Concept Article

Phase-Out Planning for Animal Experimentation: A Definition, an Argument, and Seven Action Points

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Abstract

Since the late 2010s, the idea of phase-out planning for animal experimentation (PPAE) has come to the foreground of political debates, but central notions and arguments are understood differently by different participants and stand in need of clarification. This article draws on public communications on ten political projects related to PPAE to propose a philosophical explication of PPAE and to articulate the proponents' central moral argument. According to the argument, the phase-out of animal experimentation is morally desirable, and planned interventions are both necessary and sufficient to achieve it. The normative and descriptive premises of the argument are stated and discussed, flagging questions that need answering for a more thorough assessment of the argument. This results in a series of seven action points for researchers and stakeholders of PPAE. The overall goal is to enable an open and productive discussion about PPAE in public, political, and academic settings.

Plain language summary

In recent years, a new demand has entered the political arena: that the phase-out of animal experimentation should be planned. But it is important to understand exactly what this means. This article draws on ten documents from governments, parliaments, and NGOs to tease out what they mean by "planning the phase-out of animal experimentation." It also discusses the main argument that is advanced in favor of phase-out planning and highlights seven gaps in our knowledge that we should try to fill to move the discussion forward. In sum, the article is the first to explicitly define phase-out planning for animal experimentation and to directly discuss its pros and cons from a philosophical point of view. This is helpful in avoiding misunderstandings and talking past each other, enabling an open and productive debate.

1 Introduction

Since the mid-2010s, the idea of phase-out planning for animal experimentation (PPAE) has come to the foreground of political debates. Following early landmark publications such as the "Non-Animal Technologies Roadmap" by Innovate UK (2015) and the opinion paper "Transition to Non-Animal Research" by the Netherlands National Committee for the protection of animals used for scientific purposes (NCad, 2016), animal protection nonprofits have adopted the vocabulary of "plans," "strategies," and "roadmaps," calling for "concrete measures" and "reduction targets" to end animal experimentation (e.g., ECI, 2021b; PETA, 2021; AFRUK, 2022; AFR, 2023a). To an extent, this has resonated politically. In 2021, a non-legislative resolution was adopted by the European Parliament (EU Parl) titled "Plans and Actions to Accelerate a Transition to Innovation Without Animals," which also called for reduction targets (EU Parl, 2021). Meanwhile, the United States Environmental Protection Agency (EPA) was already working on a phase-out plan for regulatory testing on mammals within its purview (EPA, 2020, 2021). More recently, the European Commission (EC) announced the development of a phase-out plan for regulatory animal testing in the EU, although it also rejected a proposal to develop a more general phase-out plan for animal experimentation (EC, 2023).

While the timely topic of PPAE has been discussed in academic literature (Baumgartl-Simons and Hohensee, 2019; Herrmann, 2019; Marshall et al., 2022), specifically philosophical attention has been scarce. This is so even though the debate relies on some difficult-to-interpret ordinary-language concepts (e.g., is a phase-out plan just a list of actions or something more specific?), and even though some of the crucial claims in the debate are normative in nature, proponents argue that PPAE is not just cost-effective or expedient but morally imperative (see Section 3). So, a philosophical clarification could help facilitate the public, political, and academic debate. To that end, this contribution articulates a definition of PPAE and the main moral argument in its favor, highlighting issues that need addressing in order to more thoroughly assess the case for PPAE.

The real-world starting point of this clarification consists in public communications on ten PPAE-related political projects and documents:

(i) Innovate UK's "Non-Animal Technologies Roadmap for the UK" (Innovate UK, 2015);
(ii) the Denktank report "In transition! Netherlands leads internationally in animal-free innovation" (Denktank, 2015);
(iii) the NCad opinion "Transition to Non-Animal Innovation" (NCad, 2016);
(iv) the EPA's "New Approach Methods Work Plan" (EPA, 2020, 2021) and a related earlier strategy paper (EPA, 2018);
(v) the EU Parl resolution "Plans and Actions to Accelerate a Transition to Innovation Without the Use of Animals in Research, Regulatory Testing, and Education" (EU Parl, 2021);
(vi) the European Citizens' Initiative "Stop Vivisection" (ECI, 2013) and the EC's response to it (EC, 2015);
(vii) the European Citizens' Initiative "Save Cruelty-Free Cosmetics: Commit to a Europe Without Animal Testing" (ECI, 2021a, 2021b) and the EC's response to it (EC, 2023);
(viii) PETA's campaign titled "The Research Modernization Deal" (PETA, 2021);
(ix) a petition to the UK government and parliament titled "Plan to Phase Out Animal Experiments" spearheaded by Animal Free Research UK (AFRUK, 2022) and other nonprofits;
(x) a petition to the Swiss parliament spearheaded by the separate, Swiss-based nonprofit Animalfree Research (AFR) titled "Keep Switzerland a Safe Place for Research – Without Animal Suffering" (AFR, 2023a,b).[1]

This selection is reasonably encompassing of prolific projects and documents that have called for, or proposed, strategies for a purposeful phase-out or at least a purposeful total reduction of animal experimentation. They include initiatives that are government-led (i-iv), legislative-led (v), and civil society-led (vi-x). They are all concerned with a "purposeful" reduction or phase-out in the sense that they do not merely call for legislative or regulatory changes that may accidentally entail a reduction or phase-out (as might changes in animal research regulation, animal testing requirements, or overall science funding), but they call for planning with the *goal* of total reduction or phase-out.[2] Consequently, mere 3Rs initiatives (Neuhaus et al., 2022) were not included, as the 3Rs do not strategically aim at an overall reduction or phase-out (Eggel and Würbel, 2020; Müller, 2023; Rodriguez Perez et al., 2023). The Directive 2010/63/EU was also not included because, although it endorses the goal of a phase-out in its article 10, it does not specifically call for, or lay out, a planning process to reach it.

Drawing on this material, the first half of this article will give an account of recent political developments relevant to PPAE and will then draw upon the projects under consideration to provide a philosophical explication of the concept of PPAE (Section 2). The second half will then articulate the main moral argument for PPAE that can be found in the materials, dissecting it premise by premise (Section 3). The main aim is to clarify both the normative and descriptive assumptions of the argument under a charitable interpretation. Along the way, issues will be flagged that need addressing in order to assess the case for PPAE, culminating in seven action points.

