gender are not different in kind and undermines the ontological priority of biological sex (Shattuck-Heidorn and Richardson 2019; Pape 2021; Lockhart 2022). Indeed, Lu Ciccia (2024) argues that the concept of sex must be eliminated from biomedical research precisely to reject such an artificial partitioning of "pre-social biological attributes" (p. 105). In sum, sex as a social category is perfectly compatible with modest biological sex eliminativism.

Different sex eliminativisms therefore offer different recommendations to practitioners. Some sex eliminativists might recommend expansive changes, especially rephrasing or reframing research questions to focus on specific variables of interest (e.g., hormones, gamete sizes) instead of sex categories as a proxy (Freeman and López 2018). Other sex eliminativists might recommend that sex continue to be used in biological practice, but only as a social construct. Certainly, there could be even more varieties of sex eliminativism. Thus, one should not reject sex eliminativism because of assumed implications for biological practice; there are several ways to practice biology consistent with eliminativism.

Again, it is possible to be anti-realist about biological sex on the basis of the arguments made in Sects. "Against realism about biological sex" and "In favor of anti-realism about biological sex" without recommending any changes to biological practice. According to a conventionalist view, there is no real or overarching concept of biological sex, but we should permit biologists to appeal to fictitious concepts in practice. It might turn out to be the case that the practical benefits of continuing to use sexes outweigh the harms, in which case a conventionalist would recommend continuing a business-as-usual approach, despite having determined that biological sex is not ontologically or conceptually real. However, we have attempted in this section to make sex eliminativism — the view that biological sex is not only unreal but also unhelpful to use in practice — more plausible.

In total, our arguments have put sex eliminativism on the table as a serious candidate view about biological sex. We have discussed some arguments against various

[32] For specific accounts of *how* sex is socially constructed, enacted, and produced in biomedicine, see Latham (2017); Karkazis (2019); Pape (2021); Ásta (2023). For a view that blurs the distinction between social and biological reality, see Prum (2023). Currah's (2022) argument in particular speaks to a proliferation of social uses of "sex" which may also resist unification.

realist accounts, and have provided an argument in favor of sex anti-realism, establishing at least that the debate between realism and anti-realism about sex is not resolved. Finally, we have argued for practical benefits of sex eliminativism over sex conventionalism, thus establishing the plausibility of sex eliminativism. In the following section, we close with some broader reflections on why introducing eliminativism as a candidate view is a good idea.

The significance of sex eliminativism

We have offered a statement of biological sex eliminativism and held it up against its rivals, both realist and anti-realist, and provided (defeasible) reasons why these other accounts do not succeed. At this point, the reader may or may not be convinced by sex eliminativism. But taking eliminativism seriously, about sex and maybe many other concepts, has something to offer, even if we ultimately reject it.[33] Taking eliminativism seriously (1) foists a contrastive standard on other ontologies of sex, (2) expands the possibility space for thinking about sex in the near and far term, (3) reveals what is at stake in the debate, and (4) provides some metaphilosophical provocations about the relationship between science and philosophy. Here we explore each of these in turn.

Contrastivism. First, eliminativism is a serious rival to extant accounts of biological sex. Whatever we want from a concept of sex, alternative accounts should show that they are better than eliminativism with respect to that standard. Regardless of which concept(s) win this contest, taking eliminativism seriously dramatically shifts the burdens of argument. Accounts of biological sex are not entitled to assume that we should adopt a realist metaphysics of biological sex; they must give reasons. Any account of sex, realist or conventionalist, needs to satisfy whatever desiderata we agree upon in a particular context, and also to do *better than eliminativism* at satisfying them. More broadly, we can distinguish a contrastive role for eliminativism from the common philosophical practice of treating eliminativism as a last resort: something that can only be taken seriously once all alternatives have been considered and rejected.

Bets-hedging eliminativism. Second, sex eliminativism might make sense in the long term, even if it seems unpalatable in the short term. There are empirical and pragmatic arguments for this claim. Our approach to realist accounts of biological sex has been one of naturalized metaphysics. An account of biological sex should be accountable to the best of our biological knowledge, so evidence about birds, bees, and other systems of incredible sexual diversity can count as evidence against, e.g., phenotypic, chromosomal, or gametic accounts. In the short term, defenders of essentialist or HPC views may be able to cope with one or two counterexamples to an account of biological sex; in the long run, biologists may accumulate more relevant evidence about sexual diversity. Realists may therefore want to hold sex eliminativism on the horizon, keeping track of the accumulation of anomalies for their favorite theory of biological sex, or keep an eye out for anomaly-suppressing

[33] This discussion is inspired by Stroud (1984) and Haber (2020).

practices (see Thinius and Trappes 2024). Similarly, Taylor and Vickers (2017) have argued that scientific concepts tend to "fragment" over time as uses and aims of scientists proliferate. Those who think sex can be unified in the present may nonetheless anticipate that this will be more difficult in the long run.

Eliminativists are accountable not only to realists but also to anti-realist conventionalists. Although we are sympathetic to conventionalism's commitments to naturalism and pragmatism, we worry that these views are too deferential to biologists. Against the conventionalist, the eliminativist has to show that biological sex should be abandoned even as a 'useful fiction.' The utility of this fiction may depend in part on our access to alternative operationalizations of the phenomena of interest. Since this access depends on the state of science, all else being equal, we should expect it to improve over time. Having eliminativism on the table may accelerate this process.