2 Defining phase-out planning for animal experimentation

The rise of PPAE as a political demand in the 2010s and early 2020s appears to have resulted from two concomitant developments:

First, in civil society, European animal advocates seem to have grown increasingly frustrated with the perceived lack of action following the adoption of the Cosmetics Directive 76/768/EEC, which was meant to end animal testing for cosmetics purposes, and later of Directive 2010/63/EU, which in article 10 acknowledges the "*final goal of full replacement of procedures on live animals for scientific and educational purposes as soon as it is scientifically possible to do so*." As early as 2012, the European Citizens' Initiative "Stop Vivisection" called for the abolition of Directive 2010/63/EU and demanded that "*a new proposal aimed at phasing out the practice of animal experimentation*" be put forward, receiving over a million verified signatures (ECI, 2013). Some nonprofits proposed specific measures that should be included in a phase-out plan, the most fleshed-out proposal to date being PETA's "Research Modernization Deal" (2021). The first major political breakthrough of PPAE followed with the adoption of the EU Parl resolution called "Plans and Actions to Accelerate the Transition to Innovation Without the Use of Animals in Research, Regulatory Testing and Education" (2021). The resolution criticized that "*there has been little change in the overall number of animals used for scientific purposes*" and called for an "*action plan*" including "*a clear and ambitious timeline and list of milestones*" (EU Parl, 2021). Being a non-legislative resolution, however, it did not have an immediate effect. Meanwhile, another European Citizens' Initiative calling for PPAE was launched in 2021, called "Save Cruelty-Free Cosmetics: Commit to a Europe Without Animal Testing," (ECI) supported by animal protection nonprofits and some cosmetics companies, receiving over 1.2 million verified signatures (ECI, 2021b). While the Initiative's title and first objective called for a strengthening of the EU's existing ban on animal testing for cosmetics, it also called for a phase-out plan for regulatory animal testing and a separate phase-out plan for animal experimentation in general (ECI, 2021a,b). In its response, the EC dismissed the idea of a general phase-out plan

[1] As the Denktank report and AFR's petition do not exist in English, all references to them are rendered in the author's translation from the original Dutch and German.

[2] An arguable exception is the first document, Innovate UK's "Non-Animal Technologies Roadmap" (Innovate UK, 2015), which only aims to *phase-in* non-animal technologies but does not explicitly aim at a *phase-out* of animal methods. Another arguable exception is PETA's "Research Modernization Deal" (PETA, 2021) because it does not explicitly call for government planning, but directly suggests specific measures to achieve a phase-out. Both projects are still included because they contain a range of strategic suggestions that are helpful to a discussion of PPAE.

for animal research but did announce the development of a more limited phase-out plan for regulatory animal testing (EC, 2023). In the United Kingdom and in Switzerland, parliaments have been petitioned to approve PPAE (AFR, 2023a; AFRUK, 2022), but no commitments to planning have yet been made.

The second development concerns the interplay of science and politics. In the 2010s, governments on both sides of the Atlantic requested input from scientists on how policies relevant to animal experimentation could be improved. In the Netherlands, then-State Secretary Sharon Dijksma created a dedicated think tank to reflect on funding allocation in alternatives to animal testing (Denktank, 2015: 13). The report produced by the think tank seems to have been the first to cast animal experimentation in the theoretical framework from technology transition studies called the multi-level perspective (MLP), also referred to as the "transition perspective" (Geels, 2002; Loorbach and Rotmans, 2006; for more see Section 3). Upon publication of this report, then-Dutch Minister for Agriculture Martijn Van Dam requested an opinion from NCad on how the Netherlands could become an international leader in scientific innovation without animals by 2025, which was understood to include a "phase-out timetable" (NCad, 2016: 11). The opinion was produced over the period of just a few months based on a series of expert roundtables and inputs to online discussion forums open to stakeholders (NCad, 2016: 13). Animal experimentation was divided into four sections – regulatory testing, basic research, applied and translational research, education – and different steps towards a phase-out were suggested for each (NCad, 2016: 15). In recent years, the NCad opinion paper was followed up by "ambition statements" on animal experimentation in higher education (UvN and NFU, 2023) and immunology (NCad, 2023), as well as so-called "target images" (NCad, 2021a,b,c), which describe strategies for specific domains of research – so far for cardiovascular research, vocational education, and academic education. Independently from the Dutch development, the British innovation agency Innovate UK had explored more strategic steps to promote non-animal technologies and produced the report "A Non-Animal Technologies Roadmap for the UK: Advancing Predictive Biology" (Innovate UK, 2015). Though this roadmap did not explicitly aim at reducing animal experimentation and only at supporting alternatives, it represented a shift towards a more transformative and strategic, as opposed to a merely regulatory, approach to animal experimentation.

In the United States, too, PPAE was first explored at the request of a government official. Then-Administrator Andrew Wheeler asked for a plan to reduce the EPA's requests and funding for mammalian studies by 30% by 2025 and to phase them out completely by 2035 (EPA, 2020: 3). The EPA complied and announced in 2019 that it would no longer support mammalian studies after 2035 (Grimm, 2019). In 2020, the EPA then presented its "New Approach Methods Work Plan" (EPA, 2020). The plan defined "new approach methods" (NAMs) as including any alternatives in line with the "3Rs" (Russell and Burch, 1959) suitable for the assessment of the same ecotoxicological endpoints as previous – vertebrate – animal experiments, but also other strategies to reduce the reliance on said testing, such as read-across techniques (EPA, 2018: 7). This definition entails that testing on non-vertebrates rather than vertebrates could count as a NAM. The EPA's phase-out timeline from the 2020 plan was however no longer mentioned in an updated version published the following year (EPA, 2021). The plan was officially dropped in 2024 (Grimm, 2024).

Ardent opposition against PPAE has come from animal research interest groups and research institutions. For example, ahead of the publication of the EC's response to the ECI "Save Cruelty-Free Cosmetics," the Dutch animal research organization Stichting Informatie Dierproeven (SID) published an open letter in the name of 22 medical and research organizations titled "An Abrupt Ban on Animal Research Stops Access to Latest, Lifesaving Medication" (SID, 2023). The EPA's phase-out announcement was similarly criticized by groups for the defense of animal research, as well as some environmental groups worried about weakening ecotoxicity testing (Grimm, 2019, 2024). Some attempts at encouraging PPAE have also failed due to lack of support. In Switzerland in 2021, parliament had the option of putting PPAE on the ballot as an indirect counterproposal to a popular initiative calling for a total animal experimentation ban (see Confederation, 2022). Parliament however declined because the initiative itself, whose broad wording would also have banned human clinical trials and all imports of products tested on animals, was not deemed a serious enough contender to warrant a counterproposal (SDA, 2021).

The debate about PPAE has given rise to a convoluted cluster of notions: "plan," "roadmap," "strategy," "timeline," "timetable," "milestone," "goal," "target," "action," "measure," "deliverable," "phase-out," "ban," and more. In the absence of explicit definitions and accounts of how these notions relate to each other, what exactly do they imply?[3] The SID open letter, which assumes that a phase-out plan always implies a ban of animal experimentation ahead of the science, shows that there is a lack of common understandings. It also shows how uncertainty about PPAE's true implications can be exploited by those opposed to change (see generally Bloomfield, 2015). Thus, some philosophical clarification might help to enable an open and informed debate about PPAE.

A philosophical explication is a form of definition (see Gupta and Mackereth, 2023). In contrast to a stipulative or out-of-the-blue definition (such as "let 'X' mean 'tree'"), it aims to capture a preexisting definiendum that is found in ordinary language. However, in contrast to a lexical or dictionary definition, it does not aim to reproduce all the different facets and vaguenesses of the definiendum in the definiens, but rather tries to achieve greater clarity in the definiens than the definiendum through simpli-

[3] There is in fact one explicit definition of a "phase-out plan" to be found in the projects: AFR's "*a specific catalogue of measures tied to specific milestones on the way to a specific goal, the elimination of animal experimentation*" (AFR, 2023b). However, this piece of text was suggested to the organization by this very author on the basis of earlier research similar to the present article (see conflict of interest statement).

fication. A good explication captures the conceptual core of the definiendum while also increasing clarity for practical purposes.

In the rest of this section, the following explication of PPAE will be drawn from the projects under consideration:

Explication of phase-out planning
Phase-out planning for animal experimentation is the activity of determining and mutually integrating:
(i) Measures: Actions to be taken by the authorities that adopt the plan.
(ii) Milestones: Outcomes to be brought about, the ultimate outcome being the inexistence of (certain domains of) animal experimentation in the respective jurisdiction.
(iii) Monitoring: Relevant information to be gathered to assess the fit of measures to milestones.
The intended result of the activity of PPAE is a document, the phase-out plan.

In the following subsections (2.1-2.3), consider the three "Ms" of phase-out planning – measures, milestones, monitoring – in turn. What does it mean to plan them, and what does it mean to plan them well? The ten projects under consideration will now be mined for answers to these questions.

2.1 Measures

It stands to reason that a plan, being a prescriptive document, requires something it tells an agent (most likely an authority) to do. Of course, a plan might have other functions too, such as expressing values or endorsing long-term goals, and some calls for PPAE do demand a symbolic (re-)endorsement of the phase-out of animal experimentation (e.g., AFR, 2023a; ECI, 2021a). On the whole, however, the emphasis in the projects is on action. To get a sense of what kinds of actions have been proposed, consider the following unordered and inexhaustive list of examples:
– Increase of funding for NAM[4] innovation (ECI, 2021a; EU Parl, 2021; Innovate UK, 2015; NCad, 2016)
– Increase of funding for research that utilizes NAMs (ECI, 2021a; EU Parl, 2021; PETA, 2021)
– Decrease of funding for animal research (ECI, 2021a; EU Parl, 2021; PETA, 2021)
– Promoting public-private partnerships for NAMs (EU Parl, 2021; Innovate UK, 2015; NCad, 2016)
– Promoting chain-oriented support for NAMs from niche innovation to market (Innovate UK, 2015; NCad, 2016)
– Revisiting authorities' own regulations to identify reform potential for greater NAM acceptance (EPA, 2020, 2021; NCad, 2016)
– Redefining chemical testing endpoints to increase NAM applicability (EPA, 2020, 2021)
– Establishing NAM validation standards and transparent regulatory acceptance pathways (EPA, 2020, 2021; NCad, 2016)
– Creating information portals about NAMs to facilitate trust (EPA, 2020, 2021)
– Promoting NAMs in teaching and training (ECI, 2021a; EPA, 2020, 2021; EU Parl, 2021; NCad, 2016; PETA, 2021)
– Organizing workshops with stakeholders and experts to develop ten-year visions for NAM establishment (NCad, 2016)
– Reviewing published research to identify areas in which animal use has not been productive (AFR, 2023b; PETA, 2021)
– Introducing tax breaks for investments into NAMs (NCad, 2016)
– Creating new organizational bodies to monitor progress and coordinate action (EU Parl, 2021; Innovate UK, 2015; NCad, 2016)
– Collaborating internationally with other agencies engaged in a phase-out (NCad, 2016)
– Coordinating internationally to promote the acceptance of NAMs in regulatory testing (EU Parl, 2021; NCad, 2016; PETA, 2021)

Of course, when it comes to potential government actions to phase out animal experimentation, the idea of bans looms large. Calls for a total ban on animal experimentation date back to the 19th century (Franco, 2013) and continue well into the present day, as illustrated by the Swiss popular initiative "Yes to the Ban on Animal and Human Experiments" (Confederation, 2022). The SID open letter is a stark example of how the idea of premature bans is invoked to argue against PPAE (SID, 2023). However, bans are not suggested at all by any of the projects under consideration.[5] Rather, phasing-out is largely treated as a matter of phasing-in, establishing, and centralizing NAMs (see generally Hebinck et al., 2022). This may be better captured by the notion of "transition" (as used by Denktank, 2015; NCad, 2016) rather than "phase-out." A unilateral focus on phasing-in over phasing-out may however bear the risk that NAMs and animal experiments both continue, rather than one replacing the other, and thus phase-in measures alone may not suffice for a feasible phase-out plan.

What makes for *good* measures? The feature most often highlighted in political calls for PPAE is "clarity" or "concreteness" (AFR, 2023a; AFRUK, 2022; ECI, 2021a; EU Parl, 2021), which can be understood as the precision of action definition. In other words, a measure is clear or concrete to the extent that the conditions of carrying it out are delineated without vagueness or ambiguity. Clarity or concreteness is a plausible desideratum for good measures given that a strategic plan serves a prescriptive purpose and typically relies on the coordination of several authorities and stakeholders. A plan whose measures are defined too vaguely may fail to create common expectations and enable unified action.