The second way eliminativism might defeat conventionalism in the long run is analogous to the trajectory of debates about race as a biological variable. The pragmatic and political context concerning race has changed dramatically over time. A generation of scholarship generated evidence that race as a biological variable was unwarranted on pragmatic, political, and empirical grounds. Even fictionalism was taken to carry too much metaphysical and epistemological weight, and to run a risk of reification (Yudell et al. 2016). Arguably, feminist scholarship and political activism about sex and gender might effect a similar change in the mid to far term regarding the use of sex as a biological variable. Our optimism about these projects grounds our optimism about sex eliminativism, and we suspect that present day conventionalists would share this optimism. For conventionalists, keeping eliminativism on the table is a way of hedging their bets.

What do we want from a concept of sex? Third, our thinking about sex eliminativism has something in common with philosophical debates about eliminativism in other biological contexts: these debates reveal disagreement about what philosophers and scientists want a concept to do. In the case of the species concept, Brigandt's (2003) defense of pluralism in the face of Ereshefsky's (1992, 1998) eliminativism reveals that philosophers have different standards for pluralism about ontological as opposed to "investigative" kinds, an argument which echoes the apparent disagreement between the sex eliminativist and the sex contextualist. Similarly, in the case of the biodiversity concept, Santana's (2014, 2018) eliminativism highlights the desiderata that the components of a multifaceted concept be adequately correlated and that they outperform rival categories or ontologies. And from Haslanger (2000)'s ameliorative approach to gender and Richardson's (2022) similar approach to sex, we learn that some philosophers prioritize political projects over scientific ones, an approach we broadly endorse. Articulating eliminativism has forced us to map the terrain of extant accounts of sex and to ask whether these accounts share a standard for what an account of biological sex ought to offer. In this sense, taking eliminativism seriously has already been extremely revealing.

Who gets to decide? In addition to helping us make explicit what we want from a concept of sex and how we should test various concepts against one another according to those criteria, taking eliminativism seriously puts front and center a core methodological debate philosophers of science have to contend with: who gets to decide which concepts are useful and should be retained? In the context of sex,

among other biological concepts like species and biodiversity concepts, biologists claim that these concepts are doing important, explanatory work for them and want to retain the concepts as they are currently used. For some philosophers of science, the biologists' attestation is important if not sufficient evidence that the concepts actually are useful and actually should be retained. It is important for any naturalistic, practice-oriented philosopher of science to do work that respects science as it is actually done, but many philosophers (including ourselves) want to preserve a critical role for philosophy of science — we want to maintain the possibility of telling the scientists that they are wrong, when we think they are. Hoping to preserve this evaluative stance opens up many questions about when we should listen to biologists, which biologists we should listen to, who else we should listen to besides biologists — for example, perhaps the people affected by the meanings of terms should have a say (Nguyen & Sundell 2024) — and which topics (e.g., definitions of concepts and the usefulness thereof) we take to be within biologists' expertise. Suggesting eliminativism as a candidate view about any biological concept, including sex, highlights variation in underlying methodological commitments, and calls for philosophers to be explicit about the role they take the word of biologists to play in their own research.

Conclusion

We have problematized actual and possible concepts of biological sex and motivated eliminativism as a viable rival. In addition to highlighting conceptual challenges for monist and pluralist accounts, our inventory of biological sex concepts has revealed a variety of definitions of biological sex, figuring in diverse, legitimate biological and philosophical research contexts. Without prioritizing some of these aims as more "biological" than others, the most promising prospect for realist accounts of biological sex appears to be a version of pluralism on which it remains unclear whether any property, mechanism, or function can hold "sex" together across diverse research contexts. Given that these pluralists have little to lose in the way of realism about biological sex, we have argued that anti-realism is plausible and that eliminativism may be epistemically and pragmatically superior to realism and conventionalism as an approach to biological sex in evolutionary biology and biomedicine.

Our approach has focused on motivating, rather than defending, eliminativism, for three reasons. First, our analysis suggests a number of possible paths forward for sex monists and pluralists that have yet to be developed in the literature, and we are optimistic that others might both make these arguments and show why they are superior to eliminativism. We have attempted to map out several possible views, including eliminativism, putting them on the table and in dialogue with one another and indicating where more work needs to be done. We would welcome further contributions that continue to lay out additional views about sex, including some we have perhaps missed entirely, because only with many candidate views at our disposal can we evaluate them on their merits. Second, a definitive argument for eliminativism depends on setting the right standards for biological sex concepts. We have adopted a relatively minimal, but not uncontroversial, set of considerations for

evaluating existing views. However, disagreement about the stakes for biological sex (particularly about whether ethical and political considerations can be divorced from epistemic ones) and for biological kindhood may be productive for philosophers and biologists going forward. Finally, a strong argument for eliminativism hinges on careful accounting of the positive and negative work being done by concepts of biological sex, compared to alternative concepts. We hope that philosophers and scientists will generate such alternatives, perhaps even in response to eliminativism. Likewise, we think that ethical and political implications are relevant to an all-things-considered evaluation of biological sex. In that case, philosophers of biology are ill-equipped to make the determination on our own, and had better engage in conversation with diverse scholars, policymakers, and communities to whom it matters.

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Declarations

Conflict of interest The authors have no competing interests to declare.

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