[4] Not all documents under consideration use the term "NAM" or agree on a definition of "alternatives," "non-animal technologies," and so on. For the purposes of this article, the term "NAM" will be used as a generic stand-in for suitable alternatives and strategies that can help to avoid animal testing, acknowledging that PPAE would need to define more precisely what should be phased out and what should be phased in (see Section 3.1). The term "NAM" will thus not be used in the exact sense of the EPA (2018), which counts non-vertebrate animal testing as a form of NAM.

[5] The only suggestion that comes close is PETA's call to "*immediately eliminate animal use in areas in which animals have been shown to be ineffective 'models' for humans and their use has impeded progress.*" (PETA, 2021) However, on a charitable reading this is intended merely as a call to stop licensing such procedures assuming that they bring more harm than benefit, not a call for a new ban.

2.2 Milestones

Political calls for PPAE have emphasized that specific milestones should be fixed (AFR, 2023a; AFRUK, 2022; ECI, 2021a; EU Parl, 2021). Milestones are goals, outcomes to be brought about by means of measures that help to break down the distant ultimate goal into more manageable parts (e.g., by specifying goals for different areas of animal experimentation such as toxicity testing, education, basic research, etc.; or by distinguishing between short-, medium-, and long-term goals). In the EU, calls for PPAE typically emphasize the "final goal" of an animal experimentation phase-out that is already endorsed in article 10 of Directive 2010/63/EU (ECI, 2021a; EU Parl, 2021) and then call for intermediate milestones to define a pathway to the final goal. Some calls for PPAE have simply demanded that the EC commit to "reduction targets" (ECI, 2021a; EU Parl, 2021). However, milestones do not necessarily have to be expressed in terms of a reduction of animal experimentation numbers, but can also concern funding to be established for NAMs and dedicated infrastructures to be provided, the setup of NAM education and training programs, the regulatory acceptance of NAMs (all of which are suggested by ECI, 2021a: 6), the provision of specific reports, case studies, and intermediate plans (all mentioned as deliverables by EPA, 2020, 2021), or any other intended outcome of planned measures.

A feature of milestones highlighted by the Swiss petition, but presumably implied by other projects too, is "bindingness" (AFR, 2023a). In other words, not only are milestones goals, but failure to meet them should entail consequences of some kind. What consequences those should be, none of the projects say. An uncharitable view, apparently implied by the SID open letter, is that milestones always trigger bans or quotas on animal experimentation. A charitable view would however be that failure to meet milestones requires a reevaluation, reorientation, or intensification of efforts. Thus, milestones are goals, but they are also checkpoints that can trigger a change in measures.

As for desiderata for *good* milestones, one might draw inspiration from the classic "SMART" acronym – good goals are specific, measurable, assignable, realistic, and time-related (Doran, 1981). Indeed, remarkably similar desiderata are voiced by the projects, especially in that they ask for concrete, measurable and achievable milestones (AFR, 2023a; AFRUK, 2022; ECI, 2021a; EU Parl, 2021; NCad, 2016). Assignability is not mentioned specifically, but several projects call for better coordination across different authorities and stakeholders (ECI, 2021a; EU Parl, 2021; NCad, 2016), implying that well-defined milestones can be assigned to specific agents or constellations thereof.

As it concerns time-specificity, some attempts at PPAE have attached a date to the ultimate goal – the EPA initially announced the intention to phase out mammalian testing requirements by 2035 and a 30% reduction of support by 2025 (Grimm, 2019), the NCad proposed phasing out regulatory animal testing in the Netherlands by 2025 (NCad, 2016), and EU Parl generally demanded that timelines be part of the phase-out plan (EU Parl, 2021). So far, however, the specific timelines set out in phase-out plans were not followed successfully, suggesting a lack in realistic goal setting, in efforts to actually reach the goals, or in provisions for the case of failure (or some combination of the above). There is little point in setting time-specific milestones if missing them merely leads to their abandonment.

Another repeatedly mentioned desideratum is "ambitiousness" (AFRUK, 2022; ECI, 2021a; EU Parl, 2021). While no project under consideration defines what this means, NCad and EU Parl emphasize that milestones should at once be ambitious and realistically achievable (EU Parl, 2021; NCad, 2016: 17). Indeed, by way of analogy, people who take on ambitious endeavors do not necessarily set unachievable goals for themselves. They "aim high," but they still aim, taking the attitude that it is better to have tried and failed than having missed opportunities for lack of trying. Accordingly, ambitiousness in PPAE should not be understood as indifference to achievability, but as a preference for false-positive over false-negative judgments of achievability in case of uncertainty.

Ambitiousness so understood is clearly rational for agents strongly committed to a distant goal, so long as missing milestones is not associated with great costs. This is worth noting because the costs of missing milestones may not be the same for all parties involved in PPAE. For example, failure to stay on track may reflect negatively on a government, who might therefore prefer conservatism in judging achievability, while the same failure is not to the detriment of most other societal agents, including animal protection nonprofits. However, planning authorities have a degree of control over the costs of missing ambitious milestones, as it is up to them to predefine the direct consequences of missing milestones and to communicate to the public with appropriate caution in order not to raise unrealistic expectations.

2.3 Monitoring

A crucial feature of PPAE is that it involves intentional, goal-directed action. This requires that measures and milestones are mutually coordinated, so that measures are adjusted according to whether milestones are met. This requires a system of monitoring, that is, of gathering information relevant for whether, to what extent, and in what respects progress is being made along the milestones.

In its 2021 resolution, the European Parliament underlined that the called-for action plan shall be "*accompanied by indicators, as are applied to other EU policy areas*" and that it should "*include a well-functioning system of controls*" (EU Parl, 2021). Similarly, the EPA spent considerable efforts on developing appropriate metrics to track phase-out progress (EPA, 2021). The question of what exactly to monitor is by no means trivial, and determining appropriate metrics is part of the process of PPAE. But *that* phase-out planning needs to involve progress assessment is uncontroversial.

As the European Parliament specifically called for "*reduction targets*" (EU Parl, 2021), one might think that the total numbers of procedures or of animals involved are obvious candidates for metrics. However, animal experimentation statistics may not be comprehensive. In the United States, for example, the use of mice, rats, birds, fish, reptiles, amphibians, and cephalopods is not reported (Taylor and Alvarez, 2019). Furthermore, a phase-out plan might aim at a transition that is not strictly lin-

ear but might include breakthroughs and plateaus of change (see Hebinck et al., 2022). There may be important preparatory phases of change that do not (yet) lead to a linear decrease in procedures or animals used. The purpose of monitoring is to assess whether a plan is on track, not just how similar the *status quo* is to the ultimate goal. For this, relevant total numbers will need to be combined with more complex metrics (see Marty et al., 2022 for an account of how this may be achieved in a company setting – similar processes would be required in PPAE).

Compared to measures and milestones, monitoring has not been emphasized much in political calls for PPAE, and no specific desiderata for good monitoring have been put forward. Common sense however suggests that monitoring needs to be accurate, precise, relevant, and transparent to fulfil its function in guiding measures in accordance with milestones. It is worth emphasizing that progress assessment can have both quantitative and qualitative aspects. Thus, beyond just tracking certain relevant numbers, a monitoring system may utilize methods such as interviews or focus groups to gain information based on which adjustments can be made to measures relative to milestones (see e.g., how Menon et al., 2021 investigated the impact of conducting systematic reviews upon researchers using a qualitative approach).

In sum, PPAE can be defined as the determination and mutual integration of measures, milestones, and monitoring, where the ultimate milestone is the inexistence of (some specific sector of) animal experimentation in a given jurisdiction. Having thus established the notion, we can now consider the main moral argument advanced in favor of PPAE.

3 A moral argument for phase-out planning for animal experimentation

A range of arguments have been offered why it would be desirable for science to move away from animal experimentation, including considerations about animal rights or welfare (ECI, 2021a; EU Parl, 2021), the human relevance of scientific research (Innovate UK, 2015; PETA, 2021), the responsible use of taxpayer funds (AFRUK, 2022), and the promotion of domestic innovation (AFR, 2023a; Innovate UK, 2015; NCad, 2016).[6] However, not every argument for a phase-out is an argument for *planning* it. One could also regard a phase-out as desirable but unplannable, as many things in life are. So, the central moral argument in favor of PPAE cannot rest just on the assumption that a phase-out is desirable but needs to make assumptions about how this desirable outcome can and should be achieved.

This is not lost on proponents of PPAE, who emphasize the consistently high numbers of animals that are subjected to experiments in their respective jurisdictions (AFR, 2023a; AFRUK, 2022; ECI, 2021a; EU Parl, 2021). The implication, straightforwardly, is that positive change towards a phase-out is not happening on its own and that intervention is needed. At the same time, of course, they are assuming that the *necessary* interventions are also *sufficient* to achieve a phase-out.

The basic argument can be represented as follows:

A moral argument for PPAE

1. The phase-out of animal experimentation is a morally desirable outcome.
2. Planned interventions are necessary to achieve the phase-out of animal experimentation.
3. Planned interventions are sufficient to achieve the phase-out of animal experimentation.
4. Therefore, the authorities should carry out planned interventions to achieve the phase-out of animal experimentation.

The logic of the argument is straightforward, almost trivial. At a closer look, however, several complicated issues arise that make it difficult to assess the argument's true power. The next three subsections (3.1-3.3) will dissect the argument's premises in turn, again drawing on the communications from the projects under consideration. This serves on the one hand, to get into clear view what proponents of PPAE are asking for and why, and on the other, to flag questions that need answering for a more thorough assessment of the case for PPAE.

3.1 The phase-out of animal experimentation is morally desirable

To be persuasive, the normative premise (1) must rely on an appropriate interpretation of the words "animal experimentation" and "phase-out." First, what is meant by "animal experimentation" – what exactly shall be phased out?

The main challenge in defining the target of the phase-out lies in balancing precision against moral justification. An agency like EPA is likely to approach the problem from a pragmatic angle, targeting some portion of the animal experimentation it requests and funds itself. This has the advantage that the target of phase-out is precisely defined – say, all mammalian studies requested and funded by the agency – but the ethical justification of this target is somewhat unclear. Why should mammalian studies be phased out ahead of fish studies, for instance?

Most projects under consideration seem instead to err on the side of stronger ethical justification rather than precision when defining the target of the phase-out. NCad, EU Parl, ECI, and PETA refer to animal experimentation in very broad terms, such as "*procedures on live animals for scientific purposes*" (EU Parl, 2021, §1), "*all scientific procedures using animals for research, education, and regulatory testing*" (ECI, 2021a), and "*the use of animals in research in a broad sense*" (NCad, 2016: 14). Clearly, it would be uncharitable to read this too literally, as it would even have us phase out research that does not inflict any harm on animals or, in the case of ECI and NCad, all research *about* animals

[6] All projects appear to be mainly concerned with outcomes, which is why an outcomes-oriented argument is articulated in the following. From a philosophical perspective, however, one could also argue for PPAE on other grounds, e.g., by claiming that only PPAE expresses adequate respect for the inherent value of animals. One can hardly claim to value a group for their own sake but continuously sacrifice their good for the conflicting good of other groups and not even plan to reduce the amount of conflicts. In Brigid Brophy's words, "*the moral thing to do about a moral dilemma is circumvent it*" (Brophy, 1972).

that does not interfere in their lives (e.g., careful scientific observation of animals in the field) and that is not meant to deliver any human-relevant results.[7] The moral concerns that appear to motivate the respective projects – harm to animals, irrelevance to humans, lack of reproducibility – either do not apply to such research or are not particularly pressing. A more charitable reading understands NCad, EU Parl, ECI, and PETA as targeting either (a) *scientific procedures that harm animals* or (b) *scientific procedures aimed at using animals to produce human-relevant results* or both. But either definition raises difficult boundary issues.

The former target definition – procedures that harm animals – has a great deal of purchase from an ethical point of view, as harm to animals is viewed as at least *pro tanto* morally bad by a variety of ethical perspectives (e.g., Gruen, 2015; Korsgaard, 2018; Nussbaum, 2007; Regan, 2004; Singer, 2002). Even from an exclusively human-focused perspective, the infliction of harm on animals is arguably bad, as it may harm human moral capacities (Baranzke, 2004) and can cause moral distress (King and Zohny, 2022). While there is broad agreement in philosophy that harming animals is morally problematic, there are philosophical debates about what constitutes a harm to animals; including such central issues as whether death should be considered a harm (Kasperbauer and Sandøe, 2016) and whether there can be harms to animals that do not make them worse off, for instance in breeding and genetic modification (Palmer, 2012).[8] The question of what we should count as "harming" animals, then, is not trivial.

The latter target definition – "*scientific procedures aimed at using animals to produce human-relevant results*" – appears to be operative too. Perhaps surprisingly, PETA's case for the phase-out of animal experimentation relies mainly on the claim that the results of animal studies are not human-relevant, which renders them a potential danger to humans by way of misleading results and an irresponsible use of taxpayer money (PETA, 2021 pp. 4–9; similarly AFRUK, 2022).[9] The normative strength of these concerns is fairly straightforward – few are in favor of unnecessarily harming humans and using public funds irresponsibly. But the argument raises the question what a human-relevant result is. As LaFollette and Shanks (1995: 143, 1996: 194) point out, animals in basic research typically serve not so much as direct causal analogs of human bodies, but rather as models that help to generate good *hypotheses*. But if the human relevance of animal research can lie in hypotheses rather than results, a precise definition of human relevance would require a precise definition of a good hypothesis. And while one can of course articulate criteria for good hypotheses, drawing an exact line for what is good enough will be difficult. Thus, while human-irrelevant methods are a convincing phase-out target from a moral standpoint, they are hard to pin down in practice.

The Swiss petition stands out in that it appears to make a conscious attempt to strike a balance between ethical justification and precision, qualifying the target of the phase-out as "severe" procedures (AFR, 2023a). This is a legal term under Swiss law, which categorizes animal experiments according to "severity degrees" from zero to three (Gerritsen, 2015). The petition thus calls for a phase-out of all procedures that have a non-zero severity degree (AFR, 2023b). While legal terminology helps to lend precision to the petition's demand, it has some arguable ethical downsides. As AFR itself points out (ibid.), even procedures legally categorized as "no constraint" might still inflict serious harm on animals. Swiss law, despite its recognition of certain "non-pathocentric harms" (Schindler, 2013) does not consider death to be a harm to animals. So, the killing of animals, even in great numbers, can be allowed in studies of severity degree zero. Again, greater precision comes at the cost of more questionable ethical justification.

In sum, the question of what exactly to phase out in general PPAE is not trivial. It involves a difficult trade-off between precision and ethical justification, that is to say, between a phase-out target that can easily be implemented in practice and one that is worth implementing. The debate about PPAE would be greatly advanced by contributions that can overcome this dichotomy by offering an ethical account of what kinds of animal experimentation should be phased out that is precise enough to be implemented in practice. This will have to take pragmatic considerations and nonideal circumstances into account (see also Müller, 2022).

Turning to the other key term of premise (1), what is meant by a "phase-out?" It would be uncharitable to equate a phase-out with any development whatsoever that eliminates animal experimentation, as this would count such morally dubious projects as the end of all science or even the end of humanity as possible forms of phase-out. Rather, by conversational implicature, phasing out one thing means continuing or building up another. But what do the projects under consideration imagine this process to look like?

Most of the projects appeal to the notion of "replacement" or "alternatives" familiar from the 3Rs framework (Russell and Burch, 1959), or more specifically to the goal of "full replacement" as endorsed in article 10 of Directive 2010/63/EU (AFR, 2023a; AFRUK, 2022; ECI, 2021a; EU Parl, 2021; PETA, 2021). The idea of "full replacement" implies that for every scientific objective currently addressed with animal experimentation, there shall be developed an equal or superior non-animal method.

A hidden assumption in premise (1) so understood is that the intended phase-out comes at no scientific cost whatsoever, since no animal procedure will be eliminated without proper replacement. However, as the EC pointed out in its response to the ECI, at the moment there do not exist sufficient replacements for all animal methods (EC, 2023: 17). It also argued that, given the complexity of animal methods and the open-ended range of their scientific applications, a phase-out plan that aims at full replacement is not realistic (ibid.).

[7] AFR points this out explicitly (AFR, 2023b).

[8] A major difficulty here is posed by so-called non-identity problems (Palmer, 2012). In a nutshell, an animal bred or gene-edited to have specific health conditions would not have been better off without the procedure but would not have existed at all. This raises the philosophical question whether animals can be "harmed" by such procedures if they did not make them worse-off than they otherwise would have been.

[9] PETA also mentions the ethical problems of harming animals (PETA, 2021: 10-11), but this carries less weight in the document overall.

A more robust understanding of premise (1) might conceive of the phase-out not as completely cost-free for science, but as net-neutral or net-positive. In other words, while some areas of research and education would admittedly be closed off by a phase-out of animal experimentation, equal or greater areas would be opened up by reliance on NAMs. The case for this claim would presumably have to be made separately for education, regulatory testing, and scientific research, and it faces different opportunities and challenges in each area. In general, however, proponents of PPAE would be right to point out that NAMs are often much more than mere alternatives but can deliver on scientific tasks that animal methods cannot. This includes cases in which an ostensible alternative translates better to humans than the animal experiment it replaces, but also cases in which NAMs allow answering different research questions altogether. Furthermore, NAMs may often be more cost-effective than animal experimentation (see Meigs et al., 2018) and thus also incur lower opportunity costs, as they free up funds for further research projects or other purposes that serve the public good. A phase-out could accordingly be understood as essentially a redistribution of people and resources from one imperfect area of scientific work to another. What needs to be shown, then, is that some combination of NAMs and naturally animal-free research (such as clinical and epidemiological studies) holds enough scientific potential to make up for what is lost in animal experimentation. An argument to this effect needs to be evidence-based, and a particularly crucial role belongs to systematic reviews both of animal studies and of NAM-driven research (see Ritskes-Hoitinga and Pound, 2022a,b). Contributions that can flesh out the "mixed calculation" of scientific restrictions and possibilities in greater detail would thus be helpful in advancing the debate.

The fact that a phase-out would likely be a mixed affair of restrictions and possibilities also implies that it would advantage some parties while disadvantaging others. This affects the plausibility of premise (1), which claims that the phase-out is morally desirable. Of course, proponents of PPAE need to be able to respond to blanket objections from freedom of inquiry and against government intervention in science (see e.g., Bayertz, 2006; Wilholt, 2010). More specifically, however, they also need to respond to the moral claims of those on the losing end, who may include researchers in fields disadvantaged in the course of planned interventions, but of course also laboratory animal technicians and caretakers, animal welfare officers, laboratory animal breeders, and anyone else dependent on animal experimentation.[10] What about *their* moral claims? The question might strike proponents of PPAE as repugnant given that, in their view, the animals' moral claims by far outweigh those of humans who incur costs from a phase-out. However, the view that animals' moral claims can outweigh those of humans, common as it may be among animal ethicists (e.g., Kagan, 2019; Regan, 2004; Singer, 2002), may not hold enough weight in the exclusively human political arena. What is more, even moral claims that are justifiably overridden in situations of moral conflict still exert some residual normative force (Williams, 1965), so that amends or compensation can still be required. Thus, pointing to the greater moral claims of animals is not a sufficient response to the question of what those on the losing end of transition deserve.

A more robust case for premise (1) could argue that the moral claims of those disadvantaged by the phase-out will be attended to in alternative ways. This raises the issue of just transition; the question of what moral claims are raised on the losing end of change and how these claims should be attended to (see Abraham, 2017; McCauley and Heffron, 2018; Wang and Lo, 2021). This may differ for different kinds of investments – those having to rely on animal experimentation for employment might have some claim to support, just as coal miners do in the phase-out of their industry (Abraham, 2017), while mere financial investors in animal experimentation might have as little moral claim to compensation as the financiers of coal mines. Though a comprehensive account of a just transition would exceed the space of this paper, suffice it to say here that a robust reading of premise (1) would require such an account.

In sum, premise (1) raises important issues related to the definition of the phase-out target, the mix of restrictions and new possibilities that a phase-out may bring, and issues of just transition in animal experimentation.

3.2 Planned interventions are necessary for a phase-out

A major reason for the call for PPAE has been frustration over the lack of significant change in the overall amount of animal experimentation, which is emphasized by most civil society-led projects (AFR, 2023a; AFRUK, 2022; ECI, 2021a; EU Parl, 2021). However, the mere fact that current regulation has not led to a drop in animal experimentation does not strictly imply that strategic planning is necessary. Alternatively, one could speculate that progress in scientific methodology will eventually lead to breakthroughs in NAMs that will entail a spontaneous, unplanned phase-out. However, the variety of measures suggested by the projects under consideration (see Section 2.1) suggests that proponents of PPAE are keenly aware that various factors keep animal methods central in many fields of science, for example when it comes to funding, regulation, education, and the relative weight given to applied versus basic research, none of which are likely to change without intervention by authorities.

The inference from "the phase-out has not been happening on its own" to "PPAE is necessary" could be established by a more in-depth explanation of *why* the phase-out, or at least a significant reduction in overall animal experimentation numbers, has not been happening. To see to what extent environmental factors such as institutions, regulations, guidelines, funding, publica-

[10] The uncertainty whether research generates particular societal benefits (see Grimm et al., 2017) makes it difficult to draw the line for who should count as being on the losing end of transition. Here, I focus on those who would undoubtedly have benefitted from the continuation of animal experimentation at current scale.

tion, education, and the job market shape the role of method selection in science, one may be well-advised to draw on the "science of science" (Fortunato et al., 2018). Proponents of PPAE might point out, for example, that researchers tend to focus on topics and approaches on which they are already experts (ibid.), that rarer switching between topics (and presumably methods) is rewarded (Zeng et al., 2019), and that, while NAMs have taken on an epistemic role in generating evidence, animal models have largely retained the yet more fundamental epistemic role of inspiring and shaping new research ideas in many fields (Lohse, 2021). It would be helpful if more research directly investigated the role of such conditions in the centralization and stabilization of animal experimentation.

A macro-scale account of why animal experimentation remains standard in many fields can follow NCad in utilizing the multi-level perspective (MLP) (see generally Geels, 2002; Schot and Geels, 2008; NCad, 2016 pp. 9–10, 30–34). Geels (2002) presents the MLP as a theoretical framework that conceives of socio-technical change as the transformation of *socio-technical regimes*, which represent the major agents in a sector of technology and their stable relations as codified in regulations, guidelines, or unwritten rules. In the case of animal experimentation, this presumably includes such players as academic institutions, industry, scientific associations, journals, the legislator, regulators, and nonprofits. While such regimes are initially in equilibrium, pressures from two sides can induce transformation: At the level of *socio-technical niches*, spaces that are partially closed-off from usual market pressures such as academic labs or specialized markets generate innovations. While most innovations die off, some accumulate into stronger trends that disrupt the regime. This also depends on pressures exerted by the third level, that of the *socio-technical landscape* – the changing external conditions of a sector of technology, such as climate change, pandemics, wars, or changes in international agreements. However, outside of Dutch government-led projects (Denktank, 2015; NCad, 2016) the MLP has only rarely been applied to animal experimentation (see Abarkan et al., 2022; Schiffelers et al., 2012), and more contributions on the theme would be helpful.

Ideally however, a robust reading of premise (2) would be based not only on an understanding of factors that block change in the absence of interventions, but also on an understanding of *which* interventions, and in which combination, would be necessary for change. At the moment, the discussion focuses on an unsorted "all-you-can-eat buffet" of interventions (see Section 2.1) often compiled in brainstorming sessions with experts and stakeholders. The value of this approach notwithstanding, a more systematic understanding of intervention points is needed in addition. In fact, the MLP can be used to this end (Kanger et al., 2020) and has recently been applied to think about intervention points in animal experimentation (Abarkan et al., 2022). More contributions aiming at a systematic understanding of intervention points would however be helpful.

In sum, premise (2) calls for a fuller account of the factors that keep science in a given jurisdiction in an equilibrium state that produces a roughly stable amount of animal experimentation, as well as a systematic understanding of intervention points.

3.3 Planned interventions are sufficient for a phase-out

The third premise of the argument is that planned interventions are sufficient to achieve a phase-out. The most contentious aspect of this premise is that it entails that the development and implementation of a phase-out plan on the part of the authorities can be successful, thus, that PPAE is feasible.

In its response to ECI, the EC argued that

> "*at this stage, it is not possible to predict when scientifically valid methods able to replace particular animal procedures in research will become available. Consequently, setting reduction goals seems unrealistic and these would need to be constantly adjusted*" (EC, 2023: 17)[11]

In other words, PPAE is argued to be infeasible due to the myriad ways in which, and purposes for which, animals are used in science and the uncertainty of the future availability of alternatives (with the arguable exception of regulatory testing, for which EC agreed to pursue PPAE).[12] A serious challenge to the idea of general PPAE, then, is that animal research may be intractable, and planning its phase-out may exceed the authorities' abilities.

For the projects under consideration, the claim that successful PPAE can be carried out seems to be a matter of assumption more than argument. NCad, being the only institution to have been asked to draft a general phase-out plan, seems to take the challenges most seriously. It split animal experimentation into four areas – regulatory testing, basic research, applied and translational research, education (NCad, 2016: 15) – and suggested different measures for each area. Considering the area deemed least tractable by EC, basic research, NCad recommended splitting it up further into major research fields and periodically formulating ten-year visions for each (ibid.). It would not have been clear how many iterations of this process the phase-out would take. NCad's response to perceived intractability, in a nutshell, relied on *specification* – breaking general areas down into more manageable parts – and *flexibility* – allowing milestones whose intended relation to the ultimate goal of a phase-out is tenuous. It is not clear how the formulation of yet another ten-year vision is meant to drive progress towards an eventual phase-out. The hope is that the visions themselves will eventually help to clarify that, but there are no guarantees. While flexibility helps to address intractability, it has the obvious drawback of rendering plans less coherent. The debate about PPAE would be advanced by research contributions that tackle this difficulty

[11] As an anonymous reviewer rightly pointed out, the EC's response is inadequate in that it fails to address animal experiments that can already be replaced, but have not been. An example is the rabbit pyrogen test, whose replacement by the monocyte-activation test is possible, but faces various regulatory, economic, and trust barriers (Cirefice et al., 2023).

[12] As mentioned in Section 2.1, the EC's presupposition that a phase-out consists in a succession of one-to-one replacements should be challenged.

head-on and put forward planning principles for PPAE that help to strike a balance between flexibility and coherence.[13]

Apart from a general pessimism about the intractability of animal experimentation, the EC also voiced some more specific concerns that could make successful PPAE infeasible. As quoted above, the EC argued that "*setting reduction goals seems unrealistic*" (EC, 2023: 17). It is unclear what this "seeming" is based on, as the feasibility of a plan can be assessed only once it is sketched. In addition, the EC's concern appears to be based on an excessively narrow understanding of milestones. The ECI had suggested that milestones should cover not just the reduction of animal experimentation numbers, but also "*investments in advanced non-animal models and infrastructures, education and training synergy, and regulatory acceptance of non-animal methods*" (ECI, 2021a: 6). While it may not be possible to conduct successful PPAE based on reduction targets alone, other kinds of milestones could be fixed.

Another concern raised by the EC in the very same sentence is that milestones would have to be "*constantly adjusted*" (EC, 2023: 17), implying that this would constitute a failure of PPAE. But regular monitoring and subsequent readjustment of measures and milestones are the basic functions of a phase-out plan. "Constant adjustment" is a feature, not a bug. The risk of missing milestones is furthermore accepted by ambitious plans and indeed preferred over the risk of setting the bar too low (see Section 2.2). Thus, the EC's understanding of PPAE is excessively rigid.

The EC's narrow understanding of PPAE, questionable though it is, betrays a lack of common notions among proponents, opponents, and authorities. Clearly, between the mere word "roadmap" used by ECI (2021a) and unordered lists of measures to be taken (see Section 2.1), no clear and shared concept of PPAE has yet emerged, making calls for PPAE challenging to answer for authorities and easy to dismiss based on uncharitable understandings. While this article has approached this difficulty from a conceptual angle by clarifying the general notion of PPAE, the debate would be greatly advanced by the provision of particular suggestions for how measures, milestones, and monitoring might actually be combined. These would amount to speculative proposals of phase-out plans, the kind of thing one might arrive at through PPAE. Creating such sample plans is an opportunity for interdisciplinary and cross-sectoral collaboration, although government may need to take an active role in initiating it. Once various proposals are on the table, their relative merits and the feasibility of PPAE more generally can be judged on a more secure footing than what "seems" to be realistic according to the EC.

4 Conclusion

Based on communications related to ten political projects related to PPAE, this article has provided a philosophical explication of the concept of PPAE, defining it as *the activity of developing and integrating (i) measures, (ii) milestones, and (iii) monitoring, where the ultimate milestone is the inexistence of (certain domains of) animal experimentation in a given jurisdiction*. Furthermore, desiderata for good measures, milestones, and monitoring were drawn from the communications and given a charitable interpretation, including "concreteness," "bindingness," and "ambitiousness."

The chief moral argument in favor of PPAE was then distilled from the communications: The phase-out of animal experimentation is morally desirable, and planned interventions are necessary and sufficient to achieve it. While the logic of the argument is straightforward, the plausibility of its premises is difficult to assess without further advances in research. In particular, the debate about PPAE would be advanced by:

(1a) a definition of a morally desirable phase-out target that is precise enough to be implemented in practice;
(1b) an account of the "mixed calculation" of restrictions and new possibilities that a phase-out of animal experimentation is likely to bring;
(1c) an account of just transition in animal experimentation that outlines what moral claims those on the losing end of the phase-out have and how they should be attended to;
(2a) an account of the conditions that keep animal experimentation central in many fields of science;
(2b) a theoretical framework that enables a systematic understanding of intervention points for phase-out plans;
(3a) planning principles for PPAE that help to strike the balance between flexibility and coherence;
(3b) speculative proposals for phase-out plans.

Having clarified the concept of PPAE and articulated the main moral argument in its favor, this article thus produced seven action points. However, this is not to say that proponents of PPAE, let alone the authorities they address, should sit back and wait until all this work is done. To the contrary, they should address the seven action points either to lay the groundwork of an actual phase-out plan or at least to enable well-informed and responsible decision-making about how to pursue PPAE further.

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[13] A candidate principle might be "use flexibility only as a means of last resort." This has the advantage of moving forward wherever progress is feasible while leaving "stuck" fields to further deliberation. But it also raises the question what other means are considered, such as bans. How long should we keep being flexible, and when should we prohibit practices out of which we cannot envision a softer exit?

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Conflict of interest

In 2022, the author was employed by the Swiss nonprofit foundation Animalfree Research (AFR) to compile a report on international political and academic advances related to phase-out planning for animal experimentation. AFR later launched a petition to the Swiss parliament calling for a phase-out plan, with some of the petition website's FAQ section drawing on said report. This does not constitute a conflict of interest because both the report and this article aim at a reasonably comprehensive overview of developments linked to phase-out planning for animal experimentation. However, as both the AFR petition and the FAQ section are referenced in the article, it was flagged when the reference was to the author's own text to avoid "sock puppeting."

Data availability

No datasets were generated or analyzed during the study.

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